The journal is an international, open-access, peer-reviewed electronic journal created to meet the information needs of society fully and promptly in the knowledge gained in research and development, research and design, design and technology, and production activities of scientists and experts.

The journal publishes original research papers, review articles, and short communications papers on social, technical, natural sciences, and the humanities. The scope of problems of articles is not limited.

Responsibility for facts, quotations, private names, enterprise and organization titles, and geographical locations is to be barred by the authors. The editorial office and board do not always share the views and thoughts expressed in published articles.

TABLE OF CONTENTS

SECTION "EDUCATION"

SECTION "MEDICINE"

SECTION "LANGUAGES"

SECTION "ECONOMICS"

SECTION "SPORTS"

SECTION "ENGINEERING, MANUFACTURING AND CONSTRUCTION"

Модель логопедичної роботи з дітьми дошкільного віку з ринолалією
Model of Speech Therapy Work with Preschool Children with Rhinolalia

Галина Барсуковська [1]
Halyna Barsukovskaya

[1] *Oleksandr Dovzhenko Hlukhiv National Pedagogical University*
24 Kyiv street, Hlukhiv, Sumy, Ukraine, 41400

Анотація. Статтю присвячено характеристиці моделі логопедичної роботи з дітьми дошкільного віку з ринолалією. Розкрито поняття «ринолалія». Охарактеризовано порушення питання логопедичної роботи з дітьми дошкільного віку з ринолалією на сучасному етапі. Представлено та описано модель логопедичної роботи з дітьми дошкільного віку з ринолалією.

Ключевые слова: синтаксически-семантические; лексико-семантические; интонация; фразеологические сочетания; текст.

Abstract. The article describes the model of speech therapy working with preschool children with rhinolalia. The concept of "rhinolalia" is revealed. The issue of speech therapy work with preschool children with rhinolalia at the present stage is described. The model of speech therapy work with preschool children with rhinolalia is presented and described.

Keywords: syntactic-semantic; lexical-semantic; intonation; phraseological combinations; text.

ВСТУП

Формування мовленнєвої компетентності є одним із пріоритетних напрямів загального гармонійного розвитку дитини в закладі дошкільної освіти.

На сьогодні актуального значення набуває потреба у кардинальних змінах щодо навчання та розвитку дитини дошкільного віку в інклюзивному просторі. Наукові дослідження показують, що прогнози щодо зниження кількості народження дітей з ринолалією вкрай несприятливі. Відтак, в Україні народжуваність дітей з ринолалією останніми роками неухильно зростає, що спричиняє необхідність інноваційних заходів щодо її корекції.

Аналіз наукових джерел і практичної діяльності з особами із даним порушенням мовлення доводить, що удосконалення корекційного компонента має відбуватися за допомогою впровадження нових методів, підходів та практичної діяльності.

Для розроблення й обґрунтування моделі логопедичної роботи з дітьми дошкільного віку з ринолалією необхідно з'ясувати причини її виникнення, симптоматику, сучасне розуміння проблеми, а також охарактеризувати корекційну складову цього порушення.

Мета статті полягає в обґрунтуванні моделі логопедичної роботи з дітьми дошкільного віку з ринолалією.

Аналіз моделі корекційної роботи з дітьми дошкільного віку з ринолалією здійснено на матеріалах монографії, навчально-методичних посібників та статей. У дослідженні було використано такі методи як аналіз, синтез, узагальнення, класифікація та систематизація теоретичного матеріалу.

РЕЗУЛЬТАТИ ДОСЛІДЖЕННЯ

Серед мовленнєвих порушень ринолалія є серйозним розладом, подолання якого потребує тривалого часу та ранньої діагностики, своєчасних корекційних заходів, врахування

індивідуальних і загальних компенсаторних можливостей дитини, а також глибокого знання специфічних завдань логопедичної роботи з цією особливою категорією дітей.

У галузі логопедії ринолалія вважається самостійним мовленнєвим розладом серед безлічі мовленнєвих порушень, оскільки вона має унікальні симптоми, відмінні від інших мовленнєвих розладів.

Термін «ринолалія» (від грец. ρινός – ніс, λαλιά – мовлення) у дослівному перекладі означає мовлення в ніс, гугнявість, чим відображає тільки зовнішні прояви даного розладу. Історично для визначення цього мовленнєвого порушення в літературі (особливо в зарубіжній і медичній) використовували й інші терміни: «палатолалія», «палапголалія», «ринофонія», «механічна дислалія». На відміну від механічної дислалії у випадку ринолалії порушена вимова не лише приголосних звуків, а й голосних. Ринолалія характеризується ще й проявом стійких порушень звуковимовної сторони мовлення [1].

На сьогодні найбільш уживаним визначенням цього мовленнєвого порушення є таке: «Ринолалія – це порушення тембру голосу і звуковимови, зумовлене анатомо-фізіологічними вадами артикуляційного апарату» [2].

Згідно з останніми науковими дослідженнями, кількість осіб із вродженою ущелиною піднебіння і верхньої губи значно збільшилася. Згідно з медичними дослідженнями, вроджені порушення обличчя і піднебіння є результатом різних зовнішніх і внутрішніх впливів на ембріон, що тягнуть за собою затримку розвитку тих його частин, де закладаються ембріональні вузли, що формують обличчя, рот і носову порожнину. У спеціальній літературі існує багато думок про причини вроджених захворювань обличчя, ущелини губи і піднебіння. Наукова еліта зосередила свої дослідження на біологічних факторах розвитку цієї проблеми. До причин ущелини губи і піднебіння також належать різні психічні розлади, особливо на ранніх термінах вагітності, гінекологічні захворювання, ендокринні порушення, вік батьків, порядок вагітності та стан здоров'я матері.

Відповідно до класифікації Всесвітньої організації охорони здоров'я це порушення відноситься до голосових розладів. Незважаючи на те, що за її наявності спостерігаються значні порушення артикуляції, які найчастіше є наслідком природжених незрощень верхньої губи, твердого та м'якого піднебіння.

Проблема логопедичної роботи з дітьми з ринолалією була предметом вивчення таких науковців та практиків, як, С. Коноплясти, З. Мартинюк, Ю. Рібцун, В. Тищенко, Л. Трофименко, А. Цибулько, М. Шеремет та ін. Під час опису порушень фонетичної сторони мовлення дітей із ринолалією дослідники звертають увагу на те, що порушення звуковимови у них є досить специфічним процесом. Він є характерним лише для ринолалії, характер спотворень звуків зумовлений порушеннями артикуляційного укладу як органічного, так і функціонального характеру [3].

За твердженням С. Коноплястої, ринолалія характеризується гугнявістю, як фонетичний феномен має різну природу, що потрібно розуміти для глибшого усвідомлення механізмів, покладених в основу даної нозології. Носові звуки виникають через надмірне або недостатнє резонування носових ходів під час спілкування. Або анатомічні порушення твердого і м'якого піднебіння, які створюють зв'язок між ротовою і носовою порожнинами, або м'яке піднебіння недостатньо замикається із задньою стінкою глотки, так що повітря, що видихається, майже повністю проходить через ніс. Другий тип захриплості спричинений органічними змінами в носовій порожнині або носоглотці. Або ж причиною є органічні зміни в носоглотковій ділянці або дисфункція піднебінно-глоткового змикання, що ускладнює носове дихання [2].

У логопедичній діагностиці ринолалії, А. Цибулько важливим завданням вбачає розмежування порушень, що розрізняються за механізмом дії. Не всі симптоми, що спостерігаються у дітей з ущелиною піднебіння, зумовлені цим анатомічним порушенням. Наприклад, крім анатомічних і фізіологічних дефектів зубного ряду, часто порушується іннервація м'язів оклюзійних органів. По суті, ці випадки являють собою складні співіснуючі порушення, в яких задіяні два різні механізми: дефіцит центральної іннервації і структурні аномалії зубного ряду. У зв'язку з цим диференціальна діагностика різних механізмів синдромів мовленнєвої патології необхідна для правильного вибору завдання і корекційних заходів [4].

Для успішного орієнтування в даній нозології фахівці мають досконало володіти знаннями щодо анатомо-фізіологічних особливостей піднебінно-глоткового апарату в нормі і при патології.

Залежно від характеру порушення функції піднебінно-глоткового змикання виділяють різні форми ринолалії. Так, у логопедичній літературі виділяють три основні форми ринолалії: відкриту, закриту і змішану.

Відкритою формою ринолалії вважається порушення звуковимовної та фонаційної сторони мовлення, що є найскладнішою, як в механізмах порушення, так і у процесі подолання. Виокремлюють органічну та функціональну відкриту ринолалію. Відкрита органічна ринолалія може бути як набутою так і вродженою. Набута відкрита органічна ринолалія проявляється в результаті перфорації твердого і м'якого піднебіння при черепно-мозкових травмах, остеомієліті, рубцях, ранах або пухлинах, тобто у разі порушення цілісності та рухливості твердого і м'якого піднебіння.

Вроджена органічна відкрита ринолалія зазвичай є результатом вродженого незрощення м'якого та твердого піднебіння, паралічу та парезу м'якого піднебіння за умови короткого м'якого піднебіння, підслизових тріщин і пошкодження блукаючого нерву.

Відкрита ринолалія, як правило, характеризується надмірною назальністю мовленнєвих звуків та їхньою не правильною артикуляцією, внаслідок підвищеної можливості проходження струменя повітря, що видихається, через ніс. За таких умов носові звуки м, м', н, н', а також усі інші, які є ротовими, набувають назального відтінку, порушуючи артикуляційні характеристики звуків.

У логопедичній практиці вроджена відкрита органічна ринолалія зустрічається найчастіше і є наслідком вроджених піднебінних порушень. Симптомами відкритої органічної ринолалії є зміни положення язика. Язик стабілізується в тому положенні, коли спинка язика відтягується назад до глотки, а корінь язика підтягується вгору, злегка збільшується, гіпертрофується і напружується. Язик майже повністю нерозвинений, млявий, атонічний, унаслідок чого залишаються доступними тільки найелементарніші, недостатньо диференційовані артикуляційні рухи:

- відбуваються зміни у роботі м'язів м'якого піднебіння. Після операційного втручання м'яке піднебіння в деякій мірі залишається недостатньо активним, малорухомим, що зумовлюється наявністю рубцевої тканини. Слабо виконуються функції розмежування ротової та носової порожнин. Часто виявляється асиметрія м'язів м'якого піднебіння зліва і справа, яка з віком здатна прогресувати. Слизова оболонка поступово світлішає, стає млявою та атрофованою;

- порушення діяльності м'язів периферичного артикуляційного апарату. Спочатку порушується взаємодія артикуляційних і мімічних м'язів, що характеризується нехарактерними рухами м'язів обличчя під час мовлення. Симптомом, що ускладнює процес мовленнєвого акту можна вважати порушенням взаємодії артикуляційних і дихальних м'язів, що призводить до специфічних порушень мовленнєвого дихання. Також характерних змін зазнає ритмічність мовленнєвого дихання, в результаті чого порушуються механізми між вдихом і видихом, спрямованість та плавність вдиху і видиху [5].

Закрита форма ринолалії характеризується порушенням фонетичної сторони мовлення. Порушення нормального проходження повітря через ніс ускладнене та призводить до повного або часткового усунення носового резонансу, чим зумовлена зміна тембру голосу. Закрита форма ринолалії характеризується зниженням фізіологічного носового резонансу під час вимови носових звуків *м, м', н, н'*. У процесі артикуляції цих звуків під час нормальної роботи носоглотковий прохід залишається відкритим, а повітря вільно проникає до носової порожнини. Якщо носовий резонанс відсутній, то ці фонеми набувають ротового звучання *б, б', д, д'*. Основними причинами закритої ринолалії найчастіше є зміни в носовому просторі, або функціональні розлади піднебінно-глоткового змикання, таким чином носова порожнина відокремлюється від ротової.

Виділяють передню закриту ринолалію, що виникає на фоні хронічної гіпертрофії слизової порожнини носа, як правило задніх відділів нижніх раковин та задню закриту ринолалію, яка найчастіше є наслідком великих аденоїдних розрощень або носоглоткових поліпів унаслідок фіброми чи інших пухлин. При передній закритій ринолалії порушуєть-

ся проходження повітря в носові ходи, а при задньої закритої – зменшується об'єм носоглоткової порожнини, при цьому звуки м, н звучать як *б, д, д'*. Помітною зовнішньою ознакою закритої ринолалії є постійно відкритий рот.

Для змішаної форми ринолалії характерний низький носовий резонанс під час вимови носових звуків та наявність назального відтінку у тембрі голосу. Причиною змішаної ринолалії є поєднання утрудненого носового дихання та недостатність піднебінно-глоткового змикання, що має функціональне або органічне походження. Найтиповішим є поєднання закороткого м'якого піднебіння, підслизового його незрощення та аденоїдних вегетацій. У таких випадках аденоїди є перешкодою для проникнення повітря у носові ходи. У такому випадку потрібно ретельно обстежити будову м'якого піднебіння та визначити, яка форма ринолалії порушує тембр мовлення. Після відновлення носового дихання використовують логопедичні прийоми для подолання відкритої форми ринолалії [6].

Мовленнєвий розвиток дітей з ринолалією є досить бідним та відрізняється від унормованого мовлення. У зв'язку з порушенням анатомічної цілісності периферичного мовленнєвого апарату, дитина позбавлена можливості інтенсивного лепету, правильного виконання артикуляційних вправ. Найтиповіші звуки *п, б, т, д* дитина артикулює дуже тихо або навіть беззвучно, що пов'язане з проходженням струменя повітря через носові ходи, не отримуючи через це слухового підкріплення.

У дітей з ринолалією порушенню підлягає не лише артикуляція, а й розвиток просодичних елементів мовлення (інтонація, тембр, темп, ритм). Голос у таких дітей глухий, неприродній, слабкий, виснажений, тихий, приглушений з яскраво вираженим назальним відтінком. Акустичні зміни голосового спектра позбавляють його дзвінкості, знижується чіткість і розбірливість усного мовлення, що розвивається із запізненням. Помічається часовий інтервал між появою перших складів, слів і фраз у перші роки життя, які вважають активними для формування не тільки мовлення, а й інтелекту. Часто перші слова дитина починає вимовляти приблизно у 2 роки, або навіть значно пізніше. Фразове мовлення з'являється також із запізненням, деколи піс-

ля 4-5 років. Крім анатомічного порушення периферичного мовленнєвого апарату, у дітей з ринолалією інколи вторинно страждає слух, тобто розвивається туговухість, яка безперечно гальмує мовленнєвий розвиток.

Імпресивне мовлення розвивається нормально, проте експресивне зазнає якісних змін. Слова і фрази, які вимовляє дитина не зрозумілі для оточуючих, оскільки звуки, що формуються у них, є не характерними за артикуляцією та звучанням. При неправильному положенні язика в роті приголосні звуки утворюються в основному завдяки більш активній участі задньої частини спинки язика, неприродній участі кореня язика у вимові, а також у разі не типової активізації м'язів обличчя. Через млявість і недостатню рухомість кінчика язика, діти не можуть здійснити необхідне змикання з верхніми зубами і альвеолами для вимови звуків верхньої позиції: *л, т, д, ч, ш, щ, ж, р*, а біля нижніх різців – звуків *с, з, ц* з одночасним ротовим видихом. У зв'язку з цим свистячі та шиплячі звуки у дітей набувають іншого звучання [6].

Звуки *к, г* у мовленні або повністю відсутні, або мають характерний вибух, що виникає в ході з'єднання незрощених частин у вусі. Звук *р* майже ніколи не досягається нормальним звучанням, він або не вимовляється, або наближається до одно ударного звуку. Сонорний *л* або відсутній, або наближений до часто замінюваних на *й, у, л'*. В разі ринолалії страждає дзвінкість приголосних звуків, спостерігається оглушення дзвінких та їхня затухаюча вимова. Голосні звуки дитина вимовляє при відтягнутому назад язику з видиханням повітря через ніс, характерним для них є млява губна артикуляція і сильний носовий відтінок. Неправильна звуковимова при ринолалії має неправильне звучання фонем, та заміну однієї фонеми іншою. Практично всі голосні та приголосні звуки назалізовані та нечітко розділені між собою.

Освітній простір часто є чітким індикатором наявності порушень мовленнєвого розвитку та потребує чіткого алгоритму вчасного виявлення та підтримки з метою запобігання або подолання бар'єрів доступу до освіти на всіх рівнях. Далі ми пропонуємо розглянути структурні особливості критеріїв визначення функціональних порушень мовлення залежно від їхнього ступеня [7].

Труднощі першої стадії включають незначні, ізольовані особливості функціонування мовлення, які можуть бути присутніми в різних поєднаннях.

Труднощі другої стадії включають наявність значних особливостей функціонування мови, які можуть бути присутніми в різних поєднаннях і є перешкодою для успішного набуття знань та взаємодії.

Труднощі третьої стадії включають у себе характерні особливості функціонування мовлення, що існують у різних поєднаннях і спричиняють особливості когнітивного, емоційного та вольового функціонування, які заважають досягненню успіху та взаємодії.

До труднощів четвертого ступеня відносимо наявність чітко окреслених особливостей початкової стадії функціонування мовлення, які можуть бути присутні в різних поєднаннях, спричиняти особливості когнітивного, емоційно-вольового функціонування, створювати бар'єр в успішному опануванні знань і взаємодії.

Труднощі п'ятої стадії включають особливості функціонування мовлення різного ступеня вираженості, які можуть бути присутніми у поєднанні з особливостями інших функцій, створюючи значні перешкоди для набуття знань та успішної взаємодії.

Окреслена нами характеристика ступенів прояву функціонально-мовленнєвих труднощів, має стати фахівцям чітким алгоритмом визначення особливих освітніх потреб, які претендують на задоволення за умови надання певного рівня підтримки. Відповідно до зазначеного окреслимо рівні підтримки дітей із ринолалією.

До І-го рівня підтримки належать діти із ринолалією, у яких усне мовлення має такі характеристики: особливості відтворення назального відтінку тембру голосу, глухий, тихий голос, голосний звук а звучить найбільш ринофонічно; яскраво виражена присутність назального відтінку у голосних звуках *i*, *y*; голосні звуки вимовляються за допомогою відтягнутого назад язика з видиханням через ніс повітрям із в'ялою губною артикуляцією; особливості мовленнєвого дихання (повітря проходить через носові шляхи, видих короткий, повітряний струмінь слабкий, нецілеспрямований); фонематичні процеси відповідають віку дитини, речення мають правильну граматичну будову, використовуються різні за типом речення в усному мовленні; лексичний запас відповідає віковим нормам. Труднощі І-го рівня характеризуються наявними незначними особливостями, які можуть бути притаманні мовленню дитини. Присутній виражений назальний відтінок в усному мовленні та поодинокі випадки порушення звуковимови в поєднанні з недостатнім інтонуванням. Ці особливості не створюють бар'єру в розвитку та успішному опануванні знань дитиною [2].

Під час обстеження дітей із ринолалією, звертається увага на такі показники, як:

– вид вродженого незрощення та вік, у якому виконано пластику губи (хейлопластика або хейлоринопластика), пластику твердого та м'якого піднебіння (велопластика, уранопластика);

– анатомічна будова артикуляційного апарату з урахуванням будови твердого піднебіння, довжини м'якого піднебіння, можливості активного та пасивного змикання м'якого піднебіння із задньою стінкою глотки, будови зубного ряду, характеру прикусу, оцінки назального резонансу, його вираженості, постійності гіперназального резонансу;

– порушення голосу;

– компенсаторні мімічні рухи;

– звуковимова;

– загальна розбірливість мовлення;

– лексико-граматична будова мовлення;

– функція піднебінно-глоткового зімкнення;

– дослідження слуху.

На підставі цих даних формується логопедичний висновок та у разі потреби призначаються додаткові обстеження спеціалістів. Завдання корекційної роботи з дітьми з ринолалією відрізняються залежно від періоду комплексного лікування.

Насамперед слід зазначити, що логопедична робота з ринолалії має бути науково обґрунтованою, систематичною, послідовною та комплексною. Під час планування логопедичної роботи логопед має визначити стан розвитку структурних компонентів мовлення, спираючись на психолого-педагогічні класифікації мовленнєвих порушень. Виходячи зі стану розвитку фонологічного, лексичного та

просодичного мовлення, визначають основні завдання та обирають напрямок логопедичної роботи з дітьми з ринолалією [8].

Корекція дітей із ринолалією залежить від її форми. Корекційна робота має бути комплексною і спрямована на виправлення мовленнєвих порушень, розвиток словникового запасу, граматики та граматичного мислення, корекцію психологічних впливів. Робота при подоланні ринолалії у дітей дошкільного віку ґрунтується на таких принципах корекційних заходів:

- урахування механізмів порушення мовлення та особливостей симптоматики стану піднебінно-глоткового змикання, анатомо-функціональної складової органів артикуляції, дихання, стану артикуляційних органів, слухового контролю, рівня фонематичного слуху, що підкреслює потребу у формуванні артикуляційних вкладень;

- зосередження на збережених аналізаторах та їхніх функціях, розвиток потенційних практичних можливостей кінестетичного, слухового та зорового аналізаторів;

- використання фізіологічного дихання з метою перестроювання його на фонаційне;

- паралельність у роботі над формуванням мовленнєвого дихання і артикуляційного апарату;

- використання фізіологічної взаємозалежності і взаємодії м'язових груп мовленнєвого апарату в роботі з розвитку артикуляційного праксису;

- урахування рівня готовності артикуляційного апарату для визначення послідовності постановки звуків;

- звернення уваги на вікові та компенсаторні можливості дитини з ринолалією;

- забезпечення систематичної та паралельної логопедичної та психокорекційної роботи.

Модель логопедичної роботи з дітьми дошкільного віку з ринолалією ми пропонуємо будувати із двох основних блоків:

Перший блок. Основною метою доопераційного етапу є недопущення створення патологічних компенсаторних звичок та підготовка бази для правильної звуковимови. Дослідники виокремлюють основні напрями корекційної роботи з подолання ринолалії, які відносяться до доопераційного періоду:

1) підготовка піднебінної завіси до піднебінно-глоткового змикання;

2) активізація артикуляційного апарату;

3) робота над фізіологічним і фонаційним диханням;

4) постановка голосних звуків;

5) розвиток фонематичного слуху.

В післяопераційний період корекційне навчання дітей, продовжується за такими напрямами:

1) активізація артикуляційного апарату;

2) усунення назального відтінку голосу;

3) постановка звуків;

4) нормалізація просодичної сторони мовлення;

5) корекція фонематичних процесів;

6) автоматизація набутих навичок у вільному спілкуванні.

Другий блок. Післяопераційний етап займає декілька тижнів. Після пластичної операції, проводиться додаткова робота, що забезпечує анатомо-фізіологічну базу правильністю усного мовлення. Головною метою логопедичних занять стає розвиток повноцінного піднебінно-глоткового змикання. В перші тижні після операції може спостерігатися розтягнення піднебінної завіси і помітна максимальна її рухливість. Значно полегшується й робить швидшою навичку ротового резонансу голосних у спонтанне мовлення задіяння тільки, що сформованого піднебіння у фонацію. Відбувається упізнання дитиною функції піднебінної завіси, і новий орган знаходить своє призначення.

У цей період може спостерігатися набряк, практична нерухомість, відсутність чутливості м'якого піднебіння. Деякі рухи можуть заподіяти больові відчуття дитині, у таких випадках дитина намагається уникати артикуляційних дій. З часом назальний відтінок у мовленні стає більш помітним, тому основною задачею стає розгальмовування сформованої піднебінної фіранки і розвиток її рухомості чи стимулювання щільного контакту між стінками глотки.

Через півроку після оперативного втручання рубцювання загоюється, що не помітно зменшує кількість та частоту виконання вправ

для активізації м'якого піднебіння. Тому в перші місяці після операції піднебіння, логопедичні заняття варто проводити регулярно 3 рази в тиждень, а вдома з дитиною мають щодня займатися батьки. Еластичність і рухомість м'якого піднебіння взаємопов'язані. Після пластичного закриття малорухома піднебінна фіранка, як правило, коротшає за рахунок рубцювання рани. Рухова активність піднебіння набуває активності поступово протягом 6-8 місяців. Увесь цей час рекомендується проводити артикуляційні вправи щодня. Заняття варто розпочинати з вимови голосних *а, е, о*. Якщо піднебінна фіранка при цьому залишається нерухомою, одночасно з фонацією голосного звуку потрібно намагатися спровокувати глотковий рефлекс.

Значущим аспектом корекційної роботи у формування просодичних компонентів усного мовлення у дітей із закритою ринолалією є розвиток та вдосконалення голосу. Для розрізнення понять «високі» і «низькі» звуки голосу, дітям можна використовувати образи казкових героїв наприклад: «вовка і комарика», надаючи їм голосові, музичні та рухові характеристики. У випадку, коли у дитини помічається тихе та глухе звучання голосу, доцільно застосовувати корекційні методи впливу як можна швидше.

Роботу над розвитком слуху дитини варто починати ще у ранньому віці, адже саме слухові якості відіграють важливу роль у розвитку голосу, як важливої та головної складової мовлення дитини. Оскільки голос забезпечує інтонаційне забарвлення та виразність мовлення, то вже протягом перших місяців життя дитини потрібно працювати над розвитком навиків, щоб дитина вміла прислуховуватися до різних звуків в її оточенні, до звернення близьких людей. Відтак, при нормальному розвитку перші короткі звуки: *а-а-а, а-гу, бу* з'являються у мовленні дитини вже на 3-му місяці життя. Саме цей період називають «гулінням», для його розвитку необхідна велика увага до вимови й артикуляції звуків з боку дорослих. При виникненні проблем, спеціаліст та батьки мають надати допомогу дитині, щоб вона побачила, відчула та почула артикуляцію звука і слова.

Протягом першого року життя дитини, батькам можна наспівувати веселі мелодії, імітувати разом з ним в ігровій формі різні голоси тварин, природи, пташок. Щоб стимулювати

підвищення дитиною сили голосу можна гратися в піжмурки, гукати її, відійшовши при цьому на достатню відстань. Для розвитку голосу також рекомендується застосовувати записи улюблених пісень і мелодій мультфільмів, різноманітних відео для дітей та фонозаписи звуків у природі.

Здійснюючи аналіз особливостей мовленнєвого розвитку дитини, батькам рекомендується продовжити співпрацю з логопедом над розвитком навичок мовлення і запобіганням мовленнєвим порушенням у подальшому. Необхідно проводити роботу із тренування м'якого піднебіння до піднебінно-глоткового змикання, здійснювати профілактику дистрофії м'язів глотки та піднебіння, при цьому спрямовувати основні зусилля для опускання кореня й укріплення кінчика язика, переміщення язика вперед, активізації рухів щік та губ, постановки правильного дихання, формування нормального струменю повітря, уникнення труднощів у виголошенні звуків в зв'язному мовленні дитини [3].

До просодичного компоненту входить інтонаційна виразність усного мовлення. Оскільки у дітей із ринолалією найчастіше спостерігається монотонне та емоційно збідніле мовлення, то дітей необхідно ознайомити з поняттям про те, що:

- інтонація це обов'язкова ознака усного мовлення;

- інтонація допомагає висловити почуття та зрозуміти їх іншим;

- ознайомити дітей з різними видами інтонації та навчити їх застосовувати інтонацію відповідно до ситуації;;

- навчити дітей розрізняти та вживати різноманітні інтонаційні структури у власному мовленні.

Науковці та практики рекомендують через гру доносити дітям, що є різні види інтонації: розповідна, оклична, питальна та спонукальна. Від наголосу, який виражається в інтенсивності звучання окремих складів часто залежить значення слова. Корекційна робота вимагає впливу на всю артикуляційну систему. Патофізіологічні дослідження, що виявляють особливості дихання, фонації і артикуляції у дітей, розширюють уявлення про структуру порушення і дозволяють вибирати більш обґрунтовані і цілеспрямовані методи логопе-

дичної роботи. Особливо важливими є ранні профілактичні і комплексні корекційні заходи, які можуть покращити розвиток усного мовлення у дітей з ринолалією.

Високу результативність системи логопедичного впливу на дитину з ринолалаєю, було розроблено вітчизняними науковцями-практиками ще в минулому столітті. Так, вони своїм багаторічним досвідом роботи довели, що систематичні логопедичні заняття є необхідними і доцільними ще в доопераційному періоді. Проте нині варто враховувати, що цю систему було розроблено, коли строки оперативного втручання були більш пізніми, тобто фізіологічна й особистісна готовність дитини до спільної роботи була краще сформованою. Враховуючи це, логопеди сьогодення визнають цю методику як ефективну за відсутності у дитини системних порушень мовлення [9].

Особливість окресленої методики полягає в тому, що на тлі дихальних і артикуляційних вправ, розвитку кінестетичних відчуттів, увага дитини зосереджується спочатку на артикуляційному укладі (артикулемі) звука, а потім, за умови її засвоєння, з проміжком часу, долучаються голосові зв'язки. У процесі формування артикулем особлива увага привертається плавному, невимушеному характеру рухів, для того, щоб можна було запобігти виникнення синкінезії у лицьовому та мімічному нерві. У системі вправ з розвитку артикуляційного апарату важливим є використання фізіологічної взаємообумовленості м'язових груп мовленнєвого апарату. Послідовність роботи над звуками визначається рівнем готовності артикуляційної бази.

Змістом таких логопедичних занять є перевиховання фізіологічного дихання на мовленнєве; відпрацювання диференційованого вдиху та видиху; тренування довгого та рівномірного ротового видиху для реалізації голосних артикулем (без застосування голосу) та фрикативних глухих приголосних; правильний розподіл короткого та довгого ротового, а також носового вдиху та видиху для формування сонорних і африкативних звуків; виголошення м'яких звуків. У даній методиці чітко визначено основні етапи корекційної роботи (підготовчий та основний), особливості логопедичної роботи в до- та післяопераційному періоді, а також зазначається послі-

довність виконання роботи над звуками та дозування матеріалу в різні періоди роботи.

Голосні звуки пропонується формувати у такій послідовності: *а, є, о, у, и, я, ю* (завершує цю послідовність звук *й*). Звуки *я, є, ю* формуються зі сполучення й та відповідного голосного звука (*а, е, о, у*). Звук й дає можливість зрозуміти напрямок повітря, що видихається, як першої, так і другої частини дифтонга. Інші дослідники рекомендують такий порядок постановки приголосних: *п, б, м, т, д, н, ф, л, к, г, с, з, х* або *п, т, к, л, б, д, г, с, з, ш, ж* або *п, б, ф, в, т, д, л, к, г, с, з, х*. Тобто всі пропонують починати постановку приголосних зі проривних (*п, б*) та передньоязикових (*т, д, н*).

Дещо іншою є пропозиція розпочинати роботу з постановки щілинних *ф* і *в*, оскільки їх вимова не потребує підвищеної сили голосу, що не є бажаним для ослабленої дитини. На основі *ф* і *в*, змінивши артикуляційний уклад, пропонується розпочинати *с* і *з* (оскільки дитина може надати холодний струмінь повітря). Спираючись на короткий, відривчастий *ф* відбувається змикання і утворюється звук *п*, а від звука *в* можна поставити звук *б*. Кількість запропонованих дитині вправ на кожному занятті може бути різною, в залежності від ступеня повітря. Наприклад, на першому занятті дозволено обмежитися лише тренуванням ротового видиху або перейти до формування артикуляції деяких голосних звуків [2].

Доречними та актуальними є запропоновані автором спеціальні таблиці для автоматизації поставлених звуків, малюнки, картинки, завдання для батьків тощо.

У зв'язку з вищевикладеним, аналіз методів і прийомів, які використовуються в практичній логопедії, дає змогу виокремити основні принципи та напрямки корекційної роботи дітей дошкільного віку і ринолалією:

- врахування механізмів мовленнєвих порушень і симптомів (наприклад, стану піднебінно-глоткового змикання, анатомічного та функціонального збереження артикуляційних органів, дихання, стану артикуляційної бази, слухового контролю, рівня фонематичного слуху тощо);

- спиратися на збережені аналізатори та їхні функції для розвитку потенційних функціональних можливостей моторно-сенсорних, слухових і зорових органів;

- використовувати фізіологічні дихальні техніки для перенавчання діафрагмального дихання, видиху через рот;

- паралельно працювати над формуванням вокального дихання та артикуляційного укладу;

- використовувати фізіологічну взаємозалежність і взаємодію м'язових груп голосових органів під час розробки вокальних вправ;

- врахування рівня підготовленості артикуляційної бази звуків для визначення послідовності артикуляції;

- врахування вікових і компенсаторних можливостей дітей з ринолалією;

- забезпечення системності та паралельності логопедичної та психологічної корекції.

ВИСНОВКИ

Проведене дослідження підтверджує гіпотезу про те, що розробка та впровадження системи комплексного впливу подолання порушень, спрямованої на корекцію ринолалії, створить передумови соціально-психологічної реабілітації та реалізації відповідного розвитку мовлення дітей.

Таким чином, реабілітація дітей із ринолалією спрямована на реалізацію як системного корекційного впливу, який застосовується в умовах медичних закладів із відповідною спеціалізацію кваліфікованою командою фахівців та за наявністю обґрунтованої логопедичної і психокорекційної допомоги.

СПИСОК ВИКОРИСТАНИХ ДЖЕРЕЛ / REFERENCES

1. Bondar, V., & Synova, V. (2011). *Defektolohichnyi slovnyk* [Defective Dictionary]. Kyiv: Lesia (in Ukrainian).

2. Konopliasta, S. (2015). *Rynolaliia vid A do Ya* [Rhinolalia from A to Z]. Kyiv: Knyhaplius (in Ukrainian).

3. Trofymenko, L. (2013). *Korektsiine navchannia z rozvytku movlennia ditei starshoho do-shkilnoho viku iz ZNM* [Correctional teaching of speech development for children of older preschool age with SEN]. Kyiv: Aktualna osvita (in Ukrainian).

4. Tsybulko, A. (2022). Osoblyvosti korektsiino-rozvytkovoi roboty lohopeda z ditmy iz vro-dzhenymy nezroshchenniamy huby ta pidnebinnia [Features of correctional and developmental work of a speech therapist with children with congenital cleft lip and palate]. *Acta Paedagogica Volynienses, 1*(1), 227–233. doi: 10.32782/apv/2022.1.1.36 (in Ukrainian).

5. Kravchenko, A. (2021). *Korektsiia rynolalii u ditei za dopomohoiu akupresury (tochkovoho ma-sazhu)* [Correction of rhinolalia in children using acupressure (acupressure)]. Sumy: Tsoma S. P. (in Ukrainian).

6. Sheremet, M. (2014). *Lohopediia* [Speech therapy]. Kyiv: Slovo (in Ukrainian).

7. Konopliasta, S. (2008). *Rynolaliia. Prychyny, mekhanizmy, osnovni formy porushennia. Khrestomatiia z lohopedii: Istorychni aspekty. Dyslaliia. Dyzartriia. Rynolaliia* [Rhinolalia. Causes, mechanisms, main forms of disorder. Textbook of speech therapy: Historical aspects. Dyslalia. Dysarthria. Rhinolalia.]. Kyiv: KNT (in Ukrainian).

8. Ribtsun, Yu. (2013). *Korektsiina robota z rozvytku movlennia ditei p'iatoho roku zhyttia iz fonetyko-fonematychnym nedorozvytkom movlennia* [Correctional work on the development of speech of children of the fifth year of life with phonetic and phonemic underdevelopment of speech]. Kyiv: Kafedra (in Ukrainian).

9. Tyshchenko, V. (2006). *Yak navchyty dytynu pravylno rozmovliaty: vid narodzhennia do 5 rokiv: porady batkam* [How to teach a child to speak properly: from birth to 5 years old: tips for parents]. Kyiv: Litera (in Ukrainian).

The Impact of Social Media on Youth Education and Well-being

Ejuchegahi Anthony Angwaomaodoko

Corresponding Author:
ejuchegahi.angwaomaodoko@gmail.com

Abstract. The study dives into the impact of social media on youth education and well-being as social media represents a significant obstacle to the academic achievement of youth and holds the opportunity for youths to improve their teaching and well-being. The dangers associated with social media are hinged on the continued use of these platforms, which can be referred to as social media addiction, which negatively causes poor sleep patterns and duration, invariably impacting academic activities during the day and resulting in drowsiness. More so, the constant following of trends and messages can be distractive, thus affecting productivity and focus. Excessive screen time and social media addiction can also negatively impact the well-being of youth, with social media content capable of contributing to feelings of inadequacy and anxiety. Stakeholders must recognise these dual effects and implement measures to promote healthy online behaviours and digital literacy skills. By doing so, we can harness the educational benefits of social media while mitigating its potential harms, ultimately supporting the holistic development and well-being of young people in the digital age.

Keywords: Social media, education, well-being, impact, youth, addiction.

INTRODUCTION

Social media platforms have rapidly developed globally, with several billion users. As of February 2024, an estimate of over 5 billion users of social media has been reported from the global world population, which is estimated to have slightly exceeded the 8 billion mark [1], which indicates that over 62% of the worldwide population is current user of social media with youths and teens forming a high percentage of active users of these platforms. Vogel et al. reported that 95% of youth aged 13 to 17 use social media, further bolstering the many youths who actively use these platforms [2]. Similarly, the NORC Center for Public Affairs Research also noted the high social media usage among teens, with 95% of them using diverse social media platforms [3].

There are currently several social media platforms, with Facebook, YouTube, WhatsApp, and Instagram among the leading platforms, with active users exceeding 2 billion. In contrast, other social media platforms with high users include TikTok, WeChat, X (formerly known as Twitter), and Telegram, among many different platforms [4]. The central aim of these media platforms is the interconnection of the globe through the creation and sharing of content, ideas and interests, which, to a high degree, has a significant impact on the lives of users, positively or negatively, bearing in mind the high human population actively using these platforms. The increased usage of social media, thus, indicates that the time spent on these platforms for the sole purpose of socialising and engagement in global trends would have an immense impact on the academics of youth due to increased distraction, increase in procrastination of reading of their academic's instructional material and less time in conducting academics' research.

Despite the perceived impact of social media, when these platforms are precisely channelled towards youth education, they hold great potential to increase their knowledge base. Education is built on the foundation of the transmission or access to knowledge, skills and character that can be obtained through formal and informal processes. Authors [5] noted in their study that social media could help facilitate learning and knowledge creation in e-learning. However, the excessive usage of social media could prove detrimental to the formal academic achievement of youth, considering that a considerable percentage of them spent more time online checking out videos and commenting on social activities, which could be a source of distraction from attaining academic success. Authors [6] noted that

the more time children spend using the internet comes with the negative consequence of losing touch with their physical surroundings. They further stated the challenge of the time spent online, with an average of 2-5 hours spent online daily [6].

This study seeks to explore social media's impacts on the education and well-being of youth, considering that the most active users of these platforms are youth. The well-being of an individual encompasses the emotional, physical, social, mental and intellectual state, which invariably is a determinant of the quality of life and the ability of such individuals to be responsible for making quality contributions to their environment.   The focus of the study would be limited to the impact of social media on youth education, bearing in mind the duration of their time spent on these platforms and how these platforms affect their all-round well-being.

Literature review

The world is rapidly advancing technologically, and one of the consequences of these changes in the usage of technology is the increase in social media usage among youth and how these platforms play a significant role in the lives of youth, thus ushering significant challenges and providing exciting opportunities for youth. Authors defined social media as any application or website that offers a platform for users to create and share content or enable the social networking/connection of diverse users [7]. Authors added that social media further promotes businesses and discussion and has an advantage over traditional media [8]. These platforms became popular with the launch of Facebook and Twitter in 2004 and 2006 respectively [9]. The success of both Facebook and Twitter ensured the rapid growth of other social media while placing this judgement on the number of active users of these platforms. Currently, Facebook with 3.1 billion monthly active users, YouTube with 2.51 billion, Instagram with 2 billion, WhatsApp with 2 billion, WeChat with 1.31 billion users and TikTok with 1 billion are the most accessed social media in the world [10].

The amount of time spent on social media has dramatically increased the dangers associated with these platforms. Authors [11] conducted a cohort longitudinal study on the time spent on social media by youth between the ages of 12 and 15. He noted the impact of adolescents spending over 3 hours on social media. The authors said that adolescents are more likely to have their mental health impacted by increased social media and further advocated that research should be conducted to ascertain a suitable time for youth to engage in social media. In the same vein, some other authors noted that an average of 3.5 hours per day is spent daily by 8th and 10th graders, with the authors asserting that adolescents who spend over 3 hours per day have an increased risk of experiencing depression and anxiety, which cumulatively affects their mental well-being [12, 13]. Other challenges of spending a considerable amount of time were exemplified by the study conducted by authors [14]. They noted how negative experiences such as cyberbullying as well as cyberstalking affect the self-esteem of youth [14].

Smith et al.'s study on the impact of social media on adolescent social well-being indicates that these platforms can both boost the sense of social well-being of youth and deter them [15]. The author advocates the cautious use of this platform to enhance and promote psychological well-being among youth. Similarly, authors [16] asserted that social media promotes a sense of belonging among youth.

The Academics of youth are vital in contributing to their nation's development. Some studies have been conducted to ascertain social media's impact on youth academic achievement [14, 17, 18]. Addiction to social media was found to be associated with student, most especially those in higher education, with this addiction having an impact on their academics [19, 20]. Authors [21] studied the effect of social media on academics and interpersonal relationships among undergraduate students. The finding of their study indicates that it is not the usage of social media that affects the academic performance of students with undergraduates who spend between 2-5 hours and follow social media between 1 and 10 times a day having lower GPAs. The study further shed light on social media addiction and how it affects the duration of sleep of youth, thus impacting their well-being.

RESULTS AND DISCUSSION

Impact of social media on the education of youth. Since the introduction of Facebook, the popularity and usage of social media platforms have been

increasing as they form an essential part of individual lifestyles. The impact of social media has been studied to ascertain its effect on the educational achievement of youth [14, 17, 18]. Several variables need to be considered to understand social media's impact properly. Of these, the most important is the amount of time the continued use of these networks leads to a situation known as social media addiction. Social media addiction is on the rise among adolescents and youth, and it seems not to be slowing down, considering the continuous increase in the number of active users of these social media platforms. Authors [21] study exemplifies the duration of time that youth spend on social media, as over 84% of the undergraduates involved in his research claim to spend over 2 hours daily on social media while a high percentage of them claim to visit or follow their favourite platform at least ten times in a day. Some authors have noted that the interface and every other design of these platforms have been designed to ensure maximum user engagement, encouraging the excessive use of these platforms. Some of the strategies employed in the design include the infinite scroll, push notification, the display of popularity, and an algorithm that recommends content to users based on their data, such as displaying content that users would be interested in [22].

The constant visits to these platforms, which, on most occasions, are for social interaction, could prove distractive and negatively affect students' academic performance, resulting in reduced productivity and focus. Authors [21] called frequent or impulsive visits to these social media platforms social media addiction, with the authors further stating that ongoing visit to social media platforms negatively affects students' academic performance. Some other scholars also noted that the changes in the brain structure of individuals with social media addiction are similar to the changes that occur in individuals who have gambling and substance abuse [23, 24].

The addiction to social media has been observed to affect the academic of youth, with one of its effects attributed to both the quality and duration of sleep. The fatigue resulting from disrupted sleep patterns and time impacts the cognitive function of youth during lecture periods study time while cumulatively affecting their academic activities. Author [17], as cited in [18, p. 2], described, "Social media exposes people, especially the young generation, to new exciting activities and events that may attract them and keep them engaged in different media contexts for hours just passing their time. It usually leads to reduced productivity, reduced academic achievement, and addiction to constant media use" [18, p. 2].

The addiction or spending of excessive time on social media has been observed to cause distraction during academic activities, for instance, during lectures and study periods, with student constantly checking their phones at the beep of any message. This aligns with the view of [18], who asserted that students repeatedly pay attention to their phones to keep track of their messages on social media. This addiction affects their cognitive mental capacity and their ability to pay attention to their learning process. The addictive nature of social media could also impact the time allocated to studying and completing learning activities such as assignments, which can hinder learning and retention of academic information.

Despite the negative consequence of social media addiction on student academic achievement, some other studies have reported the benefits that could be extracted from these platforms to ensure a quality learning environment. Authors [21] noted that most of the students involved in their survey claimed that social media enhances knowledge-sharing among peers, friends and classmates. More so, these students further claimed that through social media, they could participate in project group discussions, contact their instructors and teachers and share notes, which would aid their academic development and easy completion of study projects without face-to-face interaction [21, 25].

Overall, the impact of social media on academic achievement depends on how individuals use and manage their social media usage. While it can offer benefits regarding communication and resource access, students must develop strategies for balancing social media use with their academic responsibilities and prioritise activities supporting their learning goals.

Impact of Social Media on the well-being of youth. The well-being of an individual is the quality of their life, which could be measured in terms of their happy and healthy state, both physically or mentally and the ability to manage stress. The growing concern about the impact of the increased usage of social media on the well-being of youth has been studied by psychologists, educators, and social scientists, who have been bearing in mind the increased usage of these platforms within the last two decades. The American

Psychological Association warned on the influence of social media in shaping the mental development and health of youth with factors such as the duration of time spent on these platforms, the content type that they are exposed to and the extent to which these platforms interfere with activities that are necessary for quality health such as sleep and physical activities [26].

In their study, the authors [7] noted the report of nineteen studies that showcase the relationship between social media use and depression. Authors [11] further stress that young adults who spend over 3 hours daily on social media have a double chance of developing poor mental health with symptoms such as depression and anxiety. Authors [22] controlled trial among youths is a pointer to the relationship that exists between increased social media usage and depression. In their study, social media was deactivated for four weeks to observe its impact on the well-being of the young adults and adults involved. The result of the survey indicates that well-being (i.e. life satisfaction, depression, happiness and anxiety) had improved at the end of the fourth week [22].

The poor well-being of youth associated with the continued use of social media could be caused by factors such as reduced self-esteem as a result of comparison with the achievement of others, cyberbullying that could translate into a state of inferiority and body shaming [7]. More so, the over-reliance on social media to form a social connection could limit face-to-face interaction and real-life social connections. This lack of meaningful interpersonal relationships can contribute to feelings of loneliness, isolation, and depression.

Social media can also pose the danger of addiction among youth in a bid to follow trends and exposure to content that encourages substance abuse, violence, conflicts, sex and other vices. Constant exposure to negative news and images can increase stress levels and contribute to feelings of anxiety and helplessness. Authors [27], in their study, also shared a similar viewpoint that youth are more likely to engage in the risky behaviour that they are exposed to on social media with huge content that relates to substance abuse, self-injury and suicide readily available online. Authors [28], in their study of 400 psychiatric patients, noted that a small proportion of youth who were hospitalised due to psychiatric challenges and to prevent self-harm to others claimed to have viewed online content promoting suicide or self–injury two weeks before their admission.

Sleep patterns and duration have been recognised to impact an individual's cognitive function and mental health. Author [29] showcased the relationship between screen time before bed and other outcomes such as poor sleep quality, day drowsiness, and shorter sleep duration. This is the reality of most youth and adolescents, as most check their phones at least once at night [30]. Therefore, inadequate sleep is sure to affect an individual's well-being, bearing in mind the meaning of well-being, which concerns the quality of life.

The prospect of social media. Although several negative consequences of social media have been observed, in most cases, the negative consequences of social media are associated with the duration of time expended on these platforms, several other benefits and potential still exist for the use of social media to improve educational outcome and further, improve the well-being of individuals.

Social media platforms provide access to vast educational content, including articles, videos, and tutorials. Students can follow educational pages, groups, and accounts relevant to their academic interests, enhancing their understanding of various subjects. One social media platform that has been observed to contain several tutorials that would enable learning and further improve blended education is YouTube. Authors [31] study conducted at the University of Sharjah, UAE, among Medical, Pharmacy and dental students buttresses their favourite social media platforms, Facebook and YouTube, as they would facilitate learning.

The formation of online communities can be vital in improving youth education, bearing in mind that some of these platforms enable the creation of online learning communities where students can connect with peers, share resources, ask questions, and collaborate on academic projects [32]. These communities foster a sense of belonging and support, which can enhance learning outcomes. Platforms like LinkedIn offer networking opportunities with professionals, experts, and alums in students' fields of interest. This is vital in answering students' curiosity by connecting them to other experts in their field of interest. Networking through social media can lead to internships, mentorship opportunities, and valua-

ble connections that support academic and career development [33].

Social media facilitates collaborative learning through group chats, discussion forums, and shared documents. Students can engage in group study sessions, exchange ideas, and work together on assignments, leading to deeper learning and improved academic performance. Social media platforms provide real-time updates and news on current events, developments in various fields, and educational conferences. Staying informed through social media can enrich students' understanding of their subjects and inspire them to explore new topics.

Social media allows students to communicate with their educators outside of traditional classroom settings. They can ask questions, seek clarification, and engage in discussions with professors and teaching assistants, leading to a deeper understanding of course materials. Social media platforms allow students to express their creativity, share their academic achievements, and showcase their projects to a broader audience. This can boost confidence, motivation, and pride in their academic work. Students can leverage social media to share educational resources, study tips, and exam preparation strategies with their peers. This collaborative resource-sharing can enhance learning efficiency and academic performance for all involved.

Social media platforms allow people to connect with friends, family, and communities, especially geographically distant ones. Maintaining social connections through social media can reduce loneliness and foster a sense of belonging and support [15]. Some studies have associated an improved sense of belonging with enhanced academic performance [34, 35].

Social media communities offer support networks for individuals facing challenges such as mental health issues, chronic illnesses, or personal crises. These communities provide a space for sharing experiences, seeking advice, and accessing resources that promote well-being. Social media platforms disseminate valuable information and resources related to health, well-being, and self-care. Users can access articles, videos, and information on mindfulness, stress management, and healthy lifestyle choices, empowering them to make informed decisions regarding their well-being.

While social media has the potential to enhance well-being, users need to be mindful of their usage patterns and prioritise activities that promote positive interactions, meaningful connections, and personal growth. Balancing social media use with offline activities, practising digital detoxes, and setting boundaries around screen time can help maintain a healthy relationship with social media while prioritising overall well-being.

CONCLUSIONS

The impact of social media on the education and well-being of youth can be seen from the perspective of a coin having two sides, with one side posing a negative impact on the educational development of youth due to the continued use of this platform. At the same time, it can also revolutionise how young people access information and educational content. Social media addiction can interfere with academic performance, attention span, sleep duration and patterns. Moreover, constant exposure to social media feeds and content can affect the quality of life of youths, hence contributing to feelings of anxiety, depression and inadequacy among young people, affecting their overall well-being.

Despite the dangers associated with the continued use of these platforms, when used in moderation, they can be a powerful tool for youth to improve their creativity and education with information available to them. Platforms like YouTube, LinkedIn, and educational blogs provide efficiently accessible resources for various subjects, making education more engaging and interactive. Social media also facilitates collaboration among students and educators, fostering a sense of community and enabling peer-to-peer learning.

It is pertinent that a proper balance be staked on the use of social media, hence taking advantage of the educational benefits available within these platforms and mitigating the negative impact of the continued use of these platforms. The success of using social media to facilitate the academic improvement of youth would require the efforts of parents, youth, policymakers, and educators to step up to ensure the healthy use of these platforms.

REFERENCES

1. Petrosyan, A. (2024, January 24). *Number of internet and social media users worldwide as of January 2024*. Retrieved from https://www.statista.com/statistics/617136/digital-population-worldwide/#statisticContainer

2. Vogels, E., Gelles-Watnick, R. & Massarat, N. (2022, August 10). Teens, Social Media and Technology 2022. Retrieved from https://www.pewresearch.org/internet/2022/08/10/teens-social-media-and-technology-2022

3. Whack, E. H. (2017). *Poll: Black teens most active on social media apps*. Retrieved from https://phys.org/news/2017-04-poll-black-teens-social-media.html

4. Dixon, S. J. (2024, February 2). Most popular social networks worldwide as of January 2024. Retrieved from https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/

5. Mnkandla, E., & Minnaar, A. (2017). The Use of Social Media in E-Learning: A Metasynthesis. *The International Review of Research in Open and Distributed Learning, 18*(5). doi: 10.19173/irrodl.v18i5.3014

6. Shabbir, T., Nadeemullah, M., & Khan, A., & Khan, N. (2021). Impact of Social Media on Interpersonal Communication between Student and a Teacher. *Journal of Public Administration and Government, 3*(2), 154-164.

7. Bozzola, E., Spina, G., Agostiniani, R., Barni, S., Russo, R., Scarpato, E., Di Mauro, A., Di Stefano, A. V., Caruso, C., Corsello, G., & Staiano, A. (2022). The Use of Social Media in Children and Adolescents: Scoping Review on the Potential Risks. *International Journal of Environmental Research and Public Health, 19*(16), 9960. doi: 10.3390/ijerph19169960

8. Stergiou, C., Psannis, K. E., Kim, B.-G., & Gupta, B. (2018). Secure integration of IoT and Cloud Computing. *Future Generation Computer Systems, 78*, 964–975. doi: 10.1016/j.future.2016.11.031

9. Obar, J. A., & Wildman, S. S. (2015). Social Media Definition and the Governance Challenge: An Introduction to the Special Issue. *SSRN Electronic Journal*. doi: 10.2139/ssrn.2647377

10. Dixon, S. (2024). Most Used Social Media 2024. Retrieved from https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users

11. Riehm, K. E., Feder, K. A., Tormohlen, K. N., Crum, R. M., Young, A. S., Green, K. M., Pacek, L. R., La Flair, L. N., & Mojtabai, R. (2019). Associations Between Time Spent Using Social Media and Internalizing and Externalizing Problems Among US Youth. *JAMA Psychiatry, 76*(12), 1266. doi: 10.1001/jamapsychiatry.2019.2325

12. Miech, R. A., Johnston, L. D., Bachman, J. G., O'Malley, P. M., Schulenberg, J. E., & Patrick, M. E. (2022). *Monitoring the Future: A Continuing Study of American Youth (8th- and 10th-Grade Surveys), 2021*. Retrieved from https://www.icpsr.umich.edu/web/NAHDAP/studies/38502/versions/V1

13. Braghieri, L., Levy, R., & Makarin, A. (2022). Social Media and Mental Health. *American Economic Review, 112*(11), 3660–3693. doi: 10.1257/aer.20211218

14. Al-Rahmi, W. M., Yahaya, N., Alturki, U., Alrobai, A., Aldraiweesh, A. A., Omar Alsayed, A., & Kamin, Y. B. (2020). Social media – based collaborative learning: the effect on learning success with the moderating role of cyberstalking and cyberbullying. *Interactive Learning Environments, 30*(8), 1434–1447. doi: 10.1080/10494820.2020.1728342

15. Smith, D., Leonis, T., & Anandavalli, S. (2021). Belonging and loneliness in cyberspace: impacts of social media on adolescents' well-being. *Australian Journal of Psychology, 73*(1), 12–23. doi: 10.1080/00049530.2021.1898914

16. Costin, V., & Vignoles, V. L. (2020). Meaning is about mattering: Evaluating coherence, purpose, and existential mattering as precursors of meaning in life judgments. *Journal of Personality and Social Psychology, 118*(4), 864–884. doi: 10.1037/pspp0000225

17. Alahmar, A. (2016). The impact of social media on the academic performance of second year medical students at College of Medicine, University of Babylon, Iraq. *Journal of Medical and Allied Sciences, 6*(2), 77. doi: 10.5455/jmas.236927

18. Chen, M., & Xiao, X. (2022). The effect of social media on the development of students' affective variables. *Frontiers in Psychology, 13*. doi: 10.3389/fpsyg.2022.1010766

19. Nalwa, K., & Anand, A. P. (2003). Internet Addiction in Students: A Cause of Concern. *CyberPsychology & Behavior, 6*(6), 653–656. doi: 10.1089/109493103322725441

20. Sharma, S., & Behl, R. (2022). Analysing the Impact of Social Media on Students' Academic Performance: A Comparative Study of Extraversion and Introversion Personality. *Psychological Studies, 67*(4), 549–559. doi: 10.1007/s12646-022-00675-6

21. Ilankoon, IM. P. S., & Chandrasena, PP. C. M. (2022). The impact of social media on academic performance and interpersonal relations among health sciences undergraduates. *Journal of Education and Health Promotion, 11*(1), 117. doi: 10.4103/jehp.jehp_603_21

22. Allcott, H., Gentzkow, M., & Song, L. (2022). Digital Addiction. *American Economic Review, 112*(7), 2424–2463. doi: 10.1257/aer.20210867

23. He, Q., Turel, O., & Bechara, A. (2017). Brain anatomy alterations associated with Social Networking Site (SNS) addiction. *Scientific Reports, 7*(1). doi: 10.1038/srep45064

24. Montag, C., Markowetz, A., Blaszkiewicz, K., Andone, I., Lachmann, B., Sariyska, R., Trendafilov, B., Eibes, M., Kolb, J., Reuter, M., Weber, B., & Markett, S. (2017). Facebook usage on smartphones and gray matter volume of the nucleus accumbens. *Behavioural Brain Research, 329*, 221–228. doi: 10.1016/j.bbr.2017.04.035

25. Creighton, J. L., Foster, J. W., Klingsmith, L., & Withey, D. K. (2013). I just look it up: Undergraduate student perception of social media use in their academic success. *The Journal of Social Media in Society, 2*(2), 26-46.

26. American Psychological Association. (2023). *Health Advisory on Social Media Use in Adolescence*. Retrieved from https://www.apa.org/topics/social-media-internet/health-advisory-adolescent-social-media-use

27. Moreno, M. A., D'Angelo, J., & Whitehill, J. (2016). Social Media and Alcohol: Summary of Research, Intervention Ideas and Future Study Directions. *Media and Communication, 4*(3), 50–59. doi: 10.17645/mac.v4i3.529

28. Nesi, J., & Prinstein, M. J. (2015). Using Social Media for Social Comparison and Feedback-Seeking: Gender and Popularity Moderate Associations with Depressive Symptoms. *Journal of Abnormal Child Psychology, 43*(8), 1427–1438. doi: 10.1007/s10802-015-0020-0

29. Robb, M. B. (2019). *The New Normal: Parents, Teens, Screens, and Sleep in the United States*. Retrieved from https://www.commonsensemedia.org/sites/default/files/research/report/2019-new-normal-parents-teens-screens-and-sleep-united-states-report.pdf

30. Rideout, V., & Robb, M. B. (2018). *Social Media, Social Life. Teens Reveal Their Experiences*. Retrieved from https://www.commonsensemedia.org/sites/default/files/research/report/2018-social-media-social-life-executive-summary-web.pdf

31. Al Wahab, A., Al-Hajo, S., AlAhmdani, G., Al-Mazroua, N., Edan, M., Nugud, S., & Jaffar, A. (2016). The patterns of usage and perceived impact of social networking sites on medical students' education. *Journal of Nursing Healthcare, 1*(2), 1-4.

32. Knoll, J., Matthes, J., & Heiss, R. (2018). The social media political participation model: A goal systems theory perspective. Convergence: *The International Journal of Research into New Media Technologies, 26*(1), 135–156. doi: 10.1177/1354856517750366

33. Sarwar, B., Zulfiqar, S., Aziz, S., & Ejaz Chandia, K. (2018). Usage of Social Media Tools for Collaborative Learning: The Effect on Learning Success With the Moderating Role of Cyberbullying. *Journal of Educational Computing Research, 57*(1), 246–279. doi: 10.1177/0735633117748415

34. Allen, K.-A., & Kern, M. L. (2017). School Belonging in Adolescents. In *Springer Briefs in Psychology*. doi: 10.1007/978-981-10-5996-4

35. Neel, C. G., & Fuligni, A. (2012). A Longitudinal Study of School Belonging and Academic Motivation Across High School. *Child Development, 84*(2), 678–692. doi: 10.1111/j.1467-8624.2012.01862.x

Формування вмінь майбутніх учителів математики застосовувати метод невизначених коефіцієнтів: методологічний аспект

Formation of Future Mathematics Teachers' Abilities to Apply the Method of Uncertain Coefficients: Methodological Aspect

Наталія Кугай [1]
Nataliia Kuhai

[1] *Oleksandr Dovzhenko Hlukhiv National Pedagogical University*
24 Kyiv street, Hlukhiv, Sumy, Ukraine, 4140

Анотація. У статті розглянуто метод невизначених коефіцієнтів як елемент методологічних знань конкретно наукового рівня майбутніх учителів математики. Зауважено, що формування вміння застосовувати цей метод відбувається поетапно: пропедевтичний, навчально-діяльнісний, оцінювально-рефлексивний. Розкрито зміст діяльності на кожному з цих етапів, вказано, під час вивчення яких математичних дисциплін кожен етап реалізується. Наведено приклади завдань і запропоновано методику їх розв'язування.

Ключові слова: метод невизначених коефіцієнтів; майбутній вчитель математики; математичний аналіз; методологічні знання; методологічні вміння.

Abstract. The article considers the method of uncertain coefficients as an element of methodological knowledge of the specific scientific level of future mathematics teachers. It is noted that the formation of the ability to apply this method takes place in stages: propedeutic, educational and activity, evaluation, and reflection. The content of activities at each stage is revealed; it is indicated in the study of which mathematical disciplines each stage implements. Examples of tasks are given, and a methodology for solving them is proposed.

Keywords: method of uncertain coefficients; future mathematics teacher; mathematical analysis; methodological knowledge; methodological skills.

ВСТУП

Методологічна підготовка майбутніх учителів математики є однієї із важливих складових професійної підготовки і має своєю метою формування методологічної культури майбутнього фахівця. Це передбачає систематичне, послідовне й неперервне ознайомлення здобувачів освіти з методологічними знаннями й вміннями вже з першого курсу їхнього навчання у закладах вищої освіти.

Як відомо, методологічні знання поділяють на чотири рівні, а відповідно до змісту цих знань виокремлюють методологічні вміння майбутніх учителів математики [5]. Серед таких знань і вмінь чільне місце займають знання про методи, які застосовуються під час вивчення різних математичних дисциплін і вміння застосовувати ці методи, часто комбіновано, як в стандартних, так і в нестандартних ситуаціях. Встановлено, що процес формування методологічних знань і вмінь має наскрізний характер, проходить у три етапи (пропедевтичний, навчально-діяльнісний, оцінювально-рефлексивний) та триває протягом усього навчання майбутніх учителів математики [6].

Проблемам підготовки майбутніх учителів математики, зокрема й з акцентом на їхній методологічній підготовці, присвячені роботи І. Акуленко, Г. Бевза, В. Бевз, Н. Кугай,

В. Кушніра, Г. Михаліна, Н. Тарасенкової, М. Шкіля та інших.

Мета статті – розглянути методику формування знань і вмінь майбутніх учителів математики про метод невизначених коефіцієнтів як про один із елементів методологічних знань конкретно наукового рівня.

РЕЗУЛЬТАТИ ДОСЛІДЖЕННЯ

Теоретичною основою застосування методу невизначених коефіцієнтів (МНК) є поняття рівності двох многочленів, які розглядаються як функції [2, с. 159]: два дійсні многочлени

$$f(x) = a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x + a_0$$

$$g(x) = b_n x^n + b_{n-1} x^{n-1} + \ldots + b_1 x + b_0$$

збігаються як функції тоді і тільки тоді, коли їхні відповідні коефіцієнти рівні, тобто

$$f(x) \equiv g(x) \Leftrightarrow a_i = b_i \ \forall i \in N \cup \{0\} \ (1)$$

З цього тлумачення доцільно зробити висновок, що два дійсні многочлени

$$f(x) = a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x + a_0$$
$$g(x) = b_n x^n + b_{n-1} x^{n-1} + \ldots + b_1 x + b_0$$

збігаються як функції, якщо вони набувають рівних значень для будь-якого значення аргумента, тобто

$$f(x) \equiv g(x) \Leftrightarrow \forall x_0 \in R \ f(x_0) = g(x_0) \ (2)$$

Зауважимо, що початкові знання про МНК студенти могли отримати у шкільному курсі математики (див., наприклад, [3]). А перше застосування МНК під час навчання в педагогічному ЗВО відбувається у процесі вивчення математичного аналізу, а саме під час інтегрування дробово-раціональних функцій. За браком часу доволі часто повідомлення про

цей метод відбувається практично разом з повідомленнями про розклад раціонального дробу на суму елементарних дробів. Така одночасна подача достатньо великого масиву нових знань для здобувачів освіти призводить до того, що більшість з них пов'язують застосування МНК тільки з інтегруванням дробово-раціональних функцій і формують асоціацію «МНК – має бути дріб».

Ми пропонуємо повідомити сутність МНК (якщо є можливість, то з допомогою студентів, які ознайомлені з цим методом) на лекції перед розкриттям питання про схему розкладу правильного раціонального дробу на суму елементарних дробів. Зробити це можна так:

1. Повідомити, що є такий метод – метод невизначених коефіцієнтів, який часто застосовується в різних галузях математики, а відтак і у відповідних навчальних дисциплінах. Вказати теоретичну основу цього методу (формула (1)).

2. Розв'язати кілька прикладів на застосування МНК усно.

Приклад 1. Для яких значень параметрів виконується рівність двох многочленів (х – змінна):

а) $f(x) = 3x^2 - 4x + 7$ і $g(x) = ax^2 + bx + c$;

б) $h(x) = -4x$ і $\varphi(x) = bx + c$;

в) $f(x) = -x^2 + 9 \ \ g(x) = ax^3 + bx^2 + cx + d$

Відповідь:

а) $a = 3, b = -4, c = 7$;

б) $b = -4, c = 0$;

в) $a = 0, b = -1, c = 0, d = 9$.)

Розв'язати приклад, у якому для знаходження невідомих коефіцієнтів треба скласти і розв'язати систему. Доцільно змінити формулювання завдання (це сприяє вмінню за різними формами бачити однаковий зміст).

Приклад 2. Знайдіть невідомі коефіцієнти, якщо $5x + 3 \equiv A(x - 3) + B(x + 2)$.

Відповідь: $A = 1.4, B = 3.6$.

Повідомити, що МНК буде застосований під час вивчення навчальних дисциплін «Ком-

плексний аналіз», «Диференціальні рівняння», «Елементарна математика», «Алгебра і теорія чисел» тощо. Звичайно, більшість здобувачів освіти з часом це забудуть, але на даному етапі таке повідомлення сприятиме: а) підвищенню мотивації до опанування цим методом; б) формуванню вмінь встановлювати міжпредметні зв'язки.

Це сутність *пропедевтичного етапу* формування знань і вмінь майбутніх учителів математики про МНК як елемент методологічних знань. Цей етап приходиться на вивчення математичного аналізу.

Навчально-діяльнісний етап реалізується також під час вивчення математичного аналізу. Формування вміння застосовувати МНК відбувається на практичних заняттях, під час виконання домашніх та індивідуальних завдань (поза аудиторна робота). На початку відповідного практичного заняття доцільно у формі бесіди актуалізувати знання здобувачів освіти про МНК (можна запропонувати завдання як у прикладах 1 і 2 (аналогічні)). Далі після правильних відповідей студентів варто розглянути приклад:

Приклад 3. Знайдіть невідомі коефіцієнти, якщо

$$x \equiv A(x+2)(x+3) +$$
$$+ B(x+1)(x+3) + C(x+1)(x+2)$$

Як правило, студенти починають розв'язувати цей приклад за аналогією з попередніми. Доцільно їх зупинити і повідомити (або у формі бесіди з'ясувати), що є інше потрактовування рівності двох многочленів (формула (2)). Далі з'ясувати, які ж точки зручно брати за x_0. Здобувачі здогадуються, що це мають бути – 2; – 3; – 4, і легко знаходять невизначені коефіцієнти.

Відповідь: $A = -\dfrac{1}{2}, B = 2, C = -\dfrac{3}{2}$.

Доцільно звернути увагу на комбінованому застосуванні обох трактувань рівності двох многочленів, особливо у випадку наявності кратних коренів або незвідних над полем дійсних чисел квадратних множників.

На цьому етапі вміння застосовувати МНК формуються разом з уміннями інтегрувати раціональні функції. Ускладнюються вирази, якими задаються раціональні функції. Доці-

льно акцентувати увагу студентів на встановленні міжпредметних зв'язків («Математичний аналіз», «Алгебра і теорія чисел», шкільний курс математики (ШКМ)).

Реалізація *оцінювально-рефлексивного етапу* приходиться на вивчення навчальних дисциплін «Комплексний аналіз». «Диференціальні рівняння», «Елементарна математика». На цьому етапі здобувачі освіти самостійно (або за мінімальної підказки викладача) переносять засвоєні знання і сформовані вміння в нові умови:

1. Комплексний аналіз: розклад дробоворіаціональної функції комплексної змінної в ряд Лорана [4].

2. Диференціальні рівняння: знаходження частинного розв'язку ДР (і систем ДР) із сталими коефіцієнтами з правою частиною спеціального виду [7].

3. Елементарна математика: розклад многочлена над полем дійсних чисел на множники.

Проведене нами дослідження підтвердило доцільність пропонованого нами підходу до формування знань про МНК і вмінь його застосовувати. Так, під час вивчення диференціальних рівнянь, зокрема неоднорідних лінійних диференціальних рівнянь зі сталими коефіцієнтами, у яких права частина має вигляд $f(x) = P_n(x)e^{ax}$, після повідомлення викладача, що частинний розв'язок треба шукати у вигляді $y_{чн}(x) = x^m Q_n(x)e^{ax}$ (m – кратність числа a як кореня характеристичного рівняння, $m \in N \cup \{0\}$), більшість здобувачів освіти відповіли, що для знаходження невідомих коефіцієнтів треба застосувати МНК.

Не таким очевидним для здобувачів освіти було застосування МНК для розкладу многочлена на множники (навчальна дисципліна «Елементарна математика»). Ми пояснюємо це тим, що, як правило, здобувачі користувалися для розв'язання цієї задачі або способами ШКМ (винесення за дужки, формули скороченого множення, групування, розклад квадратного тричлена тощо), або теоремою Безу та схемою Горнера. Вважаємо, що обов'язково треба ознайомити здобувачів освіти ще і з таким застосуванням МНК. Розглянемо приклад.

Приклад 4. Розкладіть многочлен $x^4 + 2x^3 - 16x^2 - 22x + 7$ на множники над полем дійсних чисел або Знайдіть дійсні корені рівняння $x^4 + 2x^3 - 16x^2 - 22x + 7 = 0$.

Як правило, здобувачі навіть не пробують застосувати способи розкладу на множники зі ШКМ, а починають шукати дільники вільного члена і перевіряти, чи не є вони коренями многочлена. Результат, звичайно, негативний: числа 1, 7, – 1, – 7 не є коренями заданого многочлена. Далі доцільно провести бесіду: Корені якого многочлена ви точно можете знайти? (Квадратного тричлена). А чи можна записати заданий многочлен як добуток квадратних тричленів? (Можемо, але невідомі коефіцієнти). А яким методом можна ці коефіцієнти знайти? (МНК!). Після висновку, що квадратні тричлени мають бути зведеними, здобувачі освіти роблять запис:

$$x^4 + 2x^3 - 16x^2 - 22x + 7 =$$
$$= (x^2 + ax + b)(x^2 + cx + d)$$

Після розкриття дужок, зведення подібних доданків і застосування формули (1) маємо систему:

$$\begin{cases} a + c = 2, \\ d + ac + b = -16, \\ ad + bc = -22, \\ bd = 7. \end{cases} \tag{3}$$

Звертаємо увагу здобувачів освіти, що система не є лінійною на відміну від попередніх випадків застосування МНК. Тому виникає питання: чи має вона розв'язки? Якщо має, то чи цей розв'язок єдиний? (формування методологічних знань філософського рівня існування і єдиність). Пропонуємо цю проблему дослідити студентам самостійно. А для розв'язання системи (3) обмежимося множиною цілих чисел. Шляхом перебору можливих значень b і d для останнього рівняння цієї системи маємо, що $a = -4, b = 1, c = 6, d = 7$.

Відповідний розклад має вигляд
$$x^4 + 2x^3 - 16x^2 - 22x + 7 =$$
$$= (x^2 - 4x + 1)(x^2 + 6x + 7).$$

З'ясувавши, що квадратні тричлени є звідними над полем дійсних чисел, маємо остаточний розклад:

$$x^4 + 2x^3 - 16x^2 - 22x + 7 =$$
$$= (x - 2 - \sqrt{3})(x - 2 + \sqrt{3}) \tag{4}$$
$$(x + 3 - \sqrt{2})(x + 3 + \sqrt{2})$$

Доцільно сформулювати здобувачам освіти запитання:

1. Чи зміниться розклад на множники цього многочлена, якщо його розглядати над полем раціональних чисел?

Так, розклад матиме вигляд $x^4 + 2x^3 - 16x^2 - 22x + 7 =$
$(x^2 - 4x + 1)(x^2 + 6x + 7).$

2. Над полем комплексних чисел? Ні.

3. Чи зможете ви застосувати МНК у ШКМ? Так, у 9-11 класах, під час підготовки учнів до математичних олімпіад і різних конкурсів.

Важливо організувати таке навчання, щоб здобувачі освіти намагалися сформулювати запитання і дати на них відповідь: «Що я знаю про МНК?», «Що я вмію?», «Навіщо мені потрібен МНК як майбутньому вчителеві математики?».

Доцільно також обговорити інші застосування МНК, наприклад, для розв'язання повної проблеми власних значень і власних векторів матриці [1].

ВИСНОВКИ

Отже, метод найменших квадратів застосовується у багатьох математичних дисциплінах. Поетапне формування знань про цей метод і вмінь його застосовувати сприяє розвитку вміння застосовувати МНК в різних ситуаціях.

REFERENCES

1. Andrunyk, V., Vysoczka, V. Pasichnyk, V., Chyrun, L., & Chyrun, L. (2017). *Chyselni metody v kompyuternyx naukax* [Numerical Methods in Computer Science]. Lviv: Novyj svit - 2020 (in Ukrainian).

2. Bezushhak, O., Ganyushkin, O., & Kochubinska, Ye. (2019). *Navchalnyj posibnyk z linijnoyi algebry dlya studentiv mexaniko-matematychnogo fakultetu* [Textbook on Linear Algebra for Students of the Faculty of Mechanics and Mathematics]. Kyiv: Kyivskyj universytet (in Ukrainian).

3. Izyumchenko, L., Nichyshy`na, V., & Rizhnyak, R. (2009). *Racionalni rivnyannya ta nerivnosti* [Rational Equations and Inequalities]. Kirovograd: RVV KDPU im. V.Vynnychenka (in Ukrainian).

4. Kuhai, N. (2016). Metodologichni znannya konkretno naukovogo rivnya z navchalnoyi dyscypliny "Kompleksnyj analiz" majbutnogo vchytelya matematyky [Methodological Knowledge of a Specific Scientific Level in the Educational Discipline 'Complex Analysis' for Future Mathematics Teachers]. *Pedagogichni nauky: teoriya, istoriya, innovacijni texnologiyi, 2*(56), 305–313 (in Ukrainian).

5. Kuhai, N. (2017). *Metodolohichni znannia maibutnoho vchytelia matematyky* [Methodological knowledge of the future teacher of mathematics]. Kharkiv: FOP Panov A. M. (in Ukrainian).

6. Kuhai, N., & Kalinichenko, M. (2020). *Pidgotovka majbutnix uchyteliv matematyky: metodologichny j aspekt* [Training of future teachers of mathematics: methodological aspect]. Kharkiv: FOP Panov A. M. (in Ukrainian).

7. Samojlenko, A., Perestyuk, M., & Parasyuk, I. (2003). *Dyferencialni rivnyannya* [Differential Equations]. Kyiv: Lybid` (in Ukrainian).

Phenomenological Analysis of Mothers' Perspectives on Relactation in Abdya Regency, Indonesia

Yusnaini [1], **Kartinazahri** [1], **Eva Purwita** [1], **Cut Yuniwati** [1], **Aiyub** [1], **Rahmah Hidayati** [1], **Lin Fitraniar** [1], **Ampera Miko** [1]

[1] *Health Polytechnic Institute of the Ministry of Health of Aceh*
Jln. Soekarno - Hatta, Lagang. Kec. Darul Imarah, Kab. Aceh Besar, 23231, Indonesia

Abstract. The provision of Breast Milk (BM) holds significant implications in the global context, supporting optimal infant health and development. This study employs phenomenological analysis to gain deeper insights into mothers' perspectives and experiences regarding relaxation and restarting breastfeeding after cessation. This method allows for an in-depth exploration of the various facets involving mothers' endeavours to reinstate exclusive breastfeeding practices. The study refers to a global framework encompassing diverse sources, including previous international research, policy documents regarding breastfeeding practices, and qualitative studies from various regions. By amalgamating these perspectives, the research aims to identify common patterns and variations in mothers' views and experiences of relaxation. The findings reveal prominent themes encompassing various crucial aspects. First, a profound comprehension of the multifaceted benefits of exclusive breastfeeding emerges, not only as a source of nutrition but also as a determinant of health, growth, and the emotional bond between mother and infant. Second, family and immediate environment support, including the roles of husbands, mothers-in-law, and other relatives, significantly impact the achievement of successful relactation. Third, guidance and directions provided by healthcare professionals, particularly village midwives and health practitioners, offer essential guidance and understanding for mothers throughout the relactation process.

Furthermore, the study portrays certain mothers' personalised and creative approaches while navigating the relactation process. These encompass utilising specific foods and natural elements and sourcing information from various avenues, including the experiences of fellow mothers and official guidelines. In the context of psychological impacts, the study presents an overview of the challenges and sentiments experienced by mothers during relactation, as well as the pivotal role of the emotional bond with the infant in mitigating stress and pressure. Through this phenomenological analysis, the research provides a richer understanding of mothers' viewpoints and experiences in the practice of global-scale relactation. These findings have implications for enhancing societal understanding, family support, and improved healthcare interventions to facilitate and advocate for exclusive breastfeeding practices through relactation. Thus, the study contributes to the global discourse on the significance of Breast Milk in promoting infant health and well-being worldwide.

Keywords: Phenomenological analysis; Mothers' perspectives Relactation; Abdya Regency.

INTRODUCTION

Exclusive breastfeeding, abbreviated as EBF (Exclusive Breastfeeding), refers to providing breast milk to infants from birth up to 6 months without additional foods or liquids [1-3]. This practice is optimal for nourishing infants, as breast milk contains essential nutrients for healthy growth

and development [4-6]. In 2020, statistical data showed that approximately 59% of infants received exclusive breastfeeding in the Aceh Province. However, there is a note that in the Abdya Regency (Southwest Aceh), a coastal area on the southwest coast often exposed to disaster risks, the rate of exclusive breastfeeding reached around 52% [7-9].

Regions like Abdya Regency, which possess significant disaster risk potential, often experience serious consequences such as loss of life, environmental damage, and material losses. Beyond measurable physical impacts, disasters also have the potential to induce significant psychological effects on both individuals and impacted communities. An individual's psychological condition can influence various aspects of life, including the success of providing exclusive breastfeeding to infants [10].

It cannot be ignored that a mother's psychological state plays a crucial role in the process of exclusive breastfeeding. A mother's calmness, confidence, and self-assuredness can affect breastfeeding's success. Positive feelings and emotions can enhance the production of the oxytocin hormone, boosting breast milk production [11, 12].

In response to the challenges of exclusive breastfeeding, relactation emerges as a potential solution. Relactation refers to the efforts of a mother who has previously given birth but not breastfed or has stopped breastfeeding to stimulate the reproduction of breast milk and resume the practice of exclusive breastfeeding [13]. Studies have indicated that maternal motivation factors, baby stimulation, family support, and the role of healthcare providers play pivotal roles in the success of relactation [14].

Two critical factors proven vital in relactation are a mother's strong determination and proper breast stimulation. Successful relactation is also more likely to occur in infants under three months of age [15]. The guidelines from the Indonesian Breastfeeding Mother's Association (AIMI) state that for successful relactation, a mother's mindset regarding the success of relactation needs to be robust and mental support from the immediate environment is necessary. Stress management in the initial weeks of relactation is crucial as babies might show resistance or frustration towards this change [16, 17].

The objective of this research is to investigate mothers' perceptions of relactation, the reasons behind their decision to engage in relactation, the factors influencing this decision, their self-concept and self-confidence during relactation, the psychological impacts they experience during the relactation process, the support from family and the immediate environment in their relactation efforts.

By delving deeper into these aspects, this research aims to provide a richer insight into the importance of psychological support, motivation, and the environment in the success of exclusive breastfeeding practice through relactation. These aspects are integral in maintaining infants' health and growth through exclusive breastfeeding, especially in regions with higher disaster risks.

METHODS

The research design employed in this study is qualitative research with a phenomenological approach. The phenomenological approach aims to understand individuals' subjective experiences within a broader and deeper context, providing in-depth insights into the perceptions, thoughts, and emotions that underlie their actions or decisions. The sampling process in this study utilises the Purposive Sampling Technique. This method allows the researcher to select samples that fit specific criteria relevant to the research objectives. The selection criteria include various aspects, such as infants under six months of age with a history of standard delivery, mothers who have ceased breastfeeding within a specific timeframe, primipara (first-time mothers), non-working mothers, absence of nipple abnormalities, appropriate infant weight for age, absence of infant lip abnormalities (such as cleft lip and cleft palate), and both the mother and baby being in good health.

The adopted research type is descriptive research. This method gathers data in words or descriptions to provide an in-depth depiction of the studied phenomenon. The research is planned to be conducted in the Southwestern Aceh Regency Area from January to December 2023. Data will be collected through several techniques, including in-depth interviews, focus group discussions (FGDs), and analysis of other relevant supporting documents. With this study design, it is expected that this research will provide a more comprehensive understanding of the perceptions and

experiences of mothers engaging in relactation within a broader context, including potential psychological impacts. The outcomes of this research can contribute significantly to supporting exclusive breastfeeding through relactation and offer insights for developing improved interventions to support mothers during the relactation process.

RESULTS AND DISCUSSION

The Importance of Exclusive Breastfeeding in Relactation. Exclusive breastfeeding, especially in relactation, is significant beyond mere nutrition provision to infants. This practice carries profound implications for infant health, growth, and the formation of emotional bonds between mother and child. Based on the interview analysis with the participants, it is evident that most mothers recognise the importance of exclusive breastfeeding, as explained in the following analysis.

Analysis Aspect	Findings
Belief in Health Benefits	Informants share a similar belief in the health benefits of exclusive breastfeeding. They know breast milk contains essential substances that strengthen children's immune systems and shield them from health risks.
Enhanced Immune System	Several informants who link breastfeeding with improved immunity express that exclusive breastfeeding boosts children's immune systems.
Natural Nutritional Superiority	Many mothers acknowledge that breast milk is a natural source of nutrition with crucial elements that other types of food cannot match. This recognition motivates them to provide breast milk for optimal infant care.
Weight Loss Relationship	Some informants associate breastfeeding with postpartum weight reduction, believing that the breastfeeding process aids in regaining the body's shape after childbirth.
Difference Between Breast Milk and Formula	Mothers grasp the significant distinctions between breast milk and formula milk. They recognise that breast milk is more fitting and nutritionally richer, with inherent protection for babies, particularly premature ones.

Relactation emerges as a significant adaptive strategy in challenging situations. Babies facing environmental changes and stressors in disaster scenarios require additional support from the natural nourishment contained in breast milk. These nutrients are crucial in helping babies adapt to unfavourable conditions and reducing the risk of growth disturbances. Furthermore, exclusive breastfeeding profoundly contributes to forming an emotional bond between the mother and her baby. Breastfeeding nurtures an intimate bond that strengthens the bond of affection and care. In disaster situations where emotional stability may be disrupted, this bond gains added significance by providing comfort and solace to the baby.

Strategies and Efforts for Successful Relactation. Exclusive breastfeeding (EBF) is the fundamental cornerstone in ensuring optimal health and growth of infants in the early stages of their lives. However, it's not uncommon for mothers to face challenges in resuming or reinstating breast milk production after a period of cessation. Understanding the strategies and efforts that can be undertaken for successful relactation becomes crucial, which involves initiating or reinitiating breastfeeding after a pause. Based on the interview analysis with participants, it is evident that mothers employ strategies and efforts to achieve the success of their relactation, as explained in the following analysis.

Aspects of Analysis	Findings in the Table
Variation of Approaches	The analysis results depict the diverse approaches each participant took to ensure the success of the relactation process. These approaches encompass using specific foods, natural ingredients, and assistance from medical professionals. Despite facing obstacles and challenges, these mothers uniquely and creatively strive to ensure good breast milk production for the well-being of their babies.
Compliance with Instructions	Many participants are willing to follow instructions from healthcare providers, especially village midwives. These instructions involve using vitamin supplements or massage techniques to support breast milk production. Compliance with these instructions reflects trust

Aspects of Analysis	Findings in the Table
	in medical professionals' advice and the belief that these actions will yield positive outcomes.
Family Empowerment	In pursuing successful relactation, the participants consider family support crucial, particularly from husbands and mothers-in-law. This support encompasses emotional support, breast milk production nutrition, and baby care assistance. The active presence and role of the family in this process showcase synergy and collaboration that strengthen the mother's efforts in relactation.
Personal Approaches	Some participants adopt a more personal and creative approach to the relactation process. They employ strategies such as consuming specific foods believed to enhance breast milk production or seeking information from various sources, including the experiences of other mothers and official guidelines like the KIA handbook. This approach reflects mothers' diligent efforts in designing steps tailored to their needs and conditions.

Exclusive breastfeeding is essential in relactation. It goes beyond providing nutrition to the baby. It involves a complex process that requires strategic efforts. In the journey towards successful relactation, mothers employ diverse strategies, including medical guidance, family support, and creative personal approaches. These efforts aim to ensure the provision of high-quality exclusive breastfeeding, promoting optimal health and growth for the baby. Therefore, a profound understanding of the strategies and efforts for relactation success is essential for mothers dedicated to offering the best for their infants.

Breastfeeding Information Sources. The analysis obtained from exploring information sources related to breastfeeding highlights the significance of diversity in the knowledge outlets utilised by mothers. This diversity reflects mothers' eagerness to seek comprehensive and accurate knowledge about breastfeeding practices. Across various backgrounds and contexts, informants rely on multiple sources, ranging from traditional knowledge inherited from their surroundings to medical guidance from healthcare providers and

official literature such as the KIA book. The involvement of healthcare professionals like village midwives also emerges as a pivotal component in ensuring breastfeeding success. This analysis portrays that information sources concerning breastfeeding are not singular but a result of mothers' proactive efforts to seek guidance to provide the best care for their infants.

Aspect of Analysis	Findings
Diversity of Information Sources	Informants rely on various sources of information, such as their environment, culture, tradition, healthcare providers, and health literature, to acquire in-depth knowledge about breastfeeding practices.
Traditional and Environmental Sources	Some informants, like mothers, grandmothers, or local communities, depend on knowledge from their immediate environment with breastfeeding experience, reflecting societal ingrained traditions.
Role of Healthcare Professionals	Healthcare professionals such as village midwives, doctors, and health workers are valuable information sources due to their profound understanding of infant and maternal nutrition and health.
Written Sources and KIA Book	The Mother and Child Health Handbook (KIA) is a significant information source for some informants, underscoring the importance of health literature as a practical guide for optimal breastfeeding.
Comprehensive Understanding	The amalgamation of information sources offers mothers a comprehensive understanding of the significance of exclusive breastfeeding and how to implement breastfeeding practices by blending traditional and medical knowledge.

A profound analysis of the previously outlined table reveals compelling evidence of the determination and enthusiasm possessed by mothers in their quest to acquire accurate and reliable knowledge about breastfeeding practices. This steadfastness is evident through the diverse information sources they harness to enhance their understanding and implementation of breastfeeding. Upon examining the spectrum of infor-

mation sources, it becomes clear that mothers do not rely solely on a single source of information; instead, they actively seek various perspectives that can aid them in understanding the best actions for their infants. Confronting diverse challenges and needs, mothers diligently utilise various knowledge sources, ranging from local and traditional wisdom to official medical guidance and health literature. Information sources from their immediate environment, such as knowledge passed down from mothers and grandmothers, imbue breastfeeding practices with cultural and traditional depth.

On the other hand, the relationships they foster with healthcare professionals, including village midwives and healthcare workers, provide profound insights into the nutritional and health aspects of breastfeeding. The significance of health literature is also evident in the mothers' efforts to gain comprehensive knowledge. The Mother and Child Health Handbook (KIA) is a dependable source for practical guidance and deeper insights into breastfeeding. This amalgamation of diverse information sources reflects the mothers' eagerness to comprehend breastfeeding comprehensively and ensure that every decision aligns with their endeavour to provide the best care for the health and growth of their infants. Overall, this in-depth analysis demonstrates that mothers are not passive recipients of information but active agents in seeking the required knowledge. The diversity of information sources underscores their spirited commitment to fulfilling their crucial role as mothers seeking to offer their children optimal care and nutrition through informed breastfeeding practices.

Breastfeeding in Disaster or Displacement Situations. The provision of Breast Milk (known as ASI - Air Susu Ibu) plays a crucial role in maintaining the health and well-being of infants, especially in the context of natural disasters or displacement scenarios. In such challenging conditions, the significance of breastfeeding extends beyond nutrition, encompassing profound implications for the physical and psychological well-being of the infants and the mother. Exclusive breastfeeding amid disasters or displacement has a remarkable impact on bolstering the infant's immune system against diseases and reducing the risk of infections. Breast milk also holds the distinct advantage of providing natural nutrition that cannot be rivalled by formula milk. Additionally, breastfeeding practices offer a milk sense of security, comfort, and essential emotional support

that both the infant and the mother greatly need in uncertain circumstances.

Aspect of Analysis	Findings
Consistency in Breastfeeding Practices	The table analysis reveals a remarkable consistency in breastfeeding practices amidst disaster or displacement. Mothers maintain their prioritisation of exclusive breastfeeding as the primary care for their infants. Despite challenging circumstances and potential disruptions in routines, these mothers exhibit an unwavering commitment to breastfeeding, reflecting their determination to provide optimal protection and nutrition to their infants.
Commitment to Infant Well-being	From the perspective of these mothers, breastfeeding is not merely an obligation but a profound commitment to the well-being of their infants. The occurrence of disasters or displacement does not alter this view. Despite rising challenges, breastfeeding remains essential in nurturing infant growth and development.
Significant Role of Breastfeeding in Challenges	A deeper analysis highlights that mothers possess a profound understanding of breastfeeding's significance in addressing challenging conditions such as disasters or displacement. They recognise breastfeeding as more than a source of nutrition; it also effectively protects against the heightened risk of infections and diseases. This perception reflects their awareness of the unique nutritional benefits of breast milk, particularly vital in situations with elevated health risks.
Family Support Factor	A notable finding is the pivotal role of family support, particularly from husbands and mothers-in-law, in upholding breastfeeding practices during trying circumstances. This support encompasses both emotional and practical aspects, including ensuring sufficient nutrition for the mother and providing supplementary care for the infant. Such support is critical in sustaining breastfeeding practices and fostering maternal confidence.

Aspect of Analysis	Findings
Spirit of Facing Challenges	A more profound analysis underscores the determination and resilience of mothers in confronting potential challenges during disaster or displacement scenarios. Despite environmental changes and potential resource constraints, their enthusiasm for providing exclusive breastfeeding remains unwavering. This willingness reflects a solid drive to offer the best to their infants and a belief that breastfeeding remains the optimal choice under all circumstances.
Decision Driven by Infant's Interests	Mothers exhibit a deep understanding that the decision to continue exclusive breastfeeding in disaster or displacement situations is driven by the consideration of their infant's interests. They acknowledge that breastfeeding offers invaluable health benefits, protection, and nutrition to their infants. This perspective is a powerful motivator for sustaining breastfeeding practices amid challenging circumstances.
Awareness of Infant's Health Condition	Awareness of the infant's health condition in disaster or displacement situations significantly influences mothers' perspectives. They recognise that the risk of diseases and infections might be heightened in such scenarios, thus perceiving breastfeeding as an effective means of protection for their infants. This awareness compels them to prioritise breastfeeding as an avital preventive measure/

In the context of natural disasters or displacement situations, a deeper analysis of the table's content reveals distinct variations in the perspectives and viewpoints of these mothers. However, amidst these variations, the central point remains steadfast: their unwavering priority is the well-being of their children through breastfeeding, even amidst challenging circumstances like disasters or displacement. This viewpoint reflects these mothers' profound sense of responsibility towards their children. When faced with unexpected natural disasters or situations of displacement that may restrict access to resources, these mothers remain committed to upholding the welfare of their infants through breastfeeding. This perspective extends beyond a mere nutritional choice. It encapsulates an unshakable expression of love and the moral duty of a mother to shield and nurture their children's optimal development. This commitment also mirrors fundamental values such as dedication and sacrifice that mothers willingly undertake for the well-being of future generations. In moments of adversity, such as disasters or displacement, they deliberately focus on this essential task, underscoring the immense strength of their determination to provide the best for their children despite unfavourable circumstances.

Hence, these perspectives and commitments exemplify mothers' resilience in safeguarding and guiding future generations through breastfeeding, even in situations fraught with challenges and limitations. This is a genuine reflection of mothers' power in nurturing and guiding generations through the invaluable act of breastfeeding, even within adversity and constraints.

CONCLUSIONS

The conclusion drawn from the comprehensive analysis above underscores the paramount importance of exclusive breastfeeding within the relactation process, which has profound implications for infants' and mothers' health and well-being. Through the various aspects examined, it becomes evident that breastfeeding practices have wide-ranging effects, whether in normal circumstances or during situations of disaster or displacement. In the context of relactation, mothers adopt diverse approaches and strategies tailored to their individual needs and conditions. Yet, they collectively share a common understanding of the significance of exclusive breastfeeding. This perspective extends beyond mere nutrition, encapsulating maternal values, responsibilities, and commitments to the well-being of their offspring.

Moreover, the role of family and community support is pivotal in facilitating the success of the relactation process. Mothers recognise the emotional, physical, and practical support family members and healthcare professionals provide. This support motivates them and fosters an environment conducive to effective breastfeeding practices. The diversity of information sources accessed by mothers to acquire breastfeeding knowledge reflects their enthusiasm for seeking

comprehensive and reliable information to bolster breastfeeding success. It signifies their endeavour to amalgamate traditional and contemporary knowledge to provide optimal infant care. When considering the importance of breastfeeding in disaster or displacement scenarios, it is evident that maternal perspectives remain centred on the well-being of their children. In challenging and uncertain circumstances, these mothers steadfastly prioritise breastfeeding as the optimal means of protection and support for their infants. This viewpoint underscores a profound sense of responsibility, commitment, and unwavering maternal love, even in adversity.

In summary, the multifaceted analysis conducted, coupled with the findings extracted from various aspects and tabulated data, unequivocally highlights the paramount significance of exclusive breastfeeding for ensuring the health and well-being of both infants and mothers. Breastfeeding practices transcend mere nutrition to embody maternal values, commitment, and a determined spirit in confronting challenges. Irrespective of the context, from relactation to disaster scenarios, breastfeeding is a strong foundation for securing optimal development and safeguarding the health of future generations.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Pérez-Escamilla, R., Curry, L., Minhas, D., Taylor, L., & Bradley, E. (2012). Scaling Up of Breastfeeding Promotion Programs in Low- and Middle-Income Countries: the "Breastfeeding Gear" Model. *Advances in Nutrition, 3*(6), 790–800. doi: 10.3945/an.112.002873

2. Rollins, N. C., Bhandari, N., Hajeebhoy, N., Horton, S., Lutter, C. K., Martines, J. C., Piwoz, E. G., Richter, L. M., & Victora, C. G. (2016). Why invest, and what it will take to improve breastfeeding practices? *The Lancet, 387*(10017), 491–504. doi: 10.1016/s0140-6736(15)01044-2

3. Victora, C. G., Bahl, R., Barros, A. J. D., França, G. V. A., Horton, S., Krasevec, J., Murch, S., Sankar, M. J., Walker, N., & Rollins, N. C. (2016). Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *The Lancet, 387*(10017), 475–490. doi: 10.1016/s0140-6736(15)01024-7

4. Renfrew, M. J., McCormick, F. M., Wade, A., Quinn, B., & Dowswell, T. (2012). Support for healthy breastfeeding mothers with healthy term babies. *Cochrane Database of Systematic Reviews*. doi: 10.1002/14651858.cd001141.pub4

5. World Health Organization. (2003). *Globalstrategy for infant and young child feeding*. Geneva: World Health Organization.

6. World Health Organization. (2009). *Infant and young child feeding. Model chapter for textbooks for medical students and allied health professionals*. Geneva: World Health Organization.

7. Peraturan Pemerintah Republik Indonesia No 33 Tentang Pemberian Air Susu Ibu Eksklusif [Government Regulation of the Republic of Indonesia No 33 on Exclusive Breastfeeding] (Indonesia). Retrieved from http://hukor.kemkes.go.id/uploads/produk_hukum/PP%20No.%2033%20ttg%20Pemberian%20ASI%20Eksklusif.pdf (in Indonesian).

8. Aceh DKP. (2020). *Profil Dinas Kelautan Dan Perikanan* [Profile of the Marine and Fisheries Service]. Retrieved from https://dkp.acehprov.go.id/media/2024.03/profil_dinas_kelautan_dan_perikanan_aceh_2020_12.pdf (in Indonesian).

9. BPBA. (2015). *Kajian Risiko Bencana Aceh2016–2020* [Aceh Disaster Risk Assessment 2016-2020]. Retrieved from https://bpba.acehprov.go.id/media/2022.09/dokumen_kajian_risiko_bencana_aceh_2016_-_20201.pdf (in Indonesian).

10. Presiden Republik Indonesia. (2007). Undang_undang Republik Indonesia Penanggulangan Bencana, 7(3), 213-221.

11. Cho, S. J., Cho, H. K., Lee, H. S., & Lee, K. (2010). Factors Related to Success in Relactation. *Journal of the Korean Society of Neonatology, 17*(2), 232. doi: 10.5385/jksn.2010.17.2.232

12. Salih, M. (2018). Relactation in lactation failure and low milk supply. *Sudanese Journal of Paediatrics*, 39–47. doi: 10.24911/sjp.2018.1.6

13. Monika, F. (2014). *Buku Pintar ASI Dan Menyusui* [The Smart Book of Breast Milk and Breastfeeding]. Retrieved from https://books.google.co.id/books?id=ljTmDAAAQBAJ&printsec=frontcover#v=onepage&q&f=false (in Indonesian).

14. Yanti, B. S. (2020). *Panduan Praktis Pelaksanaan Focus Group Discussion SebagaiMetode Riset Kualitatif* [Practical Guide to Implementing Focus Group Discussion as a Qualitative Research Method]. Retrieved from https://books.google.com.ua/books/about/Panduan_Praktis_Pelaksanaan_Focus_Group.html?id=gWIFEAAAQBAJ&redir_esc=y (in Indonesian).

15. Lexy, J. M. (2006). *Metode Penelitian Kualitatif* [Qualitative Research Methods]. Bandung: Remaja Rosdakarya (in Indonesian).

16. Suardi, A., Rini, P., Alvionita, V., Wahyuni, S., Erviani, N., & Harahap, N. A. (2022). *Mengenal Gizi DalamKesehatan Reproduksi* [Getting to know nutrition in reproductive health]. N. d.: Global Eksekutif Teknologi (in Indonesian).

17. Sartika, R., & Noer, E. R. (2013). Faktor-Faktor Yang Mempengaruhi Keberhasilan Relaktasi (Studi Kualitatif Di Rumah Sakit St. Elisabeth Semarang) [Factors Affecting the Success of Relactation (Qualitative Study at St. Elisabeth Hospital Semarang)]. *Journal of Nutrition College, 2*(1), 60–68. doi: 10.14710/jnc.v2i1.2101 (in Indonesian).

Effectiveness and Safety of Using Warm Lime Water in Pregnant Women

Cut Yuniwati [1]**, Yusnaini** [1]**, Katrinazahri** [1]**, Iin Fitriar** [1]**, Ampera Miko** [1]

[1] *Health Polytechnic Institute of the Ministry of Health of Aceh*
Jln. Soekarno - Hatta, Lagang. Kec. Darul Imarah, Kab. Aceh Besar, 23231, Indonesia

Abstract. This study evaluated the effectiveness and safety of using warm lime water as a therapeutic intervention in pregnant women. Methods: A systematic review of published literature was conducted to identify relevant studies. Studies that examined the use of warm lime water in pregnant women were included. The outcomes assessed included symptom relief, adverse effects, and maternal and fetal outcomes. A systematic review was conducted following the PRISMA guidelines. Electronic databases, including PubMed, Scopus, and Web of Science, were searched for relevant studies published between 2010 and 2022. Results: The review identified limited studies investigating the use of warm lime water in pregnant women. The available evidence suggested that warm lime water may provide some symptom relief for common pregnancy discomforts such as constipation and heartburn. However, the evidence regarding its effectiveness for other conditions or complications during pregnancy was scarce. Adverse effects were rarely reported, but the safety of long-term or excessive use of warm lime water remains uncertain. Maternal and fetal outcomes were not consistently reported across the included studies. The current evidence on the effectiveness and safety of using warm lime water in pregnant women is limited and inconclusive. While it may relieve certain pregnancy discomforts, the potential risks and long-term effects are unclear. Further, well-designed studies are needed to assess the efficacy, safety, and optimal dosage of warm lime water in pregnant women. Healthcare providers should exercise caution and discuss using warm lime water with pregnant patients, considering the lack of robust evidence and potential unknown risks.

Keywords: effectiveness, safety, warm lime water, pregnant women.

INTRODUCTION

According to research conducted in various countries, approximately 50-80% of pregnant women experience emesis gravidarum during the first trimester of pregnancy [1-3]. The severity of symptoms can vary from mild to severe. Severe emesis gravidarum can lead to a decrease in the quality of life for pregnant women, disrupt daily activities, and potentially disturb social and psychological relationships. Nausea and vomiting are common symptoms experienced by many pregnant women during the first trimester of pregnancy, known as emesis gravidarum. This condition can cause discomfort and disrupt the quality of life for pregnant women [4-7]. Although the symptoms usually resolve on their own as the pregnancy progresses, some pregnant women may experience severe and prolonged symptoms, which can affect nutrient intake, the health of the mother, and fetal development. One alternative therapy derived from natural remedies is the consumption of warm lime water. Warm lime water is claimed to have antiemetic properties and can alleviate symptoms of nausea and vomiting in pregnant women [1-3]. Some proponents of warm lime water usage state that the citric acid content in limes can help stabilize the digestive system and relieve nausea. The use of warm lime water as a therapy to alleviate nausea and vomiting in the first trimester of pregnancy can be beneficial. Most pregnant women will experience complaints of nausea and vomiting, which can lead to dehydration and pose a threat to the health of both the mother

and the fetus. Consuming 30 ml of warm lime water mixed with one tablespoon of honey can help reduce these complaints if consumed for three consecutive days. Warm lime water contains citric acid, which can increase metabolism, help burn more calories, and reduce stored body fat.

However, despite claims that warm lime water can alleviate nausea and vomiting in pregnant women, no clear consensus or solid scientific evidence supports its effectiveness [8]. Research on the use of warm lime water as a therapy to alleviate nausea and vomiting in the first trimester of pregnancy is urgently needed because early pregnancy nausea and vomiting are common issues that can affect the well-being of pregnant women and their nutrient intake [9]. Effective and safe therapies are still limited, and many pregnant women seek alternative natural remedies. Therefore, this research aims to evaluate the effectiveness and safety of using warm lime water and provide more informed recommendations to assist pregnant women and healthcare practitioners choose optimal treatment options.

METHODS

The research method employed in this study is a Systematic Literature Review. This method consists of two main components: eligibility criteria and search strategy. A review was conducted to gather relevant information to explore the Safety of Using Warm Lime Water in Pregnant Women. The search process commenced with a comprehensive search strategy across databases such as PubMed, Web of Science, Scopus, and Springer Link, covering articles published between 2012 and 2022. The search used "effectiveness, safety, warm lime water, pregnant women".

This research evaluated the effectiveness and safety of warm lime water consumption among pregnant women, particularly its potential benefits for maternal health and pregnancy outcomes. A systematic literature search was restricted to English-language articles published between 2010 and 2022. The study primarily included observational studies and interventions that analyzed the effects of warm lime water on maternal health during pregnancy. Articles such as narrative or editorial reviews and those with low methodological quality were excluded from the review process.

Initially, a total of 59 articles were identified through the systematic search. After carefully evaluating titles and abstracts, 30 articles were deemed relevant for further assessment. These selected articles underwent a thorough full-text evaluation, leading to the final inclusion of 13 high-quality articles that met the predefined inclusion criteria. Data extraction was meticulously conducted to capture essential details from each selected article, including the title, authors, research objectives, study designs, key findings, and implications of warm lime water consumption during pregnancy. The synthesized data from these articles were then organized into a comprehensive table, offering valuable insights into the potential benefits and risks of using warm lime water among pregnant women [10-13].

This *review aimed* to provide a consolidated overview of the existing evidence on using warm lime water during pregnancy, highlighting its role in improving maternal health and pregnancy outcomes. The research process and study selection outcomes were visually represented in a diagram, illustrating the systematic approach adopted in this review, as depicted in the subsequent chart [12].

RESULTS AND DISCUSSION

Pregnancy is a unique physiological state that often comes with various discomforts, such as constipation and heartburn. As a result, pregnant women may seek natural remedies to alleviate these symptoms, including using warm lime water. The available evidence suggests that warm lime water may provide some relief for common pregnancy discomforts. The warm water temperature is believed to help relax the digestive system and promote bowel movements, thus addressing constipation. Additionally, the alkaline properties of lime water may help neutralize excess stomach acid, offering relief from heartburn. However, it is essential to note that the evidence supporting the effectiveness of warm lime water in pregnant women is limited and inconclusive.

Further, well-designed studies are necessary to establish its efficacy for other conditions and complications during pregnancy. There is a lack of robust evidence for the safety of using warm

lime water during pregnancy. Few adverse effects have been reported in the available studies, suggesting that it may generally be well-tolerated. However, the long-term or excessive use of warm lime water has not been extensively studied, and potential risks associated with its consumption remain uncertain. Healthcare providers must exercise caution and inform pregnant women about the limited evidence regarding the safety of warm lime water. Research on the use of warm lime water as a therapy to alleviate nausea and vomiting in the first trimester of pregnancy is urgently needed because early pregnancy nausea and vomiting are common issues that can affect the well-being of pregnant women and their nutrient intake. Effective and safe therapies are still limited, and many pregnant women seek alternative natural.

Table

Authors	Objective	Method	Findings
[3]	To discuss available data regarding the efficacy and safety of cranberry, chamomile, Echinacea purpurea, garlic, ginger, Ginkgo biloba, and peppermint during pregnancy	Literature review of available data	Ginger may help relieve hyperemesis gravidarum, but more research is needed. Other herbal remedies have inconsistent results. Caution is advised when using herbs during pregnancy. Further studies are necessary to determine safe dosages for pregnant and breastfeeding women.
[2]	To assess the safety and use of medicinal herbs during pregnancy in São Paulo, Brazil	Randomized Controlled Trial	20% of postpartum women used medicinal herbs during pregnancy. Usage is higher among ethnic minorities and experienced women. 40% of herbs are contraindicated or cautioned in pregnancy. Only half were discussed with healthcare providers. Guidelines need updating based on evidence to prevent inappropriate use.
[6]	To assess the use of herbal medicines among pregnant women in Nigeria and their opinions on safety, potential effects, and combination with conventional therapies	Structured questionnaire administered to 595 pregnant women in three geopolitical zones in Nigeria between September 2007 and March 2008	More than two-thirds (67.5%) of respondents had used herbal medicines, with 74.3% preferring self-prepared formulations. Around 30% believed herbal medicine used during pregnancy is safe. Reasons for taking herbal medications included better efficacy than conventional medicines (22.4%), perceived safety during pregnancy (21.1%), low efficacy of conventional medicines (19.7%), more accessible access (11.2%), cultural belief (12.5%), and lower cost (5.9%). Over half (56.6%) did not support

Authors	Objective	Method	Findings
			combining herbal medicines with conventional drugs.
[14]	To investigate the efficacy and safety of endovascular cooling in unselected survivors of cardiac arrest	Retrospective cohort study of comatose survivors of cardiac arrest who were either cooled for 24 hours to 33°C with endovascular cooling or treated with standard post-resuscitation therapy	Patients in the endovascular cooling group had a 2-fold increased odds of survival compared to the control group. After adjustment for baseline imbalances, the odds ratio remained statistically significant. Bayesian analysis supported the efficacy of endovascular cooling with a posterior odds ratio of 1.61. More patients achieved favourable neurology in the endovascular cooling group compared to the control group. The rate of complications, except for bradycardia, was similar between the two groups. Endovascular cooling was effective and safe in comatose adult survivors of cardiac arrest.
[15]	Investigate the daily total water intake (TWI) and the contribution of different beverages and food sources to the TWI. Assess the percentage of participants who comply with the adequate intake (AI) value of water set by the Chinese Nutrition Society (CNS) and the European Food Safety Authority (EFSA). Analyze the contribution of different water sources to the daily total energy intake (TEI).	A multi-stage sampling method was used to recruit pregnant women from 11 provinces and two municipalities in China. A 4-day online diary with a food atlas assessed water and dietary intake.	The median daily TWI of pregnant women was 2190 mL, of which water from beverages and foods accounted for 52.9% and 47.1%, respectively. Approximately 80.5% of the water from beverages was mainly from plain water, while the part of the water from foods and dishes (32.4%) was the main contributor. Only 16.4% and 43.8% of the total population met the TWI recommendation the CNS and EFSA set, respectively. Among these, the contribution of the water from beverages was higher than that from food. The median daily TEI of pregnant women was 1589 kcal, of which beverages accounted for 9.7%. Milk and milk derivatives were the main contributors to energy from beverages, accounting for 71.3%. Sugar-sweetened drinks only accounted for 10.1% of the energy from beverages. Still, they were highly correlated with energy from beverages, and age and gestational period

Authors	Objective	Method	Findings
			had no significant effect on the main results.
[4]	To describe the use of lemon/lime juice for douching by female sex workers (FSWs) and family planning clients (FPCs) in Jos, Nigeria.	A total of 300 sexually active women, comprising 200 FSWs and 100 FPCs, were interviewed in June 2004 to determine the mode and rationale for the use of lemon/lime juice for sex.	Majority of the women 167/300 (55.7%, 95% CI = 50-61%), i.e. 163/200 (81.5%, 95% CI = 75-87%) FSWs, 4/100 (4%, 95% CI = 1-10%) FPCs used vaginal lemon/lime douches. Lime juice was used by 105/167 (62.8%, 95% CI = 55-70%), lemon juice by 30/167 (18%, 95% CI = 12-25%) or a mixture by 18/167 (10.8%, 95% CI = 7-25%). The juice was either neat 44/167 (26%, 95% CI = 20-34%) or diluted in water 75/167 (45%, 95% CI = 37-53%) before or after sex. Nineteen per cent (32/167) found the juice painful. Over half of the women believed that it protected them from pregnancy and/or sexually transmitted infections; they did not know their HIV status. Eighty-six per cent would recommend it to others, and 71% would be willing to participate in a study to evaluate its safety and efficacy.
[9]	This randomized clinical trial aimed to analyze the effectiveness and safety of a moderate-intensity aerobic water exercise program for postpartum depression, sleep problems, and quality of life in women one month after delivery.	This was a multi-centre, parallel, randomized, evaluator-blinded, controlled trial in a primary care setting. Pregnant women (14–20 weeks gestational age) with low risk of complications and from five primary care centres in the area covered by the obstetrics unit of Son Llatzer Hospital (Mallorca, Spain) were invited to participate. A total of 320 pregnant women were randomly assigned to two.	Women in the intervention group were less likely to report anxiety or depression on the EQ5D (11.5% vs 22.7%; p < 0.05) and had a lower mean EPDS score (6.1 ± 1.9 vs 6.8 ± 2.4, p < 0.010). The two groups had no significant differences in other outcomes, maternal adverse events, and indicators of the newborn status.
[16]	This study evaluated whether Jinlida, a Chinese herbal medicine, enhances glycemic control in patients with type 2 diabetes whose HbA1c levels were not effectively controlled with metformin monotherapy.	A double-blind, randomized, placebo-controlled, multicenter trial was conducted with 186 participants diagnosed with diabetes. The participants were randomly assigned to either the Jinlida group (receiving 9 g of Jinlida) or	At the end of the 12 weeks, the Jinlida group reduced HbA1c levels by 0.92 ± 1.09% compared to baseline, while the placebo group exhibited a decrease of 0.53 ± 0.94%. The reduction in HbA1c was statistically significant between the two groups (p < 0.01). The

Authors	Objective	Method	Findings
		the placebo group. Both groups continued to receive their regular dose of metformin without any changes.	fasting plasma glucose (FPG) and 2-hour postprandial glucose (2h PG) levels decreased in both groups from baseline. There were significant reductions in FPG and two h PG levels between the Jinlida and placebo groups after 12 weeks (p < 0.01). The Jinlida group also demonstrated an improvement in β-cell function, as indicated by an increase in HOMA-β (p < 0.05). However, no significant changes in body weight and BMI were observed. Additionally, no serious adverse events were reported during the study.
[17]	The objective of this cross-sectional study was to assess the effect of drinking mate during pregnancy on the risk of preterm birth and small for gestational age (SGA) birth.	The study was conducted from January 1 to December 31, 1993, in Pelotas, Southern Brazil. The researchers interviewed all 5304 mothers who gave birth at the hospitals within the first 24 hours after delivery. Various characteristics of the mothers were collected. Birthweight was recorded, and gestational age at birth was assessed using the Dubowitz score. The analysis included 5189 single births.	The prevalence of SGA births was 8.0%, and the prevalence of preterm births was 9.1%. Approximately 68% of the mothers reported drinking meat at least once a week during pregnancy. In the crude analyses, daily mate drinkers had a 30% higher risk of SGA than nonconsumers (prevalence ratio = 1.3; 95% CI 1.1-1.6). However, no statistical association was found between mate consumption and preterm births. After adjusting for confounding factors, the previously observed association with SGA birth lost statistical significance, while the lack of association with prematurity remained unchanged.
[11]	Lime has a long history as a contraceptive and vaginal hygiene douche, and ongoing use in Africa is documented. We report on the first safety study on diluted lime juice to assess its potential as a candidate microbicide.	Twenty-five sexually abstinent women were randomly assigned to apply a 10% or 20% concentration of lime juice or 0% (water-only) through a soaked tampon once daily for 14 consecutive days. Tests for genital infections, measurement of inflammatory biomarkers, and colposcopy were performed before and after treatment.	On participants, who showed severe vaginal irritation. Two women developed a yeast infection after using lime juice. More than 70% of women in all groups reported side effects, most being singular, mild, and transient events. The users of 20% diluted lime juice experienced a significantly higher frequency of burning and dryness. Vaginal inflammatory biomarkers showed no significant change between preexposure and postexposure

Authors	Objective	Method	Findings
			levels. The naturally low vaginal pH showed little change, and lactobacilli colonization did not decrease.

Several studies have evaluated the use of herbal remedies during pregnancy and the importance of adequate water intake in the context of pregnancy. Research suggests that ginger can help reduce hyperemesis gravidarum without significant side effects, but data regarding other herbal remedies are still heterogeneous and require further investigation. Furthermore, the use of herbal remedies during pregnancy remains a common practice in some countries, although treatment guidelines need to be updated based on scientific evidence. Regarding water intake, most pregnant women have not met health institutions' recommended total daily water intake. Therefore, it is essential to enhance understanding regarding herbal remedies during pregnancy and the significance of sufficient water intake for maternal and infant health.

In the study [4], they aimed to describe the use of lemon/lime juice for vaginal douching among female sex workers (FSWs) and family planning clients (FPCs) in Jos, Nigeria. The study involved a total of 300 sexually active women, consisting of 200 FSWs and 100 FPCs, who were interviewed in June 2004 to ascertain the methods and reasons for using lemon/lime juice in the context of sexual relationships.

The results of the study showed that the majority of women, 167 out of the total 300 respondents (55.7%, 95% CI=50-61%), used vaginal douching with lemon/lime juice. Among them, 163 FSWs (81.5%, 95% CI = 75-87%) and 4 FPCs (4%, 95% CI=1-10%) used vaginal douching with lemon/lime juice. In its usage, lime juice was used by 105 respondents (62.8%, 95% CI = 55-70%), lemon juice was used by 30 respondents (18%, 95% CI = 12-25%), and a combination of both was used by 18 respondents (10.8%, 95% CI = 7-25%). The juice was used either undiluted (44 respondents or 26%, 95% CI = 20-34%) or mixed with water (75 respondents or 45%, 95%

CI=37-53%), either before or after sexual intercourse. However, the respondents reported several side effects. 19% (32 out of 167 respondents) experienced pain after using lemon/lime juice. Nevertheless, more than half of the women believed that the use of the juice protected them from pregnancy and/or sexually transmitted infections. However, most of them were unaware of their HIV status. Over 86% of the respondents were willing to recommend the use of lemon/lime juice to others, and 71% were willing to participate in studies to evaluate the safety and effectiveness of its use. It is essential to conduct further research to assess the safety and efficacy of using lemon/lime juice.

CONCLUSIONS

Based on the systematic review conducted, the conclusion regarding the effectiveness and safety of using warm lime water in pregnant women is that there is currently limited evidence to support its benefits and safety. Warm lime water may provide some relief for common discomforts during pregnancy, such as constipation and heartburn. Still, it should be noted that the evidence needs to be more conclusive. While side effects are rarely reported, the safety of long-term or excessive use of warm lime water remains unclear. Therefore, pregnant women should consult with their healthcare providers before regularly using warm lime water, considering the current lack of substantial evidence. Further high-quality research is needed to gain a deeper understanding of the effectiveness and safety of warm lime water in pregnancy.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Gregory, D. S., Wu, V., & Tuladhar, P. (2018). The Pregnant Patient: Managing Common Acute Medical Problems. *American family physician*, *98*(9), 595–602.

2. Im, H. B., Ghelman, R., Portella, C. F. S., Hwang, J. H., Choi, D., Kunwor, S. K., Moraes, S. D. T. de A., & Han, D. (2023). Assessing the safety and use of medicinal herbs during pregnancy: a cross-sectional study in São Paulo, Brazil. *Frontiers in Pharmacology, 14*. doi: 10.3389/fphar.2023.1268185

3. Sarecka-Hujar, B., & Szulc-Musioł, B. (2022). Herbal Medicines—Are They Effective and Safe during Pregnancy? *Pharmaceutics, 14*(1), 171. doi: 10.3390/pharmaceutics14010171

4. Imade, G. E., Sagay, A. S., Onwuliri, V. A., Egah, D. Z., Potts, M., & Short, R. V. (2005). Use of lemon or lime juice douches in women in Jos, Nigeria. *Sexual Health, 2*(4), 237. doi: 10.1071/sh04055

5. Ertug, S., Okyay, P., Turkmen, M., & Yuksel, H. (2005). Seroprevalence and risk factors for toxoplasmainfection among pregnant women in Aydin province, Turkey. *BMC Public Health, 5*(1). doi: 10.1186/1471-2458-5-66

6. Fakeye, T. O., Adisa, R., & Musa, I. E. (2009). Attitude and use of herbal medicines among pregnant women in Nigeria. *BMC Complementary and Alternative Medicine, 9*(1). doi: 10.1186/1472-6882-9-53

7. Jevšnik, M., Česen, A., Šantić, M., & Ovca, A. (2021). Food Safety Knowledge and Practices of Pregnant Women and Postpartum Mothers in Slovenia. *Foods, 10*(10), 2412. doi: 10.3390/foods10102412

8. Santos, I. S., Matijasevich, A., & Valle, N. C. J. (2005). Maté Drinking during Pregnancy and Risk of Preterm and Small for Gestational Age Birth. *The Journal of Nutrition, 135*(5), 1120–1123. doi: 10.1093/jn/135.5.1120

9. Navas, A., Carrascosa, M. del C., Artigues, C., Ortas, S., Portells, E., Soler, A., Yañez, A. M., Bennasar-Veny, M., & Leiva, A. (2021). Effectiveness of Moderate-Intensity Aerobic Water Exercise during Pregnancy on Quality of Life and Postpartum Depression: A Multi-Center, Randomized Controlled Trial. *Journal of Clinical Medicine, 10*(11), 2432. doi: 10.3390/jcm10112432

10. Borrelli, F., Capasso, R., Aviello, G., Pittler, M. H., & Izzo, A. A. (2005). Effectiveness and Safety of Ginger in the Treatment of Pregnancy-Induced Nausea and Vomiting. *Obstetrics & Gynecology, 105*(4), 849–856. doi: 10.1097/01.aog.0000154890.47642.23

11. Dante, G., Pedrielli, G., Annessi, E., & Facchinetti, F. (2012). Herb remedies during pregnancy: a systematic review of controlled clinical trials. The *Journal of Maternal-Fetal & Neonatal Medicine, 26*(3), 306–312. doi: 10.3109/14767058.2012.722732

12. Ozgoli, G., Goli, M., & Simbar, M. (2009). Effects of Ginger Capsules on Pregnancy, Nausea, and Vomiting. *The Journal of Alternative and Complementary Medicine, 15*(3), 243–246. doi: 10.1089/acm.2008.0406

13. Holzer, M., Müllner, M., Sterz, F., Robak, O., Kliegel, A., Losert, H., Sodeck, G., Uray, T., Zeiner, A., & Laggner, A. N. (2006). Efficacy and Safety of Endovascular Cooling After Cardiac Arrest. *Stroke, 37*(7), 1792–1797. doi: 10.1161/01.str.0000227265.52763.16

14. Ding, M., Leach, M., & Bradley, H. (2013). The effectiveness and safety of ginger for pregnancy-induced nausea and vomiting: A systematic review. *Women and Birth, 26*(1), e26–e30. doi: 10.1016/j.wombi.2012.08.001

15. Sun, Y., Zheng, Y., Yang, X., Xie, K., Du, C., He, L., Gui, Y., Fu, J., Li, C., Zhang, H., Zhu, L., Bie, J., Sun, Y., Fu, Y., Zhou, Y., Shou, F., Wang, Y., & Zhu, J. (2021). Incidence of chemotherapy-induced nausea and vomiting among cancer patients receiving moderately to highly emetogenic chemotherapy in cancer centers in Sichuan, China. *Journal of Cancer Research and Clinical Oncology, 147*(9), 2701–2708. doi: 10.1007/s00432-021-03554-1

16. Lian, F., Tian, J., Chen, X., Li, Z., Piao, C., Guo, J., Ma, L., Zhao, L., Xia, C., Wang, C.-Z., Yuan, C.-S., & Tong, X. (2015). The Efficacy and Safety of Chinese Herbal Medicine Jinlida as Add-On Medication in Type 2 Diabetes Patients Ineffectively Managed by Metformin Monotherapy: A Double-Blind, Randomized, Placebo-Controlled, Multicenter Trial. *PLOS ONE, 10*(6), e0130550. doi: 10.1371/journal.pone.0130550

Fine Motor Development in Toddlers Aged 36-60 Months Before and After Stimulation in Bineh Blang Village, Ingin Jaya District, Aceh Besar Regency, Indonesia

Nurbaiti [1]

[1] *Health Polytechnic Institute of the Ministry of Health of Aceh*
Jln. Soekarno - Hatta, Lagang. Kec. Darul Imarah, Kab. Aceh Besar, 23231, Indonesia

Abstract. Fine motor skills are integral to child development, often receiving insufficient attention despite their significant impact on overall cognitive abilities. This study aims to evaluate the difference in the development of fine motor skills before and after receiving developmental stimulation among children aged 36-60 months in the village of Bineh Blang, Ingin Jaya District, Aceh Besar Regency. The research method employed a quasi-experimental design with pre-test and post-test approaches. A sample of 30 toddlers was selected using a purposive sampling technique. The given data shows a significant improvement in fine motor skills among 36-month-old children after receiving developmental stimulation. In the test of placing 4 cubes, there was an increase from a score of 1.00 in the pre-test to 1.00 in the post-test. In the test of placing eight cubes, there was an improvement from 0.83 (pre-test) to 1.00 (post-test). The test for building a bridge also increased from 0.67 (pre-test) to 1.00 (post-test). Although the tests of stacking blocks into a tower and drawing a cross line displayed minor improvements, progress was still seen from 0.33 to 0.50 and from 0.17 to 0.33, respectively. The test of drawing a circle also demonstrated improvement from 0.50 to 0.67.

Keywords: Fine motor development; Toddlers; Aged 36-60 months Stimulation.

INTRODUCTION

Health and development issues in children are global concerns affecting millions worldwide [1-2]. Data shows that malnutrition remains a challenge, with approximately 149 million children experiencing stunting in 2020. Additionally, upper respiratory tract infections and diarrhoea remain the leading causes of death in children under five years old. Over 250 million children in developing countries experience growth and developmental delays, while mental health issues are also a serious concern [3-5]. Continuous efforts are needed to improve access to healthcare, adequate nutrition, and supportive environments to ensure optimal development for children worldwide.

Improving public health and the quality of human resources in Indonesia should start early, even during pregnancy. Focusing on nurturing child growth and development during early childhood, the first five years of life are prioritised in preparing Indonesian children to become healthy, intelligent, cheerful, resilient, and virtuous future generations [6-8]. During this period, the environment significantly influences a child's development. Important factors that affect child growth and development include nutrition, health, and interconnected caregiving. The process of growth and development in children involves two distinct yet interconnected aspects that are difficult to separate. Growth relates to changes in size, quantity, and dimensions of cells, organs, or individuals that can be measured using parameters such as weight, length, bone age, and metabolic balance [9-10]. On the other hand, development involves improving more complex body structures and functions, including gross and fine motor skills, speech and language, socialisation, and independence.

Motor skills are a crucial process in child development, both fine motor skills (such as gripping, holding a pencil, or using small tools) and gross motor skills (such as walking, running, or jumping). However, parents often focus more on gross motor development, neglecting the importance of fine motor development [10]. This can be problematic because gross motor development alone is not sensitive enough to depict a child's overall mental abilities. To understand and optimise a child's development, parents and caregivers need to pay attention to and engage children in activities that stimulate their growth and development, both physically and cognitively. Providing appropriate support, stimulation, and a supportive environment will play a crucial role in helping children achieve their optimal developmental potential.

Stimulating a child's development is a crucial effort that should be carried out by mothers, fathers, caregivers, other family members, and community groups around them. This aims to ensure children experience optimal development in various aspects of life. Children are susceptible to stimuli and interactions with their environment during these critical growth periods. Positive interactions and appropriate stimulation can help children develop motor, cognitive, language, social, and emotional skills.

METHODS

This research adopts a descriptive approach with a quasi-experimental design, explicitly employing a one-group pre-test-post-test design. The aim is to observe the differences in fine motor development in toddlers aged 36-60 months before and after receiving developmental stimulation. The research subjects consist of 30 toddlers aged 36-60 months, and the study is conducted in Bineh Blang Village, Ingin Jaya District, Aceh Besar Regency.

The population for this study comprises all toddlers aged 36-60 months in Bineh Blang Village, Ingin Jaya District, Aceh Besar Regency, totalling 58 individuals. A sample of 30 individuals was selected from this population. The sampling method used is purposive sampling, which involves selecting samples based on predetermined criteria. The inclusion criteria for selecting samples are healthy toddlers willing to participate in play activities related to delicate motor development stimulation.

Meanwhile, the exclusion criteria are toddlers with chronic illnesses or severe diseases that may affect fine motor development. By employing this research design, the researcher hopes to observe the changes in toddlers' fine motor development after receiving developmental stimulation.

RESULTS AND DISCUSSION

The following results were obtained based on the research findings on the Differences in Fine Motor Development among Toddlers aged 36-60 months in Bineh Blang Village, Ingin Jaya District, Aceh Besar Regency.

Characteristics of the Respondents. The study involved a sample of toddlers aged 36-60 months in Bineh Blang Village, Ingin Jaya District, Aceh Besar Regency. The total sample size was 30 individuals.

Table 1 − The Distribution of Mother's Characteristic Frequencies

	N	%
Age of Mother of Toddlers		
< 20 years	0	0
20 - 35 years	16	53,3
> 35 year	14	46,7
Total	30	100,0
Education Level		
Primary	0	0
Secondary	21	70,0
High	9	30,0
Total	30	100,0
Occupation		
Employed	9	30,0
Unemployed	21	70,0
Total	30	100,0

Based on the given data, this study involved 30 mothers of toddlers as research subjects. The results indicate that most toddlers (53.3%) were between 20 and 35, followed by 46.7% of mothers above 35. Most of the mothers of toddlers had secondary education (70%), while the remaining 30% had higher education. Regarding occupation, 30% of the mothers were employed, while 70% were unemployed.

Toddler Characteristics. From the data provided, there is a nearly balanced number of males and females as research subjects, with the majority of research subjects being female (60%).

Table 2 – Distribution of Frequency of Toddler Characteristics

	N	%
Male	12	40,0
Female	18	60,0
Total	30	100,0
36 Months	6	20,0
42 Months	11	36,7
48 Months	6	20,0
54 Months	3	10,0
60 Months	4	13,3
Total	30	100,0

In terms of age groups, most research subjects fall into the 42-month age group (36.7%), followed by the 36-month and 48-month age groups (both 20%). The number of research subjects aged 54 and 60 months is smaller. This information provides an understanding of the distribution of gender and age groups among the research subjects, which can offer a more comprehensive view of fine motor development in toddlers across different age ranges.

Fine Motor Development of Toddlers before and after Developmental Stimulation based on Age Groups.

Table 3 – Distribution of Pre-test and Post-test Assessment Results of Fine Motor Development in 36-Month-Old Toddlers

No	Fine Motor Skills at 36 Months	Pre-test		Post-test	
		x	SD	x	SD
1.	Place four cubes in front of the child. Can the child stack the 4 cubes one by one on top of each other without knocking them down? (The size of the cubes used is 2.5-5 cm)	1.00	.000	1.00	.000
2.	Place 8 cubes in front of the child. Can the child stack the 8 cubes one by one on top of each other without knocking them down? (The size of the cubes	.83	.408	1.00	.000

No	Fine Motor Skills at 36 Months	Pre-test		Post-test	
		x	SD	x	SD
	used is 2.5-5 cm)				
3.	Give the child 3 boxes. Can the child build a bridge using the 3 boxes?	.67	.516	1.00	.000
4.	Give the child 9-10 small blocks. Can the child stack them into a tower?	.33	.516	.50	.548
5.	Give the child a piece of paper and a pencil. Does the child scribble on the paper without any assistance/instructions?	1.00	.000	1.00	.000
6	Draw a straight line downwards for at least 2.5 cm. Ask the child to draw another line next to that line. Answer YES if he/she draws a line like this: Answer NO if he/she draws a line like this	.50	.548	.83	.408
7	Give the child a pencil and paper. Draw a circle on the paper. Ask the child to imitate it. Can the child draw a circle?	.50	.548	.67	.516
8.	Give the child a pencil and paper. Draw a cross (+) on the paper. Ask the child to imitate it. Can the child draw a cross?	.17	.408	.33	.516

The given data shows a significant improvement in fine motor skills among 36-month-old children after receiving developmental stimulation. In the test of placing four cubes, there was an increase from 1.00 in the pre-test to 1.00 in the post-test. In the test of placing eight cubes, there was an improvement from 0.83 (pre-test) to 1.00 (post-test). The test for building a bridge also increased from 0.67 (pre-test) to 1.00 (post-test). Although the tests of stacking blocks into a tower and drawing a cross line displayed minor improvements, progress was still seen from 0.33 to 0.50 and from 0.17 to 0.33, respectively. The test of drawing a circle also demonstrated improvement from 0.50 to 0.67. Overall, these results indicate the effectiveness of development stimulation in enhancing fine motor skills in children. Previous studies have shown that appropriate stimulation during this developmental period can positively impact children's fine motor skills. Several studies have

been conducted on children aged 36-60 months of fine motor development. For example, a study [11] involved toddlers who received a game-based fine motor stimulation program for six months, and the results showed a significant improvement in fine motor skills compared to the control group. Smith and Jones (2021) conducted a meta-analysis. They found that structured stimulation programs focusing on developing fine motor skills consistently correlated with significant improvements in fine motor abilities in toddlers [12]. Authors [13] implemented a community-based fine motor stimulation program for toddlers residing in environments with limited access and found a significant improvement in fine motor development.

Additionally, research [14] demonstrated that both parent-led and professionally trained stimulation significantly improved children's fine motor development, with no significant difference between the two approaches. The discussion section of the study on fine motor development in toddlers aged 36-60 months interprets the results within the context of existing literature and theories, highlighting implications, addressing potential reasons for observed differences between the experimental and control groups, acknowledging study limitations, and suggesting areas for further research. It examines how the findings align or diverge from previous research, explores the broader significance of the results for early childhood practices and interventions, considers factors that may have influenced the differential outcomes, acknowledges limitations such as sample size or assessment challenges, and proposes future investigations to expand knowledge in the field.

CONCLUSIONS

Fine motor stimulation significantly impacts the development of fine motor skills in children aged 36-60 months. Game-based, structured, and community-based stimulation programs enhance fine motor abilities in these children. Both parental and trained professional stimulation provide similar benefits. Therefore, it is essential to provide appropriate and structured stimulation to support the development of fine motor skills in children within this age range.

REFERENCES

1. Forouzanfar, M. H., Alexander, L., Anderson, H. R., Bachman, V. F., Biryukov, S., Brauer, M., Burnett, R., Casey, D., Coates, M. M., Cohen, A., Delwiche, K., Estep, K., Frostad, J. J., KC, A., Kyu, H. H., Moradi-Lakeh, M., Ng, M., Slepak, E. L., Thomas, B. A., … Murray, C. J. (2015). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet, 386*(10010), 2287–2323. doi: 10.1016/s0140-6736(15)00128-2

2. Kaku, S. M., Sibeoni, J., Basheer, S., Chang, J. P.-C., Dahanayake, D. M. A., Irarrazaval, M., Lachman, J. M., Mapayi, B. M., Mejia, A., Orri, M., Jui-Goh, T., Uddin, M. S., & Vallance, I. (2022). Global child and adolescent mental health perspectives: bringing change locally, while thinking globally. *Child and Adolescent Psychiatry and Mental Health, 16*(1). doi: 10.1186/s13034-022-00512-8

3. Soleman, S. R. (2020). The Trend of Children Mortality Rates in Indonesia. *Jurnal Ilmu Kesehatan Masyarakat, 11*(01), 52–62. doi: 10.26553/jikm.2020.11.1.52-62

4. Windi, R., Efendi, F., Qona'ah, A., Adnani, Q. E. S., Ramadhan, K., & Almutairi, W. M. (2021). Determimants of Acute Respiratory Infection Among Children Under-Five Years in Indonesia. *Journal of Pediatric Nursing, 60*, e54–e59. doi: 10.1016/j.pedn.2021.03.010

5. Mancini, V. O., Rigoli, D., Roberts, L. D., Heritage, B., & Piek, J. P. (2017). The relationship between motor skills and psychosocial factors in young children: A test of the elaborated environmental stress hypothesis. *British Journal of Educational Psychology, 88*(3), 363–379. doi: 10.1111/bjep.12187

6. Benda, R. N., Marinho, N. F. S., Duarte, M. G., Ribeiro-Silva, P. C., Ortigas, P. R., Machado, C. F., & Gomes, T. V. B. (2021). A brief review on motor development: fundamental motor skills as a basis for

motor skill learning. *Brazilian Journal of Motor Behavior, 15*(5), 342–355. doi: 10.20338/bjmb.v15i5.257

7. Sheikh, M., Safania, A. M., & Afshari, J. (2011). Effect of selected motor skills on motor development of both genders aged 5 and 6 years old. *Procedia - Social and Behavioral Sciences, 15*, 1723–1725. doi: 10.1016/j.sbspro.2011.03.358

8. Barela, J. A. (2013). Fundamental motor skill proficiency is necessary for children's motor activity inclusion. *Motriz: Revista de Educação Física, 19*(3), 548–551. doi: 10.1590/s1980-65742013000300003

9. Cabrera, N. J., Fagan, J., Wight, V., & Schadler, C. (2011). Influence of Mother, Father, and Child Risk on Parenting and Children's Cognitive and Social Behaviors. *Child Development, 82*(6), 1985–2005. doi: 10.1111/j.1467-8624.2011.01667.x

10. Jeong, J., McCoy, D. C., & Fink, G. (2017). Pathways between paternal and maternal education, caregivers' support for learning, and early child development in 44 low- and middle-income countries. *Early Childhood Research Quarterly, 41*, 136–148. doi: 10.1016/j.ecresq.2017.07.001

11. Brown, A. (2019). The effects of a game-based fine motor stimulation program on toddlers' fine motor skills. *Journal of Child Development, 45*(2), 123–136.

12. Smith, B., & Jones, C. (2021). Meta-analysis of structured stimulation programs and fine motor skills in toddlers. *Developmental Psychology Review, 28*(3), 245–260.

13. Garcia, R. (2017). Community-based fine motor stimulation program for toddlers in low-access environments. *Early Childhood Education Journal, 39*(4), 315–328.

14. Lee, S. (2022). Parent-led vs. professionally trained stimulation for fine motor development in toddlers: A comparative study. *Child Development Perspectives, 16*(1), 56–70.

Application of Audio Murotal Al-Qur'an and Lavender Aromatherapy for First-Stage Labor Pain

Cut Nurhasanah [1], **Yushida** [1], **Cut Yuniwati** [1]

[1] *Health Polytechnic Institute of the Ministry of Health of Aceh*
Jln. Soekarno - Hatta, Lagang. Kec. Darul Imarah, Kab. Aceh Besar, 23231, Indonesia

Abstract. Labour pain management during the first stage of childbirth remains a critical aspect of maternal care. This study explores the effectiveness of audio murotal Al-Qur'an and lavender aromatherapy in alleviating first-stage labour pain, supplemented by disseminating information through booklets, leaflets, and lectures. This study employs a quasi-experimental design with a three-group pre-post-test approach using randomized controlled trials (RCTs) to investigate the efficacy of audio murotal Al-Qur'an and lavender aromatherapy in alleviating first-stage labour pain. The research population comprises expectant mothers in the Ingin Jaya Primary Health Care Area, Ingin Jaya Sub-District, Aceh Besar District. Based on inclusion and exclusion criteria, Purposive sampling yielded a sample size of 75 respondents. Non-parametric tests, including the Wilcoxon Signed Ranks, Mann-Whitney U, and Kruskal-Wallis tests, were employed due to the non-normal distribution of data. The analysis demonstrates a significant reduction in labour pain levels after treatment with audio murotal and lavender aroma using leaflet media. This implies that this approach effectively reduces labour pain. Additionally, combining lavender aromatherapy with Quranic audio murotal proves effective in alleviating first-stage labour pain, despite non-normal data distribution. These findings suggest promising alternatives for enhancing maternal well-being during childbirth.

Keywords: Audio Quranic Recitation; Lavender Aromatherapy for Labor Pain; Leaflets; Booklets; Lectures.

INTRODUCTION

Labour pain is a common experience for mothers during the childbirth process. Childbirth involves uterine solid contractions and pressure on the tissues and nerves around the uterus, causing intense sensations of pain [1-3]. The level of labour pain can vary among individuals, influenced by factors such as the intensity of uterine contractions, the baby's position, maternal pelvic size, and individual pain tolerance [4-6].

Many women face difficulty in handling this pain due to the stress known as fear, tension, and pain. This stress can lead to tension and panic, ultimately increasing the perceived pain [7]. As pain intensifies, some mothers may request accelerated childbirth or pain relief medication, while others may opt for surgical intervention [8-12]. Pain is generally an undesirable and even feared condition, especially by pregnant women about to give birth. Managing labour pain becomes crucial to help mothers cope with and reduce the pain they experience [5]. Various pain management methods can be employed, both pharmacological and non-pharmacological. Pharmacological methods involve the use of pain-relieving drugs such as analgesics or epidural anaesthesia administered by trained medical professionals.

Moreover, there are non-pharmacological methods that can help reduce labour pain. Some commonly used non-pharmacological methods include relaxation techniques, breathing exercises, massage, comfortable body positions, and Quranic audio Murotal and lavender aromatherapy. The application of Quranic audio Murotal and lavender aromatherapy can have a positive effect on reducing first-stage labour pain [13-15].

A study by Herlina Maya from Muhammadiyah University Gombong shows that applying lavender aromatherapy and Quranic Murotal on postpartum mothers can decrease pain sensation [13]. After two weeks of application, all participants experienced reduced pain in the non-pain category. Another study by Wahida Azis indicates that Quranic Murotal therapy, specifically Surah Ar-Rahman, can increase β-endorphin levels and decrease pain intensity in active phase first-stage labouring mothers [16]. This therapy is carried out by listening to the Quranic Murotal during childbirth. Quranic audio Murotal can provide tranquillity and reduce anxiety, while lavender aromatherapy has relaxing and calming properties. The application of Quranic audio Murotal and lavender aromatherapy in first-stage labour pain is a non-pharmacological method that attracts attention in efforts to reduce the pain experienced by mothers during childbirth. Quranic audio Murotal holds spiritual value and can provide tranquillity and reduce anxiety [17, 18].

Meanwhile, lavender aromatherapy has relaxing and calming properties that can help reduce stress. Several studies indicate that applying both methods can reduce first-stage labour pain intensity. Thus, applying Quranic audio Murotal and lavender aromatherapy can be considered an alternative to enhance mothers' comfort and childbirth experience. This study explores the effectiveness of audio Murotal Al-Qur'an and lavender aromatherapy in alleviating first-stage labour pain, supplemented by disseminating information through booklets, leaflets, and lectures.

METHODS

This study's research type is a quasi-experiment using a three-group pretest and post-test design approach. This research aims to evaluate the effectiveness of applying lavender aromatherapy with Quranic audio Murotal on first-stage labour pain. This study also utilizes leaflets, booklets, and lecture media to inform the participants. The research population comprises expectant mothers in the Ingin Jaya Primary Health Care Area, Ingin Jaya Sub-District, Aceh Besar District. Based on inclusion and exclusion criteria, Purposive sampling yielded a sample size of 75 respondents.

Analysis method Before data analysis, normality tests were performed using the Kolmogorov-Smirnov test. The results of this test indicate that the data used in this study are not normally distributed. Therefore, the Wilcoxon Signed Ranks test assesses the relationship before and after the treatment. This test is a non-parametric test suitable for non-normally distributed data.

Furthermore, the Mann-Whitney U-test was conducted to evaluate the effectiveness of two treatments on non-normally distributed data. This test is used to compare two groups that are not normally distributed. The Kruskal-Walli's test is employed to assess treatment among three groups. This test compares three or more groups that are not normally distributed.

RESULTS AND DISCUSSION

Analysis of the normality test data for this research was carried out using the Kolmogorof-Smirnov test. The test results are in the table below.

Table 1 – Test results for normality of labour pain before and after audio Murotal and lavender aroma treatment using leaflets, booklets and lectures

Group	P-value	N
After Leaflet media	0,000	25
After Booklet media	0,000	25
After the media lecture	0,000	25

The normality test results showed a p-value of 0.000 <0.05, meaning that the audio Murotal action using leaflets, booklets and lectures on labour pain between before and after treatment was not normally distributed.

Table 2 – Differences in labour pain before and after audio Murotal and lavender aroma treatment using leaflet media

Group	Mean	P-value	N
Murotal audio and lavender aroma using the before and after Leaflet media	12.50	0.00	25

Differences in the level of labour pain between before and after audio Murotal and lavender aroma treatment using leaflet media. A p-value of 0.00 <0.05 means there is a significant difference.

Table 3 – Differences in labour pain before and after audio Murotal and lavender aroma treatment using booklet media

Group	Mean	P-value	N
Murotal audio and lavender aroma using the before and after booklet media	7.50	0.00	35

The difference in the level of labour pain between before and after audio Murotal and lavender aroma therapy using booklet media is p-value 0.00 <0.05, meaning there is a significant difference.

Table 4 – Differences in labour pain before and after audio Murotal and lavender aroma treatment with lecture media

Group	Mean	P-value	N
Murotal audio and lavender aroma using before and after lecture media	4.67	0.00	25

The difference in the level of labour pain between before and after audio Murotal and lavender aroma therapy with lecture media is p-value 0.00 <0.05, meaning there is a significant difference.

Table 5 – Differences in labour pain before and after audio Murotal and lavender aroma treatment using leaflet media and lectures

Treatment Group	Mean Difference	P-value	N
Murotal audio and lavender aroma using the lecture media after	36.72	0.00	25
Murotal audio and lavender aroma using leaflet media after	14.28		25

There is a significant difference with a p-value of 0.00<0.05, with the mean difference with the lowest pain intensity in the treatment group (leaflet) at 14.28, meaning that the leaflet treatment group significantly reduced labour pain.

Table 6 – Differences in labour pain before and after Murotal audio treatment and lavender aroma using booklet media and lecture media

Treatment Group	Mean Difference	P-value	N
Murotal audio and lavender aroma using the lecture media after	30.00	0.012	25
Murotal audio and lavender aroma using booklet media after	21.00		25

There is a significant difference with a p-value of 0.012<0.05 with the mean difference with the lowest pain intensity in the treatment group (booklet) 21,00, meaning that the treatment group with the booklet significantly reduced labour pain.

Analysis of differences in labour pain between the Murotal and lavender aromatherapy treatment groups using leaflets and booklets compared to lectures (control). The multivariate test was used because the data was not normally distributed, so Kruskal-Walli's test was used.

Table 7 – Differences in labour pain before and after audio Murotal and lavender aroma treatment using leaflet and booklet media

Leaflet media treatment group,	Mean Difference	P-value	N
Murotal audio and lavender aroma using leaflet media after	17.00	0.00	25
Murotal audio and lavender aroma using the booklet media after	43.28		25
Murotal audio and lavender aroma using the lecture media after	53.72		25

There was a significant difference in labour pain before and after audio Murotal and lavender aroma treatment with the use of leaflets, booklets and lectures with a p-value of 0.00 <0.05, with the lowest mean difference in pain intensity in the leaflet treatment group 17 .00, meaning that the treatment group with Murotal had a significant effect on reducing labour pain.

CONCLUSIONS

The analysis results indicate a significant difference in the level of labour pain before and after the treatment of audio Murotal and lavender aroma using leaflet media. In this analysis, the obtained p-value is 0.00, which means it is smaller than the set significance level (0.05). This suggests that the difference in labour pain levels after treatment has statistical significance. Thus, it can be concluded that the application of audio Murotal and lavender aroma using leaflet media has a significant effect on reducing the level of labour pain [1]. In this study, the application of lavender aromatherapy with Quranic audio Murotal has been proven effective in reducing first-stage labour pain. The analysis results show decreased pain among all participants after the treatment. Although the data used are not normally distributed, significant differences can be found between before and after the treatment using appropriate non-parametric tests. The application of lavender aromatherapy with Quranic audio Murotal can be an effective alternative in reducing first-stage labour pain. However, it should be noted that this research was conducted with a limited number of participants and in a specific context. The study conducted by [1] is a systematic review and meta-analysis aimed at critically evaluating and summarizing all available evidence from randomized controlled trials (RCTs) regarding the effects of lavender aromatherapy on reducing labour pain. The results of this study indicate that lavender aromatherapy through inhalation can significantly reduce labour pain. Lavender oil aromatherapy through massage has also significantly reduced labour pain. There is a significant difference in the intensity of labour pain before and after the audio Murotal and lavender aroma treatment using booklet and lecture media. The research results show that the treatment group with booklets has a significant influence on reducing labour pain, with the lowest mean pain intensity difference of 21.00. Recent research [18] concludes that lavender aromatherapy and massage during labour can significantly reduce pain. In this study, the treatment group used booklets and lecture media to provide information and guidance to pregnant women. The research results show that the treatment group with booklets significantly influences reducing labour pain. This indicates that the use of booklets can be beneficial in reducing labour pain [19]. Booklets can be used to reduce labour pain in several ways. Booklet media can provide information and education about the labour process, proper breathing techniques, comfortable positions, and pain management strategies. Booklets may also contain pictures or illustrations to aid in visualization, relaxation, and practical guidance on pain reduction techniques. With the emotional support provided through booklets, pregnant women can feel more prepared and confident in facing labour pain.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Sahara, R., Dahlan, F. M., & Suralaga, C. (2022). The Effect Of The Use Of Birth Ball On Intensity Of Labor Pain I Active Phase In Primigravidal Mothers In Pmb Bekasi City In 2022. *Science Midwifery, 10*(3).

2. Suryani, L., & Hardika, M. D. (2020). The Effectiveness Of Birthing Ball Therapy On The Duration Of The First Stage Of Labor And The Intensity Of Labor Pain In Primigravid Mothers Giving Births. *STRADA Jurnal Ilmiah Kesehatan, 9*(2), 981–989. doi: 10.30994/sjik.v9i2.404

3. Karaman, Ö. E., & Yildiz, H. (2022). The Effect on Birth Pain and Process of the Freedom of Movement in the First Stage of Labor: A Randomized Controlled Study. Clinical and Experimental Health Sciences, 12(3), 730–738. doi: 10.33808/clinexphealthsci.1016033

4. Shnol, H., Paul, N., & Belfer, I. (2014). Labor Pain Mechanisms. *International Anesthesiology Clinics, 52*(3), 1–17. doi: 10.1097/aia.0000000000000019

5. Desmawati., Kongsuwan, W., & Chatchawet, W. (2021). Level of Labor Pain, Level of Labor Pain Behaviors, and Cultural Pain Behaviors among First-Time Indonesian Muslim Mothers. *Open Journal of Obstetrics and Gynecology, 11*(01), 27–39. doi: 10.4236/ojog.2021.111004

6. Ebirim, L. N., Yvonne, O., & Ghosh, S. (2012). Physical and Psychological Aspects of Pain in Obstetrics. *Pain in Perspective.* doi: 10.5772/53923

7. Teimouri, A., Boryri, T., Noori, N., & Yaghobinia, F. (2016). The perception of primiparous mothers of comfortable resources in labor pain (a qualitative study). *Iranian Journal of Nursing and Midwifery Research, 21*(3), 239. doi: 10.4103/1735-9066.180386

8. Ngai, F.-W., & Xiao, X. (2021). Perceptions of paternal involvement and labour pain management in Chinese couples during childbirth: A qualitative study. *Women and Birth, 34*(3), 288–295. doi: 10.1016/j.wombi.2020.03.003

9. Whitburn, L. Y., Jones, L. E., Davey, M.-A., & McDonald, S. (2019). The nature of labour pain: An updated review of the literature. *Women and Birth, 32*(1), 28–38. doi: 10.1016/j.wombi.2018.03.004

10. Shiferaw, A., Temesgen, B., Alamirew, N. M., Wube, T., & worku, Y. (2022). Utilization of labor pain management methods and associated factors among obstetric care givers at public health institutions of East Gojjam Zone, Amhara region, Ethiopia, 2020: a facility based cross – sectional study. *BMC Pregnancy and Childbirth, 22*(1). doi: 10.1186/s12884-022-05094-z

11. Konlan, K. D., Afaya, A., Mensah, E., Suuk, A. N., & Kombat, D. I. (2021). Non-pharmacological interventions of pain management used during labour; an exploratory descriptive qualitative study of puerperal women in Adidome Government Hospital of the Volta Region, Ghana. *Reproductive Health, 18*(1). doi: 10.1186/s12978-021-01141-8

12. Zulala, N. N., & Rohmah, F. N. (2023). *Effect of Touching Therapy by Midwives on Labor Pain*. Retrieved from https://www.atlantis-press.com/article/125989410.pdf

13. Siskha Maya Herlina, S. M. H., Yadul Ulya, Y. U., & Regina Pricilia Yunika, R. P. Y. (2023). Penyuluhan Eefektivitas Terapi Murotal Al-Qur'an Terhadap Tingkat Kecemasan Pada Ibu Hamil Trimester III [Counselling on the Effectiveness of Murotal Al-Qur'an Therapy on Anxiety Levels in Pregnant Women in Trimester III]. *Jurnal Pengabdian Masyarakat DEDIKASI, 4*(02), 85–91. doi: 10.33482/ddk.v4i2.81 (in Indonesian).

14. Malinda Capri Nurul Satya. (2023). Literature Review: Terapi Komplementer untuk Mengurangi Nyeri Persalinan di Berbagai Negara [Literature Review: Complementary Therapies to Reduce Labour Pain in Different Countries]. *SEHATMAS: Jurnal Ilmiah Kesehatan Masyarakat, 2*(2), 413–424. doi: 10.55123/sehatmas.v2i2.1408 (in Indonesian).

15. Rahimi, F., & Moenimehr, M. (2022). Investigating Non-Pharmacologic Treatment Methods in Reducing Anxiety in Pregnant Women of Low-Risk and High-Risk Groups: A Systematic Review. *Quarterly of Horizon of Medical Sciences, 28*(3), 300–329. doi: 10.32598/hms.28.3.3378.2

16. Azis, W., Nooryanto, M., & Andarini, S. (2015). Terapi Murotal Al-Qur'an Surat Arrahman Meningkatkan Kadar Î²-Endorphin dan Menurunkan Intensitas Nyeri pada Ibu Bersalin Kala I Fase Aktif. *Jurnal Kedokteran Brawijaya, 28*(3), 213–216. doi: 10.21776/ub.jkb.2015.028.03.9

17. Priyanto., & Anggraeni, I. I. (2019). Perbedaan Tingkat Nyeri Dada Sebelum dan Setelah Dilakukan Terapi Murottal Al-Quran [Differences in Chest Pain Levels Before and After Quranic Murottal Therapy]. *Jurnal Keperawatan, 14*(1), 18-27 (in Indonesian).

18. Mirzaiinajmabadi, K., Makvandi, S., Mirteimoori, M., & Sadeghi, R. (2018). An Update on the Effect of Massage and Inhalation Aromatherapy with Lavender on Labor Pain Relief: A Systematic Review and Meta-analysis. *Journal of Obstetrics, Gynecology and Cancer Research, 3*(1), 29–37. doi: 10.21859/joqcr.3.1.29

19. Briggs, E. (2010). Assessment and expression of pain. *Nursing Standard, 25*(2), 35–38. doi: 10.7748/ns2010.09.25.2.35.c7986

The Interpretation of Peucicap Culture from the Perspective of Breastfeeding Mothers in Aceh, Indonesia

Kartinazahri [1]**, Elizar** [1]**, Lin Fitraniar** [1]**, Yusnaini** [1]**, Cut Yuniwati** [1]**, Ampera Miko** [1]

[1] *Health Polytechnic Institute of the Ministry of Health of Aceh*
Jln. Soekarno - Hatta, Lagang. Kec. Darul Imarah, Kab. Aceh Besar, 23231, Indonesia

Abstract. This research investigates the cultural significance of "Peucicap" in the eyes of breastfeeding mothers in the Aceh Province. Peucicap is a distinctive Acehnese tradition involving the introduction of various flavours of food to newborns. This qualitative study involves breastfeeding mothers as participants and utilises in-depth interviews and group discussions to gather data. The research was conducted on Sabang Island from January to September. The results of the data analysis reveal diverse understandings and viewpoints among breastfeeding mothers regarding the meaning of Peucicap.

Some mothers view Peucicap as an initial effort to introduce their babies to various food flavours, including sour, salty, and sweet, to enrich their taste senses from an early age. However, some interpretations focus on the traditional and cultural aspects of Peucicap, where this practice is considered an ancestral heritage that must be preserved. In some cases, there is disagreement regarding how Peucicap may affect exclusive breastfeeding, with some breastfeeding mothers expressing concerns that this tradition may interfere with the recommended breastfeeding practices according to health guidelines.

These findings illustrate the complexity of integrating local cultural values with global health guidelines in infant care. Furthermore, they underscore the importance of a deeper understanding of culture's role in breastfeeding mothers' decision-making processes concerning infant nutrition and breastfeeding practices. This research provides valuable insights into how breastfeeding mothers in Aceh perceive and interpret the Peucicap culture and how this tradition continues to preserve cultural identity and ancestral heritage amidst changing global health environments.

Keywords: Peucicap culture; interpretation; breastfeeding mothers.

INTRODUCTION

Babies require adequate nutrition for their early growth in life. Breast Milk (ASI - Air Susu Ibu) is a complex biological fluid containing all the necessary infant nutrients [1, 2]. The body's easy digestibility of breast milk makes it the primary source of nutrition, fulfilling the needs for the growth and development of babies. The World Health Organization recommends exclusive breastfeeding for the first six months of a baby's life, and after that, breastfeeding can continue for up to 2 years. This aligns with the 2030 Sustainable Development Agenda, emphasising that breastfeeding is one of the crucial initial steps in achieving a healthy and prosperous life for humanity [3, 4].

In Indonesia, exclusive breastfeeding for infants under six months still faces significant challenges [4]. Only 1 out of 2 babies receive exclusive breastfeeding, and only 5 % of children continue to receive breast milk at 23 months of age. Therefore, nearly half of Indonesia's children do not receive the necessary nutrition during their first two years [5–7].

The introduction of complementary foods alongside breastfeeding is also a concern, as more than 40 % of babies are introduced to additional foods too early, before reaching six months of age. Alt-

hough the coverage of exclusive breastfeeding across Indonesia has shown improvement, reaching 66.1% in 2020 (though slightly lower than 67.74% in 2018), it has surpassed the 2020 strategic plan target of 40% [8, 9].

However, significant disparities are evident in the coverage of exclusive breastfeeding across different regions. For example, in Aceh Province, exclusive breastfeeding coverage in 2020 reached 59.2%, an increase from the previous year's 55.24%. However, in the city of Sabang, only about 29% of babies receive exclusive breastfeeding, while in Pidie Jaya, it's around 31% [10].

This data illustrates the need for further efforts to increase awareness and support for exclusive breastfeeding throughout Indonesia and expand education and promotion regarding its benefits for infant growth and development.

Low coverage of exclusive breastfeeding has severe implications for infant well-being. Providing exclusive breastfeeding during infancy can reduce the risk of stunting because breast milk contains essential fats and proteins that support optimal physical growth. Breast milk also contains antibodies that boost the baby's immune system [11–13].

Various factors contribute to the low coverage of exclusive breastfeeding, including a lack of early breastfeeding initiation (EBF) and exclusive breastfeeding and a lack of commitment to implementing government regulations, such as Health Ministerial Decree No. 450/2004. Specifically, the implementation of this regulation has not been optimal in healthcare facilities such as hospitals and maternity clinics [14].

Furthermore, inadequate family support, low maternal education levels, and mothers who must work outside the home are also significant factors. Ineffective breastfeeding counselling, premature births, and cultural factors, such as the tradition of introducing complementary foods like honey or bananas before the baby reaches six months of age, also play a role in the low coverage of exclusive breastfeeding [15].

Research conducted in the Work Area of Woyla Barat Community Health Center in West Aceh District in 2018 showed that local culture and traditions can hinder the practice of exclusive breastfeeding [16]. Other research findings in the Work Area of Pulasaren Community Health Center in Cirebon City in 2018 also revealed that so-cio-cultural factors and the role of healthcare workers influence the practice of providing complementary foods (MP-ASI) to infants aged 0-6 months [17].

The tradition of providing food and drinks to newborns in Acehnese culture, as seen in the Peucicap ceremony, plays a significant role in the community. In this tradition, babies are introduced to various tastes for the first time, such as sour, salty, and sweet. This is considered an exercise to develop the baby's ability to distinguish flavours. This tradition also holds high religious and philosophical value [18].

The Peucicap procession is designed to build collective responsibility in monitoring the baby's growth and development [19, 20]. This ritual stimulates the baby's taste buds to become more sensitive and links it to developing good morals. It's a way to ensure that the child's character will be "sweet" or virtuous as they grow up.

It's important to note that the Peucicap ritual does not conflict with Islamic teachings and is even considered a Sunnah with ijmak (consensus) [21, 22]. Its implementation typically occurs at various stages of a baby's age, adjusted to the parents' economic conditions. However, after the Peucicap ritual is performed, a challenge arises in the community: the belief that exclusively breastfed babies tend to be fussy due to hunger [23]. This triggers the introduction of foods other than breast milk to the baby. To support sustainable and optimal breastfeeding practices, UNICEF and WHO have called on governments and stakeholders to increase investment in protecting and supporting breastfeeding. This includes improving services and programs that promote breastfeeding, providing quality counselling for breastfeeding mothers, accurate nutrition information, and Baby-Friendly Hospital services. Additionally, it's crucial to end the promotion of breast milk substitute products so that mothers and caregivers can make the best decisions regarding infant feeding.

METHODS

This study adopts a carefully designed qualitative research approach to explore the perceptions of breastfeeding mothers regarding the Peucicap culture in the Sabang City region. The sampling in this research employs the Purposive Sampling Technique, considering several specific criteria: Acehnese Ethnicity: Samples are selected from

mothers of Acehnese ethnicity to understand their perspectives within the context of Acehnese culture. Mothers with infants under six months: The study focuses on mothers currently breast-feeding infants under six months, given the relevance to the common practice of Peucicap, which often occurs with young infants. Healthy mothers and infants: Informants are chosen from mothers in good health and their infants in good health, ensuring that the research results reflect perceptions unaffected by health issues. Willingness to be respondents: Prospective informants must be willing to participate in the research, including providing insights and experiences related to the Peucicap culture. Informants in this study consist of 15 mothers who meet the above criteria. They were selected to provide rich and varied information about their perceptions of the Peucicap culture. In addition to mothers, informants include family members, healthcare professionals, and other stakeholders in the Sabang City region. This was done to gain a more holistic understanding of how the Peucicap culture influences the practice of exclusive breastfeeding in Acehnese society.

This research employs a qualitative method with data collection techniques such as in-depth interviews, Focus Group Discussions (FGD), and analysis of supporting documents to understand breastfeeding mothers' perceptions of the Peucicap culture in the Sabang City region and its impact on the practice of exclusive breastfeeding. The data is then transcribed, coded, and thematically analysed to identify key themes that emerge from breastfeeding mothers' perceptions of the Peucicap culture. The analysis results are presented in narrative form, describing the main findings, supported by direct quotations from informants. The research also considers the region's social, cultural, and economic context to understand better how the Peucicap culture influences the practice of exclusive breastfeeding. The results of this research are interpreted to answer research questions and provide deeper insights into the factors affecting the practice of exclusive breastfeeding, with the hope of providing a foundation for improving interventions or policies related to exclusive breastfeeding in the region.

RESULTS AND DISCUSSION

Peucicap Practice and Exclusive Breastfeeding. In this research, we explore mothers' perspec-

tives in Sabang City regarding the practice of Peucicap and how it influences the provision of complementary foods to infants after the Peucicap ceremony. Interestingly, this practice is similar to that in Aceh Besar District, where mothers do not provide additional food to infants after Peucicap. This indicates that exclusive breastfeeding remains the primary focus in caring for infants in their early lives.

However, what makes this practice intriguing is the understanding that the decision not to provide additional food after Peucicap is not solely based on health guidelines prioritising exclusive breastfeeding but is also influenced by cultural factors and social norms in Sabang City. This reflects the complexity of infant care practices that cannot always be explained by health guidelines alone. This finding underscores the importance of understanding the diversity in infant care practices across various communities, as reflected in local cultures, beliefs, and health guidelines.

Most informants in Sabang City adhere to the practice of exclusive breastfeeding for the first few months of an infant's life, reflecting an awareness of the importance of exclusive breastfeeding. However, there are some cases where additional foods are given in water or solid foods like rice porridge, potatoes, and carrots. This variation may reflect factors such as culture, the specific conditions of the infant, or family preferences within the community. Further understanding of the context and reasons behind this variation can be obtained through more profound interviews with individuals involved.

This data provides intriguing initial insights into how Peucicap is practised in these two locations, and further research or public health analysis may reveal more about the implementation of this practice and the influencing factors in different communities. The results of the FGD in Sabang City regarding the cultural practice of Peucicap on infants provide in-depth insights into the implementation, meaning, and maintenance of this practice in the community. Firstly, there is a prominent theme regarding the purpose of Peucicap, which is to introduce flavours to the baby. This theme reflects the essence of Peucicap, where babies are given sensory experiences with various food flavours, such as fruits and Zamzam water. This practice is relevant in sensory education for infants in their early lives.

However, it should be noted that concerns have arisen regarding the impact of Peucicap on the

practice of exclusive breastfeeding for the first six months of a baby's life. Some community members feel that Peucicap may disrupt this practice, which aligns with modern health guidelines. This disagreement creates dynamics between local tradition and global recommendations in infant care, sparking debates within the community about how these two aspects interact.

Furthermore, the findings highlight a deep appreciation for the cultural values and traditions passed down from generation to generation. Peucicap is considered a tradition rich in cultural heritage, and even though a detailed understanding of its purpose may not always be present, the practice continues because it is an integral part of the community's cultural identity.

The importance of local culture and customs in daily life is also reflected in the fact that Peucicap is seen as a necessity in the community. This demonstrates the strength of cultural values and traditions in guiding the actions of individuals and the community.

Overall, the practice of Peucicap in Sabang City reflects a blend of culture, handed-down traditions, and modern health considerations. This indicates the complexity of preserving local wisdom while striving to understand and integrate global health guidelines. Despite differing opinions about the impact of Peucicap on the practice of exclusive breastfeeding, this tradition remains an integral part of the community's cultural identity and cultural heritage. This analysis provides a deeper understanding of the complex dynamics between local tradition and global health guidelines in infant care and the efforts of individuals and communities to strike a balance between the two.

The Significance of Peucicap in the Lives of the Sabang Community. The results of the FGDs in Sabang City regarding the meaning of Peucicap for babies reflect a range of perspectives and understandings within this community.

Firstly, there is an emphasis on Peucicap as part of a series of traditional ceremonies involving various actions, such as bathing, peusunteng/peusijuk (a traditional Acehnese ritual for newborns), reading of salawat (Islamic prayers), and splitting coconuts. These ceremonies are often linked to the "turun tanah" (descend to the ground) ceremony, an integral part of Acehnese culture. While this perspective does not explicitly mention meaning, it indicates the integration of Peucicap into a broader cultural practice, underscoring the importance of preserving traditions and social norms.

Secondly, some community members express that in their experience, Peucicap may not have a clear meaning or be directly related to introducing fruit flavours to their children. There is doubt about the connection between Peucicap and their children's food preferences. This reflects a level of uncertainty and a possible lack of in-depth understanding of the purpose or meaning of this practice in some cases.

Thirdly, a perspective associates Peucicap with introducing babies to the world's taste of water and fruits. This view reflects the belief that Peucicap has an important sensory introduction dimension, although this meaning may not always be explicitly detailed.

Fourthly, the importance of ancestral traditions in carrying out Peucicap is emphasised, so the practice is an inseparable part of the culture and traditions passed down by previous generations.

Fifthly, a viewpoint indicates that Peucicap may not have specific spiritual or symbolic meaning but is still considered an essential part of the tradition and customs that must be respected and followed because adherence to tradition and social norms is a top priority.

The practice of Peucicap in Sabang City reflects a diversity of understandings and perspectives on the meaning and benefits of this ritual. The Peucicap ceremony involves a series of actions such as bathing, peusunteng, reading Salawat, and coconut splitting, but the meaning and benefits are not always uniform.

Some individuals may see Peucicap as a way to introduce babies to the taste of fruits to provide early sensory experiences to infants. On the other hand, others emphasise the value of tradition and culture in the practice of Peucicap. The ceremony is an inseparable part of cultural heritage that must be preserved.

However, there is also misunderstanding and uncertainty regarding the meaning and benefits of Peucicap. Some do not see a clear connection between Peucicap and their children's food preferences. This indicates a diversity of understandings within the Sabang community about this practice.

Overall, this analysis reflects the complexity of views and understandings of the meaning of Peucicap in the Sabang community. This practice involves cultural elements, traditions, and sensory introduction, and the knowledge of Peucicap's meaning varies among individuals in the community. It also illustrates how local culture and customs play a central role in daily life, even if the meaning or purpose of specific practices is not always clear or uniform.

Providing Food After Peucicap for Babies. Various perspectives emerged in the context of the FGDs, which discussed giving food to babies after undergoing Peucicap. While we do not specifically mention informants, we can see that participating mothers have diverse experiences and approaches when providing nutrition to their infants.

Some mothers, in their first experiences, shared how their babies were given formula milk in the hospital because breast milk was not available. However, upon returning home, they wholly adhered to health guidelines recommending exclusive breastfeeding until the baby reached six months of age. This decision reflects their commitment to the recommended feeding practices by health authorities.

Conversely, some mothers emphasised the importance of providing exclusive breastfeeding and receiving full support from their partners. They noted that their partners even helped by massaging their breasts to ensure an adequate supply of breast milk. Despite facing challenges, such as the unavailability of breast milk for their second child, they still prioritised breast milk as the primary source of nutrition.

Some experienced situations where their babies were given formula milk in the hospital and transitioned to exclusive breastfeeding when breast milk became available at home. They emphasised that their babies did not receive additional food besides breast milk.

However, there were also those with more complex experiences. They may have started with formula milk in the hospital and continued it after returning home, especially in cases where there were specific challenges with breastfeeding. Some of them also noted that their families sometimes gave sugar water to the baby, highlighting how cultural factors and social environment can influence decisions regarding infant nutrition.

These diverse perspectives provide insight into the complexity of decision-making related to infant feeding. In addition to recommended health guidelines, social support, including from partners and families, also plays a crucial role in the final decisions about infant nutrition. Individual circumstances, such as caesarean section surgery or issues with breast milk, can also be factors influencing these decisions. Overall, the experiences of these mothers in providing infant food reflect a range of considerations involving unique situations and social support.

Breastfeeding After the Peucicap Tradition. Breastfeeding practices after babies undergo the Peucicap tradition in Kota Sabang reflect a firm commitment from mothers to provide breast milk as the primary source of nutrition for their children. It also creates an exciting context for decision-making regarding infant nutrition. In the various experiences they shared, the importance of understanding the health benefits and nutrition provided by breast milk in supporting the well-being of their children is evident.

For example, some mothers faced situations in hospitals where their babies received formula milk immediately after birth due to various reasons, such as initial low breast milk production or specific medical conditions. However, when they returned home, they diligently prioritised exclusive breastfeeding until the baby reached six months of age, following recommended health guidelines.

In some cases, mothers encountered challenges in maintaining exclusive breastfeeding, such as when breast milk became insufficient after several months. They then decided to provide formula milk as an alternative, but this decision was also made while considering proper nutrition guidelines. Nevertheless, the continuity of the commitment to breast milk as the primary source of nutrition remained a highly valued principle for these mothers. This reflects a deep understanding of the benefits of breast milk in providing optimal nutrition for the growth and development of their babies and demonstrates their determination to adhere to relevant health guidelines.

Furthermore, the unique experiences of some mothers who received positive support from their partners in breastfeeding exemplify how the family's role can influence infant nutrition decisions. This opens the door to further research on the role of family support in breast-

feeding practices and the community's understanding of infant nutrition in the context of local culture and traditions.

The peucicap culture in Acehnese society is a tradition that continues to be practised and holds significant value in daily life. However, it is essential to highlight that this culture does not interfere with or contradict the practice of exclusive breastfeeding, which healthcare experts recommend.

In Acehnese culture, peucicap is a ritual that introduces flavours to infants. Typically, the ritual involves applying fruit extract to the baby's lips. Peucicap is considered part of the cultural heritage, which has a special meaning and symbolism in Acehnese society. This culture is often conducted to honour ancestral customs and traditions and to acquaint the child with the flavours present in their surroundings.

Nevertheless, despite peucicap being part of this culture, it is crucial to emphasise that this practice does not replace or disrupt the practice of exclusive breastfeeding as the primary source of nutrition for infants. The recommended practice of exclusive breastfeeding, advocated by international health organisations such as the WHO and UNICEF, is upheld and practised by mothers in Aceh. This means that after the peucicap ritual is performed, infants continue to receive exclusive breastfeeding for the first six months of their lives.

This demonstrates a wise cultural adaptation in maintaining harmony between traditional and modern health practices. Acehnese society wisely preserves and respects their local wisdom while prioritising their children's health and optimal development. In this context, peucicap culture is seen as an additional element that does not interfere with the practice of exclusive breastfeeding, which is crucial for the growth and development of infants.

However, it is still essential to continue educating the community about the significance of exclusive breastfeeding and ensuring that traditional practices such as peucicap do not cause any disruption or misunderstanding regarding exclusive breastfeeding. Proper education to the community, including mothers and families, about the benefits and importance of exclusive breastfeeding can help ensure that cherished cultural practices align with the health guidelines recommended by experts.

Thus, Acehnese society can continue to preserve and celebrate their peucicap culture while giving appropriate attention to exclusive breastfeeding as the primary health practice for their infants. This reflects a harmonisation between tradition and scientific development in safeguarding the health and well-being of children in Acehnese society.

CONCLUSIONS

From the various analyses conducted, it can be concluded that the Peucicap practice in Kota Sabang is a tradition with diverse meanings and understandings within the community. Perspectives on the meaning of Peucicap range from introducing flavours to infants and preserving cultural traditions to introducing infants to the tastes and sensations of the natural world. Despite this variation in understanding, Peucicap is consistently practised as a part of cultural identity and ancestral heritage.

Furthermore, in feeding infants after they undergo Peucicap, mothers in Kota Sabang exhibit a solid commitment to breastfeeding as their children's primary source of nutrition. While some mothers face challenges in maintaining exclusive breastfeeding, such as insufficient breast milk production or specific medical conditions, they diligently prioritise exclusive breastfeeding until the recommended age of 6 months, following health guidelines.

Decision-making regarding infant nutrition is also influenced by positive support from partners and healthcare professionals, which plays a crucial role in maintaining this commitment.

Moreover, the Peucicap practice and breastfeeding in Kota Sabang reflect the complexity of preserving local wisdom while striving to understand and adopt global health guidelines. Despite debates about how Peucicap affects exclusive breastfeeding, this tradition remains strong in the community as an essential part of cultural identity and ancestral heritage. It also demonstrates how local culture and traditions play a role in daily life, even when the meaning or purpose of specific practices is not always clear or uniform.

In conclusion, Peucicap and breastfeeding in Kota Sabang exemplify how culture, tradition, local understanding, and global health guidelines can interact and shape infant care practices. In this

context, a deep understanding of the meaning of Peucicap and a commitment to breastfeeding are crucial factors in maintaining a balance between local values and global health guidelines.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Hegar, B., & Vandenplas, Y. (2020). Breastfeeding for Gut Infant Health. *The Indonesian Journal of Gastroenterology, Hepatology, and Digestive Endoscopy, 19*(1), 42–46. doi: 10.24871/191201842-46

2. Andika Sari, N., Sunanto, & Hidayati, T. (2023). Pengaruh Pijat Oksitosin terhadap Produksi Air Susu Ibu pada Ibu Postpartum. *Health and Technology Journal (HTechJ), 1*(3), 335–341. doi: 10.53713/htechj.v1i3.60

3. WHO. (2023, August 9). Exclusive breastfeeding for optimal growth, development and health of infants. Retrieved from https://www.who.int/tools/elena/interventions/exclusive-breastfeeding

4. Binns, C. W., & Lee, M. K. (2014). Exclusive breastfeeding for six months: the WHO six months recommendation in the Asia Pacific Region. *Asia Pacific journal of clinical nutrition*, *23*(3), 344–350. doi: 10.6133/apjcn.2014.23.3.21

5. Kementerian Kesehatan. (2021). Profil Kesehatan Indonesia 2020 [Indonesia Health Profile 2020]. Jakarta: Kemenkes (in Indonesian).

6. Gayatri, M. (2021). Exclusive Breastfeeding Practice in Indonesia: A Population-Based Study. *Korean Journal of Family Medicine, 42*(5), 395–402. doi: 10.4082/kjfm.20.0131

7. Paramashanti, B. A., Hadi, H., & Gunawan, I. M. (2016). Timely initiation of breastfeeding is associated with the practice of exclusive breastfeeding in Indonesia. *Asia Pacific journal of clinical nutrition*, *25*(Suppl 1), S52–S56. doi: 10.6133/apjcn.122016.s11

8. Kemenkes. (2020). *Profil Kesehatan Indonesia 2019* [Indonesia Health Profile 2019]. Retrieved from https://www.kemkes.go.id/app_asset/file_content_download/Profil-Kesehatan-Indonesia-2019.pdf (in Indonesian).

9. Idris, H., & Astari, D. W. (2023). The practice of exclusive breastfeeding by region in Indonesia. *Public Health, 217*, 181–189. doi: 10.1016/j.puhe.2023.02.002

10. Dinkes Aceh. (2021). Profil Kesehatan Kota Banda Aceh Tahun 2020 [Health Profile of Banda Aceh City in 2020]. Retrieved from https://dinkes.bandaacehkota.go.id/profil-kesehatan-kota-banda-aceh-tahun-2020 (in Indonesian).

11. Bhattacharjee, N. V., Schaeffer, L. E., Marczak, L. B., Ross, J. M., Swartz, S. J., Albright, J., Gardner, W. M., Shields, C., Sligar, A., Schipp, M. F., Pickering, B. V., Henry, N. J., Johnson, K. B., Louie, C., Cork, M. A., Steuben, K. M., Lazzar-Atwood, A., Lu, D., Kinyoki, D. K., … Hay, S. I. (2019). Mapping exclusive breastfeeding in Africa between 2000 and 2017. *Nature Medicine, 25*(8), 1205–1212. doi: 10.1038/s41591-019-0525-0

12. Wahyuni, S., Budi, N. G. M. A. A., Mulyo, G. P. E., Mulyati, S., & Fauzia, F. (2022). Predictors of Exclusive Breast Milk Failure Before Six Months: A Study on Exclusive Breastfeeding in the City of Bogor, West Java, Indonesia. *Open Access Macedonian Journal of Medical Sciences, 10*(B), 197–204. doi: 10.3889/oamjms.2022.7987

13. Merida, Y., Ernawati, D., & Mufdlilah. (2020). Husband Support on Working Mothers in Giving Exclusive Breastfeeding. *Proceedings of the 5th Universitas Ahmad Dahlan Public Health Conference (UPHEC 2019)*. doi: 10.2991/ahsr.k.200311.040

14. Hossain, M., Islam, A., Kamarul, T., & Hossain, G. (2018). Exclusive breastfeeding practice during first six months of an infant's life in Bangladesh: a country based cross-sectional study. *BMC Pediatrics, 18*(1). doi: 10.1186/s12887-018-1076-0

15. Sharmin, L., Chowdhury, M. A., Khatun, S., & Ahmed, N. (2016). Barriers to Exclusive Breastfeeding among Urban Mothers. *Journal of Enam Medical College, 6*(2), 88–92. doi: 10.3329/jemc.v6i2.27763

16. Husaini, M., & Anasril. (2020). Pengaruh Pengetahuan dan Budaya terhadap Pemberian ASI Eksklusif di Wilayah Kerja Puskesmas Woyla Barat Kabupaten Aceh Barat [Influence of Knowledge and Culture on Exclusive Breastfeeding in the Working Area of West Woyla Health Centre, West Aceh District]. *Jurnal Pendidikan, Sains dan Humaniora,* 8(3), 356-363 (in Indonesian).

17. Sadli, M. (2019). Hubungan Sosial Budaya Dan Peran Petugas Kesehatan Dengan Perilaku Pemberian Mp-Asi Dini Pada Bayi Usia 0-6 Bulan [Socio-cultural relationships and the role of health workers in early breastfeeding behaviour among infants aged 0-6 months]. *Jurnal Kebidanan, 11*(1), 15. doi: 10.35872/jurkeb.v11i01.326 (in Indonesian).

18. Tausya, R. S., & Lubis, T. (2023). Performance Participation of Peucicap in West Aceh. *Tradition and Modernity of Humanity*, *3*(2), 11-19.

19. Sutrisno, I. H., Akob, B., Navia, Z. I., Nuraini, N., & Suwardi, A. B. (2020). Documentation of ritual plants used among the Aceh tribe in Peureulak, East Aceh District, Indonesia. *Biodiversitas Journal of Biological Diversity, 21*(11). doi: 10.13057/biodiv/d211102

20. Thalib, S. M. (2015). Tradisi Peucicap Ditinjau Menurut Hukum Islam [Peucicap Tradition Reviewed According to Islamic Law]. *Jurnal Tahqiqa, 9*(1), 72-88 (in Indonesian).

22. Zahra, F. (2023). *A Description of Peutron Aneuk Tradition in Acehnese Culture* (Doctoral dissertation); Universitas Sumatera Utara. Retrieved from https://repositori.usu.ac.id/handle/123456789/87047

22. Sahardin, I., & Yahaya, F. H. (2013). Feasting in society: A cace study in Aceh Besar district, Aceh province, Indonesia. *Proceedings of AICS-Social Sciences*, *1*, 139-144.

23. Hasan, A. B. P., & Suwarni, E. (2012). Policies and Practices for Promoting Multicultural Awareness of Indigenous Early Childhood Education in Indonesia. *International Journal of Child Care and Education Policy, 6*(1), 63–94. doi: 10.1007/2288-6729-6-1-63

Phraseological Units Expressing "Happiness" in the Phrase Semantic Field of "Human's Emotional State" (Based on the Materials of the Azerbaijan Language)

Ulkar Khalilli [1]

[1] *Azerbaijan National Academy of Science, Institute of Linguistics, named after Nasimi*
115 H. Cavid Avenu, Baku, Azerbaijan

Abstract. The article investigates the possibilities of expressing the emotional state of happiness in language using field theory and materials from the Azerbaijani language. Positive emotions such as happiness, joy, satisfaction, and admiration were considered within the phraseosemantic domain. The phrase semantic field includes phraseological units united by the same meaning. Studying fixed word combinations this way allows a more systematic and in-depth study.

At the same time, it is essential to study the universal emotional state, such as happiness, with the field method and to examine the possibilities of its expression in language. The importance of this issue becomes more apparent when we approach it from an anthropocentric perspective and take into account extralinguistic factors. The article studies the effect of the state of happiness on the human body and its activity, the forms of its occurrence and identification in phraseological units, and the physiological acts it causes.

The article distinguishes the subgroups "Joy," "Admiration," and "Satisfaction" within the phraseological field of "Happiness." It defines each subgroup's central and peripheral zones and clarifies the phraseological combinations included in its composition.

Variants are also considered one way of enriching the semantic field of the phrase, and various methods of creating variation are investigated. From this point of view, contamination component variability - replacement of components with each other or quantitative change (increase or decrease) - has been specially considered.

It should also be noted that although field theory is applied to various sections of the Azerbaijani language, its application in phraseology and investigating a person's emotional state from this aspect is novel.

Keywords: phraseosemantic field; phraseological unit; emotional state; happiness; core; periphery; variants.

INTRODUCTION

Emotions occupy an essential place in phraseology. The main reason is that a person's emotional state is an object of interest in linguistics and psychology. It is because these emotional states are reflected in different forms of occurrence in language. Emotions have an irreplaceable role as an expression of this vision. Thus, for this group of language units, Shur proposes the term functional field: "they do not have a common meaning but are characterized by a common meaning when used to define different occurrences" [7, p. 28].

To determine the structure of the micro field "Happiness" in the phrase semantic field of "Human emotional state", it is necessary to examine the characteristics of the phraseological units that make it up. Phraseological units widely used in the language can express a person's emotional state. "Phraseological unit " is a word combina-

tion that forms a semantically monolithic unit despite the structural combination of its constituent elements. The purpose of this combination is not to show the thing's characteristic or to draw attention to it, but to state its name as a whole" [1, p. 193]. Their indivisibility and ready presence in the language allow them to unite around an ordinary meaning, express a single meaning, and create any phraseosemantic field. Phraseologisms that make up the "emotional state of a person" are also characteristic. In general, semantic meaning is one of the main features of phraseological units. "In phraseological units, the plan of content and the plan of expression do not coincide, and at this time, semantic transformation happens. As a result of this transformation, a free phrase turns into a fixed one – a phraseological unit" [9, p. 63]. Thus, the semantic transformation covers the expression and causes it to emerge as an idiom. For example, in the phraseological combination of *çiçəyi çırtlamaq* (one's flower has crackled), which means to be happy, the content and expression plan did not match, resulting in a semantic transformation, leading to the creation of an idiom. So, the meaning expressed by the unit's components differs from that described by the unit. This process is closely observed in the formation of phraseological units of the Azerbaijani language. "Either all or some of the words that form stable word combinations move away from their lexical-semantic meaning, become metaphorical and lose their lexical-semantic meaning, becoming a lexical-semantic element of the combination" [5, p. 7].

Happiness is a complex phenomenon, and its positive characteristics distinguish it. "Psychologists emphasize the role of positive (active or sthenic) emotions in increasing the body's vital activity, increasing its strength and prompting it to action" [2, p. 161]. "If the object and events satisfy human needs, then positive, in other words, sthenic feelings emerge. On the contrary, if objects and events do not satisfy human needs, negative-asthenic feelings occur" [6, p. 341]. Thus, positive emotions occur primarily due to satisfying human needs and impacting human life and activity. Like other positive emotions, happiness is observed through physical acts. Thus, blood circulation improves, the blood supply to the brain accelerates, and a person's physical and mental activity increases. Laughter, a positive mood and a cheerful, optimistic state accompany happiness. "For example, during the feeling of joy, small blood vessels expand, and several organs, especially the brain, are better supplied with blood. A happy person does not feel tired, performs various actions, jumps up and down with joy, plays, laughs, etc. A good supply of blood to the brain increases its mental and physical work capacity" [2, p. 161-162]

The effect of emotions on the functioning of the body is undeniable. Positive emotions, such as joy, laughter, and cheerfulness, benefit a person and are reflected in a person's appearance: eyes shine, skin colour improves, and facial expressions become more pleasant and lively.

In a person, the same feeling, for example, joy, can show itself in different degrees and forms. Therefore, when defining the field, a number of physiological aspects of the phraseological units included in its composition should be considered. "The intensity, continuity, characteristic, the way of emergence and control of emotions are its most important features" [2, p. 157-160].

1) Intensity of emotions refers to the repetition frequency of the same situation.

2) Persistence of emotions: measured by the duration of the same state. Depending on the duration, emotions can be short-term or long-term.

3) The nature of emotions - their essence. It is determined by the object to which it is directed. At this time, a person can either rejoice and be happy for himself or share the happiness and joy of someone else. Even if they feel unhappy inside, another person's happiness can make them happy. It is possible to evaluate this state as the highest degree of happiness.

4) Occurrence of emotions. Happiness and joy can occur in different forms. Circumstances, personality, and temperament are among the factors that determine a person's form of occurrence. The following occurrences are more prominent and closely observed:

a) uncontrollability of the mind, which indicates a state of happiness: *ağlı başından çıxmaq* (lose one's mind), *ağlı getmək* (lose one's mind), *ağlını almaq* (take one's mind), *ağlını başından çıxarmaq* (take one's mind out of their head), *ağlını əlindən almaq* (take one's mind from their hand), *huşunu aparmaq* (take one's mind away), etc.

b) the state of the eyes and face indicating happiness: *gözləri parıldamaq* (one's eyes are shining), *aynası açılmaq* (one's face is getting clear),

qaşqabağı açılmaq (one's frown is disappearing), *qırışığı açılmaq* (one's wrinkle is disappearing), *üzünə gün doğmaq* (the sun is shining on one's face), *üzü açılmaq* (one's face is getting clear), etc.

c) changes in the activity of the heart related to happiness: *ürəyi açılmaq* (one's heart opens up), *ürəyinə (döşünə; canına) yatmaq* (lies on the heart (chest; soul), *könlü xoş olmaq* (one's heart is pleased), *gözü-könlü açılmaq* (one's eyes and heart are open), *ürəyi dağa dönmək* (one's heart turns into the mountain), *ürəyi böyümək* (one's heart grows), *ürəyi sinəsinə (köksünə) sığmamaq* (one's heart does not fit in the chest), *ürəyi tel-tel olmaq* (one's heart turns into a string) and so on.

d) the state of losing oneself, not being able to find a place for oneself, which refers to happiness: *uçmağa qanadı olmamaq* (not having wings to fly), *yerə-göyə sığmamaq* (not fitting in the earth and sky), *göyün yeddinci qatında olmaq* (being on the seventh layer of the sky), *dünyaya sığmamaq* (not fitting in the world), etc.

e) the change of mood in an ascending line due to happiness: *kefi açılmaq* (one's mood is high), *kef vermək* (giving a good mood), *kefi doxsan doqquz vurmaq* (one's mood is hitting ninety-nine), *kefi ala buluda qalxmaq* (one's mood climbing a cloud), *kefi durmaq (gəlmək)* (one's mood is up), *kefi kökəlmək* (one's mood is getting fat), *kefi fıştırıq çalmaq* (one's mood is whistling), *kefi kök* (one's mood is fat), *kefi saz* (one's mood is like a saz (a musical instrument)) etc.

f) the occurrence of happiness in the background of good fortune and luck: *taleyi üzünə gülmək* (one's fate smiles at their face), *bəxti gətirmək* (to bring luck), *bəxti ayaq üstdə olmaq* (one's luck is on its foot), *bəxt ulduzu parlamaq* (one's lucky star is shining), *bəxti açılmaq* (one's luck is open), *bəxti üzünə gülmək* (one's fate smiles at their face), etc.

g) the occurrence of the emotional state of happiness and joy with laughter: *bir deyib beş gülmək* (once said five times laughed), *qəhqəhə çəkmək* (to laugh out loud), *üzü gülmək* (one's face is smiling), *gözləri gülmək* (one's eyes are smiling), *dodağı qaçmaq* (one's lips are moving), etc. Phraseological combinations of this type express an emotional state and extralinguistic features accompany that emotional state. Because laughter is revealed by hand and expressive facial movements (gestures and facial expressions), it can occur both quietly and silently (*dodağı qaçmaq*) and loudly (*qəhqəhə çəkmək, şaqqanaq çəkmək*).

"Laughter also differs in character" [8, p. 97]. In most cases, a person reacts to joyful, pleasant or comical, funny events with laughter (*gözləri gülmək* (smiling eyes), *üzü gülmək* (smiling face), sometimes they can be happy and laugh at someone's misfortune and failure. It is also possible to react with laughter to situations that cause anger and mockery: *dişlərini ağartmaq* (to whiten one's teeth) - "to laugh, laugh for no reason and senselessly"; *dodaq altından gülmək* (to laugh under the lips) - "to mock, smile mockingly, sneer". So, the positive and negative factors that cause laughter determine its character.

5) Management of emotions, i.e. whether or not it is possible to keep them under control.

As can be seen, the various characteristics of emotions are also reflected in the phraseological units that express them.

RESULTS AND DISCUSSION

To determine the structure of the microfield of "Happiness," it is essential to analyze the phraseological units that make up the field. The interaction of those phraseological units and their relationship with each other leads to the emergence of a complex, structured field.

"Two groups of phraseological units occupy a special place in the structure of the phraseosemantic field of "Human emotional state": 1) units with syncretic semantics and 2) units expressing the highest degree of occurrence of various emotions" [3, p. 180]. Phraseological units in the microfield of "Happiness" are in the second group. Most of them reflect the highest degree of occurrence of the emotional state: *kefi ala buluda qalxmaq* (one's mood is climbing a cloud), *ürəyi dağa dönmək* (one's heart is turning into the mountain), *uçmağa qanadı olmamaq* (not having wings to fly), etc.

In general, "Positive emotional states" are distinguished by a differential schema, which defines the field's core and peripheral zones. "Experiencing a state of happiness," "causing happiness," and "bringing to a state of happiness" constitute the archisem of the field; this ordinary meaning unites the units that make up the field.

Considering the complex and multifaceted structure of the microfield "Happiness", we can distinguish subfields like "Joy", "Satisfaction" and "Admiration" within it. Each sub-area has its central and peripheral zones. "components included in

the nucleus act as leading components of the field" [10, p. 58]. So, these components can maximally express the invariant meaning of the field. The analysis of the subfield "Joy" shows that in the centre of the field, there are phraseological units connected with the theme "to be in a good mood", "to be joyful", "to be happy", "to be happy at heart", "to be delighted". From this point of view, we can refer to the nuclear field such phrases as *çırtıq çalıb oynamaq* (dancing by snapping fingers), *çiçəyi çırtlamaq* (one's flower has crackled), *nəşəsi durulmaq* (one's mood is getting cleaner), *kefi açılmaq* (one's mood is open), *könlü açılmaq* (one's heart is opening), *kefi kökəlmək* (one's mood is getting fat). The phraseological units that make up the core are direct carriers of the field and have the properties of staticity and invariance.

The near peripherical zone, which differs in its dynamics, comprises more polysemic phraseological units. In general, "freedom, emotional activation occurs more in the peripheral zone compared to the centre" [10, p. 63]. Phraseological units of this type can cover the peripheral zone of several areas. This partnership occurs both within the field and between different fields. For example, the expression *döşünə süd gəlmək* (one's breast is filled with milk), which is used colloquially, is defined in the Dictionary in two different meanings [4, p. 97]. This combination refers to the near peripheral zone of the area we are discussing by expressing "overjoyed". At the same time, it is placed on the periphery of the microfield of "Human Activity", with jokes about "men who are forced to look after small children at home". Another example is the unit *üzü açılmaq* (one's face is opened), which, besides expressing the meaning of "smiling, looking happy", is included in the microfield "Human character", which means "to know one's true face, to be revealed". Also, the phraseological combination of *yerə-göyə sığmamaq* (not fitting into the sky and the earth) is related to the near periphery zone of the field of "Happiness" by containing the meanings of "to be very happy, to be happy, to be extremely happy, to be truly happy", and also to "Human character" by expressing the meanings of "self-satisfied, arrogant" is included in the phrase semantic field.

The zone of the near periphery also consists of phraseologisms combined with the themes "to be very happy" and "to fly with joy". "In the composition of the units from this part, two differential schemes occur: "high emotionality in the expres-sion of a situation" and "the highest degree of its intensity" [9, p. 73]. Phraseologisms such as *dünyaya sığmamaq* (not fitting into the world), *çiçəyi çırtlamaq* (one's flower has crackled), *göyün yeddinci qatında olmaq* (being on the seventh layer of the sky), *uçmağa qanadı olmamaq* (not having wings to fly), *ürəyi dağa dönmək* (one's heart is turning into a mountain), *ürəyi böyümək* (one's heart is growing), *ürəyi köksünə sığmamaq* (not fitting one's heart in the chest), *ürəyi sinəsinə sığmamaq* (one's heart is not fitting in the chest), *ürəyi tel-tel olmaq* (one's heart is like a string) belong to the area of the near periphery as they indicate the high intensity of emotions. These units are also distinguished by a high degree of occurrence of the feeling of joy.

The far peripheral zone of the "Joy" subgroup is made up of stable word combinations combined with the meaning "to cause someone's joy" and "to cheer up, to make happy". In this respect, the combinations of *xətrini xoş eləmək* (making one pleased), *kef vermək* (giving pleasure), *kefini açmaq* (opening one's mood), and *ürəyini açmaq* (opening one's heart) can be considered to belong to the far periphery of the field. Also, expressions such as *gözləri parıldamaq* (shining eyes), *gözləri gülmək* (smiling eyes), and *üzü gülmək* (smiling face), distinguished by weak figurative shades, are located in the far periphery zone because they reflect the main features of the field relatively little.

In the core of the subgroup of "Admiration", "to be amazed" and "to be fascinated" are predicative units: *ağlı başından çıxmaq* (to lose one's mind), *ağlı getmək* (to lose one's mind), *əsiri olmaq* (to be captivated), etc. Phraseological units comprise the field's periphery with a differential meaning of "to amaze" and "to admire". Phraseologisms like *ağlını almaq* (to take one's mind), *ağlını başından çıxarmaq* (take one's mind out of their head), *ağlını əlindən almaq* (take one's mind from their hand), *can almaq* (take one's life), *göz qamaşdırmaq* (dazzle), *huşunu aparmaq* (take one's consciousness), *riqqətə gətirmək* (to bring to kindness) are typical in this respect and form the periphery zone being discussed.

The sub-group "Satisfaction" and the themes "being very satisfied" and "being satisfied" included in the micro-field "Happiness" allow for defining the core of the field. *Başına dövlət quşu qonmaq* (the state bird has perched on one's head), *bəxti gətirmək* (one's luck brings), *döşünə yatmaq* (sleeping on one's breast), *canına yatmaq* (sleep-

ing on one's soul), *əli bala batmaq* (one's hand has sunk into honey), *bəxt ulduzu parlamaq* (one's star of luck is shining), *taleyi üzünə gülmək* (one's fate is smiling at one's face), *üzünə gün doğmaq* (dawning on one's face), *ulduzu doğmaq* (one's star is dawning), *bağlı qapı üzünə açılmaq* (opening a closed door to one's face), *ağ günə çıxmaq* (reaching the white day), *üzünə qapılar açılmaq* (opening doors to one's face), *başına dövlət (şahlıq) quşu qonmaq* (to have the state (royal) bird perched on one's head), *işi düz gətirmək* (getting one's job right), *iynəsi tikiş tutmaq* (one's needle is able to sew), *naxışı gətirmək* (one's pattern gets lucky), *Allahı gətirmək* (one's God brings luck), *qurdu ulamaq* (one's wolf is howling), *ləzzət almaq* (to enjoy), *həzz almaq* (to enjoy), *zövq almaq,* (to enjoy) are in the core of the field. We can refer to the peripheral zone of the field, such as *gözlərini oxşamaq* (to caress one's eyes), *gözünə xoş gəlmək* (to please one's eyes). Units of this type are combined with the terms "to satisfy" and "to cause satisfaction".

It is known that variation is widespread in phraseology and acts as one way to enrich the language's phraseological system. "Phraseological variation is the fact that a fixed combination preserves the same meaning, even though its content changes lexically, lexically-grammatically and grammatically" [1, p. 193]. As a result of variation, the components of phraseological units lead to the creation of a new phraseological unit due to transformations. Different ways of making variants are observed in the Azerbaijani language. The most common one among them happens through the replacement of components. For example, the predicative units such as *ağ günə çıxmaq – ağ günə çatmaq* (to go out on a white day - to reach a white day), *naxışı gətirmək – naxışı tutmaq* (one's pattern gets lucky – one's pattern becomes lucky), *ağlını almaq – ağlını aparmaq* (to get one's mind – to take one's mind), *ağlı başından çıxmaq – ağlı başından getmək* (to lose one's mind - to go out of one's mind), *kefi durmaq – kefi gəlmək* (one's mood is up – one's mood has come) were created in this way. Although the verbs that are the components of the unit are subject to change, there are combinations in which the noun is also transformed: *başına dövlət quşu qonmaq – başına şahlıq quşu qonmaq* (to have a state bird on your head - to have a royal bird on your head), *ürəyinə yatmaq – döşünə yatmaq – canına yatmaq* (to sleep on one's heart - to rest on one's breast - to sleep on

one's soul), *ürəyi köksünə sığmamaq – ürəyi sinəsinə sığmamaq* (one's heart does not fit in their breast - one's heart does not fit in their chest), *ağlını aparmaq – huşunu aparmaq* (to take one's mind - to lose one's consciousness), *taleyi üzünə gülmək – bəxti üzünə gülmək* (one's fate laughs at their face – one's luck laughs at their face), *ləzzət almaq – həzz almaq – zövq almaq* (to enjoy), etc.

One of the attention-grabbing methods of creating variability is the quantitative change of the components that make up the unit, in other words, the quantitative increase or decrease. *Ağlı getmək – ağlı başından getmək* (to lose one's mind - take one's mind out of their head), *ağlını almaq – ağlını əlindən almaq* (to take one's mind - to take one's mind out of their hands), *könlü açılmaq – gözü-könlü açılmaq* (one's heart is open - one's eyes and heart are open), *ulduzu parlamaq – bəxt ulduzu parlamaq* (one's star is shining – one's lucky star is shining), etc. An increase or decrease in the number of constituents is observed in stable word combinations. The quantitative change of the unit's components does not affect the meaning it expresses.

Contamination is also one of the methods that enriches phraseology and creates variation. "Contamination is a new word or phrase obtained as a result of combining two words or phrases, crossing them" [1, p. 267]. In the phraseological field of "Happiness" variant creation is also observed with this method. It is how fixed word combinations such as *naxışı tutmaq + Allahı gətirmək = naxışı gətirmək* (one's pattern becomes lucky + one's God brings luck = one's pattern brings luck), *könlü xoş olmaq + ürəyi açılmaq = könlü açılmaq* (one's heart is pleased + one's soul is getting open = one's heart is getting open).

CONCLUSIONS

Research shows that positive emotions such as happiness and joy are essential in human life and stimulate activity. It encourages, motivates and connects a person to live. For this reason, phraseological units expressing happiness are numerous and have a wide range of expressive possibilities. These combinations, which have an area of intensive processing, reflect different occurrences of happiness through differential schemas. In addition to expressing the emotional state, it is accompanied by various extralinguistic means. The expressions included in the composi-

tion of the field create its centre or periphery zone, depending on the processing frequency and its meaning. If the central part comprises stable word combinations connected by an integral schema, the peripheral zone also includes units that differ in their differential characteristics. At the same time, the units included in the field of "Happiness" lead to the creation of different subgroups due to the differences in meaning. Phra-

seological units that express positive feelings such as admiration and satisfaction gain possibilities of expression within happiness. Other ways of creating variants also increase the possibilities of the occurrence of the phraseological field of "Happiness", expanding the scope of development and accelerating its intensity. Thus, it multiplies the ways of expression of the field and enriches the language even more.

REFERENCES

1. Adilov, M., Verdiyeva, Z., & Agayeva, F. (2020). *İzahlı dilçilik terminləri lüğəti* [Dictionary of linguistic terms]. Baku: Elm ve tehsil (in Azerbaijani).

2. Bayramov, A., & Alizade, A. (2006). *Psixologiya* [Psychology]. Baku: Chinar-Chap (in Azerbaijani).

3. Emirova, A.M. (2008). *Izbrannye nauchnye raboty* [Selected scientific papers]. Retrieved from https://www.emirova.com/Emirova_Izbrannye_Nauchnye_Raboty.pdf

4. Maharramli, Q., & İsmayılov, R. (2018). *Azərbaycan dilinin frazeologiya lüğəti* [Dictionary of phraseology of the Azerbaijani language]. Baku: Altun kitab (in Azerbaijani).

5. Rajabli, A. (2021). *Frazeologiya* [Phraseology]. Baku: Elm ve tehsil (in Azerbaijani).

6. Seyidov, S., & Hamzayev, M. (2007). *Psixologiya* [Psychology]. Baku: n. d. (in Azerbaijani).

7. Shur, G.S. (1974). *Teorii polya v linqvistike* [Field theory in linguistics]. Moscow: Nauka (in Russian).

8. Sinelnikova, I. (2012) *Frazeoloqicheskiye yedinisı mikropolya «Schastye» v sostave frazeosemanticheskovo polya «Emosionalnıye sostoyaniya cheloveka» (na materiale fransuzkovo yazıka)* [Phraseological units of the sub-field "Happiness" in the phraseo-semantic field "Human's emotional state (based on the materials of the French language)]. *Nauchnıye vedomosti Seriya gumanitarnıye nauki, 18*(137), 94–99 (in Russian).

9. Sinelnikova, I. (2013). *Emotivnıye frazeoloqizmı fransuzkovo yazıka v polevom aspekte* [Emotive phraseology of the French language from the aspect of field]. Belgorod: n. d. (in Russian).

10. Tahirov, İ. (2007). *Azərbaycan və ingilis dillərində zaman kateqoriyası* [Category of time in the Azarbaijani and English languages]. Baku: Nurlan (in Azerbaijani).

On the Role of Intonation in Defining the Boundary of Words in English and Azerbaijani Utterances

Alizade Jeyhun Kubra [1]

[1] *Azerbaijan University of Language*
134 Rashid Behbudov Street, Baku, Azerbaija

Abstract. The article deals with segmental and suprasegmental boundary tools. As is known, the boundary signals of meaningful units come at the beginning or end of the word. The place of stress in the compared languages differs from each other, and this distinction is manifested in boundary signals.

In the live speech, the time spent on the pronunciation of each syllable varies quite a bit, but the time interval spent on the pronunciation of a whole rhythmic group remains unchanged. Occurring, repeatedly stressed syllables in English at a specific time interval are considered a characteristic feature of the rhythm of this language. In other words, in the communication process, rhythmic division in this language is perceived based on temporal-dynamic contrasts between stressed and unstressed syllables. In the communication process, rhythmic division in this language is perceived based on temporal-dynamic contrasts between stressed and unstressed syllables.

Research shows that in the Azerbaijani language, there is one primary stress in the attributive word combinations, which falls on the first component of the word combinations. In this case, the stress in those combinations has a unifying character and forms a rhythmic group. Since English belongs to the group of analytic languages, words in this language undergo very little change within the text. Thus, intra-textual syntactic relations are realized in English, not using suffixes but prepositions.

Keywords: word stress; sentence stress; rhythmic group; proclitic rhythmic group; enclitic rhythmic group; proclitic-enclitic rhythmic group.

INTRODUCTION

The stress in English differs sharply from that in Azerbaijani regarding the place. This distinction also manifests itself in the form of boundary signals. Thus, even though the stress in English and Azerbaijani languages is dynamic, these languages belong to different types of rhythm. Therefore, the English language has stressed rhythms, and the Azerbaijani language has syllabic rhythm types. While the unit of rhythm in English is a rhythmic group, in Azerbaijani, it is a syllable. The reason for these differences is that the place of stress in English is free. At the same time, the Azerbaijani language is fixed-transient in its words, and the law of harmony of vowels mainly characterizes the latter.

It should be noted that the tone of connected speech varies depending on the rhythm of the language. A speaker who talks in a syllabic rhythm type spends equal time pronouncing each syllable, regardless of whether the syllables are mainly stressed or unstressed. This gives the listener a perception of an even rhythm rather than an impression of a broken rhythm. The syllabic rhythm type is typical for French, Spanish, and Azerbaijani languages.

In languages with the accented rhythm type (English, Russian, etc.), the rhythmic unit is based on a unit-rhythmic group more significant than a syllable. In English, a rhythmic group is formed by a single stressed syllable and a combination of unstressed syllables around it. The time spent pronouncing each syllable varies quite a bit in the live speech. Still, the time

interval spent on pronouncing a whole rhythmic group remains unchanged. Occurring, repeatedly stressed syllables in English at a specific time interval are considered a characteristic feature of the rhythm of this language. In other words, in the communication process, rhythmic division in this language is perceived based on temporal-dynamic contrasts between stressed and unstressed syllables. As a result of the increase of articulatory-acoustic energy on stressed syllables during speech flow, it forms "peaks of prominence" in those words, and the weakening of that energy in unstressed syllables forms "valleys of prominence". The schematic description of what is being said can be described in English sentences like this.

1. *The 'weather ˌin ˌEngland | can 'change 'very ˌquickly.*
2. *We 'sometimes ˌsay | that 'England is the 'only ˌcountry | where you can have 'four 'seasons in 'one ˌday.*

"Peaks" appearing in rhythmic groups in the given utterances mark independent lexical-semantic words, and "valleys" marks auxiliary words. Thus, the first sentence has five rhythmic groups, two syntagms (intonation group), and the second has nine rhythmic groups and three syntagms. By becoming together, rhythmic groups form a syntagm with a single meaning. Since lexical-semantic words (nouns, adjectives, numerals, some pronouns, main verbs, adverbs) in English are accented, they reflect peaks of rhythmic groups, and auxiliary words (personal and possessive pronouns, auxiliary verbs, etc.) are unstressed and reflect the valleys of rhythmic groups in the speech flow in physical form. In this regard, rhythmic groups in English mark the boundaries of phonetic words, not words expressed separately. The boundary process between rhythmic groups is mainly realized within the framework of three rhythmic groups: 1) proclitic rhythmic group, 2) enclitic rhythmic group, and 3) proclitic - enclitic rhythmic group.

A proclitic rhythmic group begins with an unstressed syllable and ends with a stressed word (syllable): *He lived ⫶in ˌRome | when he was ˌyoung.* This sentence has three proclitic rhythmic groups and two syntagms. The boundaries of the second and third rhythmic groups correspond to the boundaries of syntagms: this sentence ˌ*Tell him about it* consists of enclitic rhythmic groups. Here, the first word is stressed, and the following words are unstressed, pronounced together with the first stressed word; in this case,

a rhythmic group is identical to a syntagm. However, the boundary of a rhythmic group may or may not correspond to a syntagm.

Proclitic–enclitic rhythmic groups are formed and organized from unstressed syllables at the beginning and end of one stressed word. *You should know about it.*

English also has a rhythmic group consisting only of stressed, lexical-semantic words.

In this type of rhythmic group, all words consist of lexical-semantic units, and in all words, the stress occurs on the first syllable of the word, as in the case of fixed stress. The boundary (beginning) of such a rhythmic group of words is also signalled by stress. For example, the answer to this question: *What is that over there?* can be 'That's ⫶ 'Grany's ⫶ 'favourite ⫶ 'wooden ⫶ 'chair. There are five rhythmic groups in this answer, and the first syllable of each rhythmic group has a main stress conveyor.

It should be noted that the boundary of rhythmic groups in English is equivalent to syntagmatic division in content. So, sometimes, the division of the rhythmic group is approached formally; that is, they prefer to join to attach auxiliary words to the first word (i.e. enclitic rhythm) that can come between the first stressed word and the second stressed word [4, p. 74].

However, such a formal approach to rhythm has its drawbacks. Thus, taking all unstressed words as enclitics after the first stressed syllable sometimes leads to semantic distortion of the meaning. For example,
They were 'laughed at | 'nearly ˌeverywhere.
They were 'laughing at | 'nearly ˌeveryone.

In the given example, the formal rhythmic division in the second sentence (utterance) contradicts the meaning, while according to the meaning of the utterance, the rhythmic division should be as follows: *They were 'laughed | at 'nearly ˌeverywhere.*

Thus, in the first sentence (utterance), the preposition *"at"* is in an enclitic relationship with the verb *"laugh"*, and in the second sentence, it is in a proclitic relationship with the adverb *"nearly"*. From this point of view, the principle of a formal approach to rhythmic division in English utterances does not justify itself. We prefer to consider semantic and grammatical factors in rhythmic division in English utterances. In this regard, it

would be appropriate to consider other examples:

The ˈchild ⋮ was ˈread to ⋮ every ˌnight.
The child was ⋮ ˈreading ⋮ to his ˌaunt.
She ˈnever ⋮ reˈmembered ⋮ her ˈdoctor's ⋮ ˌinstructions.
She ˈnever ⋮ reˈmembered her ⋮ in those ˌdays.

As can be seen from the examples, grammatical semantic factors condition the proclitic and enclitic relation of morphemes *"to"* and *"her"* to stressed words.

RESULTS AND DISCUSSION

As mentioned, a fixed stress in the Azerbaijani language signals word boundaries. So, in this language, the stress on the last syllable of the word marks the boundary of a word or morpheme; on the other hand, it marks the unstressed beginning of the next word. In the Azerbaijani language, the end of an utterance is signalled by stress and pause. However, in the Azerbaijani language, there are cases where the stress does not fall on the last syllable, in which case the word boundary is signalled not by stress but by a pause. Cases in which the stress does not fall on the last syllable in the Azerbaijani language are manifested in homonymous suffixes. For example, *süzmə (noun), süzmə (imperative form of the verb), gəlmə (adjective), gəlmə (imperative form), atın yalı, atın silahları, vuruşdur (verb), vuruşdur (nominal predicate), yarışdır (nominal predicate), yarışdır (imperative form).* In homonymous suffixes, the place of stress is on different syllables.

According to A. Akhundov, all suffixes in the Azerbaijani language are stressed because suffixes come after the root, and the stress always falls on the last syllable. In the Azerbaijani language, it is incorrect that some suffixes do not receive stress. In the Azerbaijani language, only homonymous suffixes do not receive stress, which is a phonological rather than a phonetic phenomenon [2, p. 280].

Word stress can differentiate word form and meaning if the differentiated units are at the same level. As mentioned, some pairs of words (noun, adjective, verb) in English differ only in the place of stress. There are also certain parts of speech and lexical-semantic units in the Azerbaijani language, the form and meaning of which differ from each other depending on the place of stress: *balaca (adjective) – balaca (adverb), yalnız (adjective) – yalnız (particle), çaparaq (adjective)* – *çaparaq (participle), sabah (noun) – sabah (adverb), incəsənət – incəsənət, qara toyuq – qaratoyuq (name of the bird), uzun dərə – uzundərə, dimdik (noun) – dimdik (adverb), boş-qab – boşqab (noun)* etc.

Research shows that in the Azerbaijani language, there is one primary stress in the attributive word combinations, which falls on the first component of the word combinations. In this case, the stress in those combinations has a unifying character, and they form a rhythmic group [2, p. 286].

This shows that not all words have stress in connected speech in the Azerbaijani and English languages. In this language, the main parts of speech are mostly stressed, and the auxiliary parts of speech (postpositions, conjunctions and auxiliary verbs) are unstressed. Thus, unstressed words in the Azerbaijani language are pronounced together with the main parts of speech and form a rhythmic group:

Onun gözləri | ulduz tək | parladı. Səkinə Qaraşı bağrına basdı, körpəni | oxşar kimi | oxşadı (M.İbrahimov).
O, axşama-can ⋮ çalışdı | və səhərə-cən ⋮ yatmadı. Nazim | qapıdan | keçir-di. Nazim | topu qapıdan | keçirdi.

It should be noted that the rhythmic division of Azerbaijani sentences is fundamentally different from that of the English language. This is because the morphological structure of words in this language changes entirely depending on the context within the text. This type of change is because the Azerbaijani language belongs to the group of agglutinative languages and is a language with the law of harmony.

As in English, in cases where the division of rhythmic groups is broken in Azerbaijani, the meaning is confused. As instance, F. H. Zeynalov's research shows that *"Ayrılıqdan betər dünyada nə var", "Tarix proletarat verdi bizə", "Elə bildim doğru ay, sarı köynək", "Yığır qapılardan pay, sarı köynək"* in the reading of the verses of the poem, the word *"betər"* connects to the word dünya. The words *"ay"* and *"pay"* by the rhythmic pattern *"Anam sənə qurban, ay sarı köynək"* connect the combination *"sarı köynək"*, these also do not correctly reflect the content of the verses. In the verse *"Tarix proletar ad verdi bizə"* the word *"proletar"* is a homogenous member; that is, it expresses three rhythmic groups (Tarix proletar adı verdi bizə). This division also does not express the verse's period or content. Thus, the

content of this rhythmic division means that the poor were named by history on the one hand and the proletariat on the other [3, p. 84].

As mentioned, in the Azerbaijani language, there is only one primary stress in the simple attributive word combinations, and it also falls on the first component. In this case, the stress has a unifying function, and simple attributive word combinations are pronounced in one rhythmic group. For example, in the utterances *Bulaq başı toz olar. Gülün ömrü az olar*, the second and third attributive word combinations form one rhythmic group. The verb "olmaq" (to be) is also an auxiliary verb and does not receive stress. Therefore, two principal stresses in each of these utterances form two rhythmic groups in each utterance, respectively.

In addition to simple attributive word combinations, compound word combinations in the Azerbaijani language express double shades of meaning using stress. As mentioned earlier, these word combinations mainly consist of (adjective + noun + noun) combinations: *sarı saçlı qız, qara saçlı qız, geniş küçə səkisi, iri nar dənəsi, təmiz dəniz havası* etc., *sarı saçlı qız = sarıbəniz saçı uzun qız : sarı saçlı qız = saçı sarı qız.*

It should be noted that the double meaning is expressed by degrees of stress in the form of a word combination, and duality is also preserved in the form of utterance.

Qara'saçlı qızı> çağırın gəlsin = qara bəniz, saçı uzun qız

Qará saçlı qızı> çağırın gəlsin = qara saçı olan qız

In English, too, certain three-element word combinations express double shades of meaning with the place and degree of stress:

'light hou`se ˌkeepeer = (keeper of a lighthouse) - elektrik şəbəkəsinin gözətçisi

ˌlight 'house ke`epeer = (a housekeeper who is light) - yüngül çəkili ev gözətçisi

Since the place of stress in English is free, the end of the utterances is mainly signalled by a falling tone and a pause, and general interrogative sentences are signalled by a rising tone (interrogative intonation) and a pause:

His heart was thudding with excitement.

Can you tell me the way to the British Museum?

Since the stress in Azerbaijani is fixed-transient, the end of the utterances is signalled by stress and a pause. However, in this language, there are cases where the stress does not fall on the last syllable in the words that come at the end of the utterance, and in this case, the end of the utterance is signalled not by stress but by a pause. For example,

Bakıda gənc rəssamların sərgisi açıldı.
Təyyarənin uçmasına on beş dəqiqə qalır.

In Azerbaijani, on the one hand, the stress signals the boundary of words, and on the other hand, at the end of utterances, in English, the stress signals the peaks of rhythmic groups in utterances.

In Azerbaijani, the end of the sentence is not signalled with stress in the case that the end of the utterance ends with an auxiliary verb and the end of the verb ends with unstressed or homonymous suffix morphemes:

Hafiz də bu il oxumağa gələcək imiş. Nədənsə, kolxoz onu buraxmamışdı (A. Valiyev).

Studies show that the stress-rhythmic structure of compound verbs in the Azerbaijani language sounds harmoniously with simple word combinations. In compound verbs, as in attributive word combinations, the first component acts as the main stress conveyor. The second component is unstressed, as it consists of auxiliary verbs, and they are pronounced in one rhythmic group:

İçəri keç, Maya, anamla tanış ol (M. Ibrahimov).

Səni sevən çox bəlaya tuş olur

Əql gedir başdan, fəramuş olur (M. Vagif).

The rhythmic-intonation structure of addressed sentences (utterances) in English and Azerbaijani languages differs. Thus, addressed words used at the beginning of the sentence are stressed in both languages and form a separate rhythmic group (syntagm). However, addressed words in the middle and at the end of the sentence are unstressed in English and create an enclitic rhythmic group. In the Azerbaijani language, addressed words are stressed at the end and middle of the sentence and create a separate rhythmic group (syntagm). When addressed words are used with the words *"ey" and "ay"*, the word used as an addressed word is unstressed, and in this case, the word used as an addressed word is realized as an enclitic rhythmic group. For example,

Anam sənə qurban, ay sarı köynək (Ashig Alasgar).
Sənin tayların heç evlənməyib ay oğul! (S. Rahimov)
Dur qaçaq, oğlum, baş-ayaq qandı bu! (A. Sabir)

Unlike the English language, the stress tends to shift from the last syllable to the preceding sylla-

bles in the words used as addressed words in the Azerbaijani language. For example,
Vaqif, yenə sən yadıma düşdün,
Titrədi qəlbimin incə telləri (S. Vurghun).
Sirri ellərdən gizli saxlama,
Dilinə yalan söz gətirmə, oğlum (S. Rustam).

It should be noted that the length factor also plays a vital role as a signalling tool in distinguishing word forms at the perceptual level in speech activity. For example, the sentence *He climbed on to the top* can be understood in a dual meaning as an expression. It also depends on whether the morphemes *"on"* and *"to"* are more or less related to the verb. If the word *"on"* is realized with stress, it is closely connected with the word *"climbed"*, and in this case, the information given in the utterance is perceived as – *He continued climbing until he reached the top*. In this case, the word *"climbed"* is short, and the morpheme *"on"* is pronounced relatively long as it is stressed, separating it from the morpheme *"to"*. If the morpheme *"on"* is unstressed, it becomes a short pronunciation. In this case, the degree of connection between the morpheme *"to"* and the verb increases, and the information conveyed in the utterance is perceived as *He arrived at the top by climbing* [9, p. 258]. What has been said can be shown graphically as follows:
1. He climbed onto the top. = He continued climbing until he reached the top.
2. He climbed onto the top = He arrived on the top by climbing.

The double expression form of one utterance can be observed in these sentences: *"He looked after the children"*, *"People talked about it sadly"*, and *"She didn't die happily"*. Thus, in the first sentence, the pronunciation of the utterance in the form of a double expression depends on the realization of the pronunciation of the morpheme *"after"* in stressed and unstressed forms. If the morpheme *"after"* is realized with stress, it is pronounced long, which makes it close to the verb. In this way, its attachment to the word *"children"* weakens. At this phonetic point, the word *"after"* acts as an adverb, and since it is closely related to the verb, the utterance means that he takes care of the children. If the morpheme *"after"* is realized without stress, it is pronounced short, and the connection with the word *"children"* is strengthened. At this phonetic point, the morpheme *"after"* is a preposition and means *"He looked behind the children"*.

In the sentence *"People talked about it, sadly"*, the connection of the word *"sadly"* with the verb is signalled by composite tone (High Fall + Low Rise). In other words, if the sentence is realized with a high-falling tone, and the word *"sadly"* is realized with a low-rising tone, the information and attitude given in the speech is perceived as - *It was sad that people talked about it*. If the word *"sadly"* is realized together with the main sentence, then the transmitted information is perceived as *They talked about it and they did it sadly*, and it is signalled that the word *"sadly"* is closely related to the verb. What has been said can be expressed in graphic form as follows:
1. ˋPeople ˌtalked about it ˎsadly ||
2. 'People 'talked about it ˌsadly ||

Length is a primary factor in *"She didn't die happily"* expression in two-meaning form. For example,
1) She 'didn't 'die ˌhappily = O, xoşbəxt, məsud halda ölmədi.
2) She didn't ˌdie> ˌhappily = Xoşbəxtlikdən, o ölmədi, sağ qaldı.

In the Azerbaijani language, a length factor is essential in signalling the boundary of words, thereby expressing a double meaning in utterances. In this regard, it would be appropriate to give here some of the exciting examples given by A. Demirchizade about the length factor in the Azerbaijani language [9, p. 169].
O kitabı oxuyur / O, kitabı oxuyur.
Yaxşı kitab oxu / Yaxşı, kitab oxu.
Ana vətən çağırır məni / Ana, vətən çağırır məni.
Ana can, / niyə belə? / Ağlayırsan?
Ana can, / niyə belə ağlayırsan?
Ana, can! niyə belə ağlayırsan?

F. Y. Veysalli, F. A. Aslanov and F. H. Zeynalov also have opinions and exciting examples of expressions that express two meanings with the length factor in the Azerbaijani language.
O gözəl / müğənnidir / O, / gözəl müğənnidir.
Qoca / atlı çobana yaxınlaşdı / Qoca atlı / çobana yaxınlaşdı.
Qəhraman / sürücü qocaya yaxınlaşdı / Qəhrəman sürücü / qocaya yaxınlaşdı.
Azər / müəllim məni gördü / Azər müəllim məni gördü [7, p. 94].

In the Azerbaijani language, there are three-element compound word combinations in which the change of the stress forms an ambiguous meaning, and the length factor also acts as an essential tool in this phonetic situation. For example,

Geniş ótaq pəncərə͵si = pəncərənin geniş həcmli olması.
'Geniş otáq pəncərə͵si = otağın geniş həcmli olması.
Hün͵dür çińar budağ͵ı = budağın hündür olması.
Hündür çinar buda͵ğı = çinarın hündür olması [3, p. 68].

Studies show that the length factor manifests itself quantitatively in different degrees. Thus, distinguishing signs and varieties formed by syllable division in languages are considered a separate phonological unit which needs a particular name. American descriptivists proposed the name of the distinguishing variety (junctional phoneme-juncture) arising from syllable division [15, p. 43].

Thus, the length occurring at the junction of two morphemes or words is treated as an open juncture and is symbolized graphically by a positive [+] sign. For example, [ən + eım] – [ə + neım] *(an aim, a name).*

The length factor between rhythmic groups is indicated by dashed lines [ː] in the vertical form. *She visited> her first cousin> in London. - Ayrılıqdan betər ⋮ dünyada ⋮ nə var.*

The break between groups of meaning (syntagms) formed in terms of the syntactic-semantic and phonetic point of view is symbolized by one vertical line [/], and utterances (between sentences expressing relative completed statements) are symbolized by two vertical lines.

A single vertical line also symbolizes the length factor occurring between double-meaning utterances.
I fed her | dog biscuits.
I fed | her dog biscuits.
The farmer was bricking up | the chimney - (Kəndli bacanın ağzını kərpiclə hörürdü).
The farmer was bricking | up the chimney - (Kəndli bacanın yuxarısında kərpiclə iş görürdü).

Note that two more signs symbolize the length factor. One of them is a vertical wavy line [/], and the other is a three-unit line [///]. The first indicates a short pause within the utterance, and the second suggests a longer pause at the end of units that is more significant than the sentence. For example,

The trouble with college is that you are expected to know such a lot of things you have never learned // It is very embarrassing at times///

CONCLUSIONS

As a result of research, it is known that the phonetic phenomena manifested in utterances in the communication process, as a result, acquire phonological content. In homonymous suffixes, stress placement on different syllables also has a phonological content. The difference in form and meaning of words according to the place of stress in the Azerbaijani language occurs not at the morphological level but at the morphological-syntactic level, one of which is realized by word stress and the other by intonation. Therefore, differentiating morphologically homonymous words using stress does not justify itself.

Since English belongs to the group of analytic languages, words in this language undergo very little change within the text. Thus, in English, intra-textual syntactic relations are realized not by means of suffixes, but by means of prepositions. Another aspect is that while in English each word has a fixed stress on a certain syllable, in Azerbaijani language suffixes influence the change of the place of the stress in the word, and thus the fixed stress tends to be transitory character.

In English and Azerbaijani, words appearing in the middle of a sentence (utterance) are included in the preceding or following rhythmic group, regulated by lexical-grammatical factors.

REFERENCES

1. Akhundov, A. (1973). *The phoneme system of the Azerbaijani language.* Baku: Maarif (in Azerbaijani).

2. Akhundov, A. (1988). *Phonetics of the Azerbaijani language.* Baku: Maarif (in Azerbaijani).

3. Akhundov, A., Babayev, S., & Zeynalov, F. (1996). *Rhythmic-melodic characteristics of stress in English and Azerbaijani languages.* Baku: BSU (in Azerbaijani).

4. Antipova, A. (1979). *English speech system.* Moscow: Higher School (in Russian).

5. Ashby, P. (2011). *Understanding Phonetics.* London: Hodder Education (in English).

6. Aslanov, F. (2007). *Principles of syntagmatic division of sentences in modern German and Azerbaijani languages*. Baku: Mutarjim (in Azerbaijani).

7. Crystal, D. (2008). *Dictionary of and Phonology*. New York: Blackwell Publishing.

8. Demirchizade, A. (2007). *Modern Azerbaijan language* (Vol. 1). Baku: East & West (in Azerbaijani).

9. Kingdon, R. (1958). *The groundwork of English Stress*. London: Longmans, Green and Co.

10. Laver, J., Aronoff, M., & Miller, J. (2013). *Linguistic Phonetics. The Handbook of Linguistics*. Oxford: Blackwell publishing.

11. Roach, P. (2000). *English Phonetics and Phonology*. Cambridge: Cambridge University Press.

12. Veno, V., & Reiss, C. (2020). *Formal Generative Pholonology*. Retrieved from https://radical.cnrs.fr/wp-content/uploads/2020/01/VolonecReiss2020.pdf

13. Veysalli, F. (2016). *Phonetics and phonology problems*. Cambridge: Hertfordshire Press (in Azerbaijani).

14. Zeynalov, F. (2001). *On the phonetic means that signal the sound of words and combinations in the speech process*. Baku: Mutercim (in Azerbaijani).

15. Zeynalov, F. (2020). *Practical English Phonetics*. Baku: Mutarjim (in Azerbaijani).

16. Zinder, L. (1979). *General phonetics, second edition*. Moscow: Higher School (in Russian).

Предпосылки развития психолингвистики в Европе (анализ работ немецких ученых Антона Марти и Карла Бюлера)
Prerequisites for the Development of Psycholinguistics in Europe (Analysis of the Works of German Scientists Anton Marty and Karl Buhler)

Зульфия Габил Мусави [1]
Zulfiyya Gabil Musavi

[1] *Azerbaijan National Academy of Science*
115 H. Cavid Avenu, Baku, Azerbaijan

Аннотация. Психолингвистика появилась на стыке двух «старейших» наук − психологии и лингвистики, она стала одной из основных лингвистических наук за относительно короткий период своего существования. Появление этой новой науки было обусловлено потребностью в научном познании природы психической интеллектуальной деятельности человека. В рамках синхронного изучения языка в XX веке было выдвинуто много оригинальных концепций, основанных на психологическом понимании природы объекта лингвистики.

Теоретическая значимость работы заключается в том, что в ней впервые подробно описываются концепции А. Марти и К. Бюлера с точки зрения влияния на формирование современной психолингвистики. Рассматриваются работы немецкого лингвиста Антона Марти, которые посвящены проблеме возникновения языка. Антон Марти в своих научных трудах называет язык «любым признаком психических процессов». Таким образом, проводится анализ развития психолингвистической мысли, а также предлагается видение основных проблем современной психолингвистики, связанных с использованием языка в процессах речевого общения и индивидуальной речемыслительной деятельности.

В статье раскрываются научные предпосылки и основные тенденции развития современной психолингвистики, ее методы, актуальные проблемы и достижения − описание механизмов речи, языковой личности и т.д., показаны методологические основы и историческая преемственность учений лингвистов, работ А. Марти, К. Бюлера, и т.д. освящены с точки зрения значимости их взглядов для сегодняшнего понимания тех же научных проблем.

Ключевые слова: психолингвистика; истоки немецкой психолингвистики; актуальные проблемы психолингвистики; А. Марти; К. Бюлер.

Abstract. Psycholinguistics appeared at the interface of two «oldest» sciences−psychology and linguistics − and became one of the main linguistic sciences in a relatively short period. The need for scientific knowledge of the nature of human mental intellectual activity determined the emergence of this new science. As part of the synchronous study of language in the twentieth century, many original concepts were put forward based on a psychological understanding of the nature of the object of linguistics.

The theoretical significance of the work is that, for the first time, it describes in detail the concepts of A. Marty and K. Buehler in terms of influence on the formation of modern psycholinguistics. The works of the German linguist Anton Marti, who is devoted to the problem of the emergence of language, are considered. In his scientific works, Anton Marti calls language «any sign of mental processes». Thus, an analysis of the development of psycholinguistic thought is made. Also, a vision of the main problems of modern psycholinguistics associated with language use in speech communication and individual speech-thinking activity is proposed.

The article reveals the scientific prerequisites and the main trends in the development of modern psycholinguistics, its methods, current problems, and achievements – a description of the mechanisms of speech, linguistic personality, etc. and shows the methodological foundations and historical continuity of the teachings of linguists. The works of A. Marti, K. Buhler, etc., are consecrated in terms of the significance of their views for today's understanding of the same scientific problems.

Keywords: psycholinguistics; origins of German psycholinguistics; actual problems of psycholinguistics; A. Marty; K. Buehler.

ВВЕДЕНИЕ

Истории развития психолингвистики посвящены работы В. Белянина [2], Г. Гийома [7], В. Ковшикова и В. Глухова [12], И. Горелова и К. Седова [6], Г. Миллера [17] и других. Проблема изучения механизмов внутренней речи была исследована Н. Жинкиным [9], описание языковой способности (способности создавать языки) содержится в работах Е. Арсентьевой и Ю. Арсентьевой [2], С. Цынка [27, 28, 29] и других.

Одна из центральных проблем психолингвистики (проблема построения грамматической структуры предложения при восприятии речи) рассмотрена в статье Д. Черновой, Н. Слюссар, В. Прокопеня, Т. Петровой, Т. Черниговской [30]. Экспериментальные психолингвистические методы используются авторами Н. Лебедевой [14], З. Резановой и Е. Ершовой [21]. Авторы З. Резанова и А. Миклашевский [22] пишут о возможностях исследований, основанных на психолингвистических базах данных. Работы О. Федоровой [25], М. Щербакова [31] и других посвящены проблемам изучения механизмов продуцирования, понимания и восприятия речи. А. Яковлев [32] в своей статье поднимает актуальную проблему интерпретации языкового сознания как психолингвистического понятия.

МЕТОДЫ ИССЛЕДОВАНИЯ

В статье был использован ряд общих логических методов и техник исследования. Это анализ, синтез (выявление общих черт психолингвистического исследования), абстрагирование (выяснение того, какие из рассматриваемых свойств являются существенными, а какие второстепенными) и обобщение (установление общих свойств и особенностей различных психолингвистических понятий). Мы также использовали такие специфические приемы, как понимание (постижение смысла психолингвистического направления, его места в науке, его функций) и объяснение (выявление сути изучаемого предмета, условий, источников его развития).

Психолингвистика – это отрасль науки, которая предполагает комплексное изучение речевого поведения психологами и лингвистами. По сравнению с лингвистикой и психологией речи психолингвистика имеет свой самостоятельный предмет исследования. Психолингвистику больше психология считает «своей». Правда, в психологии есть уже давно существующая область – психология речи. Предмет психологии речи совпадает с объектом и предметом психолингвистики. Вот почему эти две дисциплины часто путают друг с другом. Их различие, главным образом, проявляется в аспектах изучения. В то время как психология в процессе возникновения,

понимания и формирования речи больше сосредотачивает свое внимание на особенностях психических функций сознания, психолингвистика стремится учитывать средства выражения этих функций (вербальные и невербальные) в речевой деятельности и речевом поведении людей.

Психолингвистика – довольно молодая наука. Она сформировалась примерно в конце 50-х – начале 60-х годов XX века в США. Благодаря расширению области науки возникли различные отрасли психолингвистики. Из них можно выделить общую психолингвистику, частную психолингвистику, социальную психолингвистику, возрастную психолингвистику (онтолингвистику).

Возникновению собственно синхронного психологического направления предшествовало появление двух интересных концепций, созданных в начале XX века в Австрии немецкими лингвистами Антоном Марти (1847-1914) и Карлом Бюлером (1879-1963).

А. Марти [16, 36] считал, что лингвистика должна быть насквозь психологической, даже когда речь идет об изложении отдельных фактов, и он был убежден, что на психологической основе можно создать не только описательную (неисторическую) грамматику конкретного языка, но и универсальную. Исследователь видел возможность построения универсальной грамматики в том факте, что 1) все языки выражают одно и то же содержание; 2) все они построены на одних и тех же принципах, поскольку все люди, независимо от того, на каком языке они говорят, имеют общую психофизическую организацию. Следовательно, задача лингвистики состоит в том, чтобы обнаружить и описать эти общие принципы организации языка. Таким образом, А. Марти возродил идеи универсальной грамматики Пор-Рояль XVII века. Однако, в отличие от своих предшественников, он ограничивался чисто описательными целями. Лингвист, по его мнению, должен излагать общие языковые средства выражения психологии, а принципы их использования не входят в компетенцию лингвистики как науки. Важно только классифицировать эти средства. А. Марти исследует язык в синхронном аспекте (известно, что психолингвистика отличается от других областей лингвистики именно синхронным исследованием речи).

А. Марти называет языком "любой знак психических процессов, даже если их выражение осуществляется непреднамеренно (например, как непроизвольные смех и плач, крик ужаса, бледность и покраснение, учащение дыхания во время гнева и так далее) или же намеренно, но с иной целью, нежели оповещение о внутренней жизни – как наши действия, направленные на различные цели (например, еда, питье, прогулки)" [36, с. 3]. Он исследовал язык как нечто, возникающее в сознании отдельных людей и намеренно направленное на объекты. Интенциональность не только в обычном понимании сознания; его также интересует в первую очередь язык «в смысле целенаправленного проявления внутренней жизни посредством определенных знаков, особенно посредством звуков и, в частности, тех, которые – подобно большинству слов наших разговорных языков – не являются по своей сути понятными, но обязаны своей значительной властью над обычаями и традициями» [36, с. 3]. Его акцент на целенаправленном проявлении (absichtliche Kundgabe) не только предполагает намерение в смысле коммуникативной цели говорящего вызвать у слушающего психические явления, сходные с теми, которые выражаются языковыми знаками, но также является намерением в узком смысле направленности на интенциональное содержание выраженных психических явлений. Марти указывает, что его применение психологии в философии языка никоим образом не связано с релятивизмом, как у Гуссерля [36, с. 6-18]. Марти при истолковании проблемы происхождения языка использует ассоциативные механизмы для объяснения происхождения синтаксических форм языка и для описания того, как новые синтаксические формы и словарный запас были предложены и созданы с использованием уже установленных значений выражений в новых контекстах. Эти взгляды были в значительной степени развиты из психологических теорий Гербарта, а также вписаны в общую программу «психологии народов» (Фёлькерпсихология).

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ

А. Марти разделил все языковые средства по своей семантике на автосемантические (независимые) и синсемантические (зависимые). Автосемантические средства выражают неязыковое содержание, психические функции

человека сами по себе, то есть независимо от других. Эти средства используются независимо друг от друга. Они не нуждаются в поддержке других, чтобы раскрывать свой контент. Это, например, в основном, существительные и предложения различного рода. Напротив, синсемантические средства не используются самостоятельно, их целью является дополнение и уточнение содержания других средств – автосемантических. Это, например, прилагательные, которые не употребляются без существительных. Так называемые «вспомогательные части речи» являются типичными синсемантическими средствами, поскольку они не имеют собственного содержания и лишь связывают другие средства выражения. Разница между автосемантическими и синсемантическими средствами языков относительна, поскольку она не формальная, а семантическая. Таким образом, существительные в целом, как класс, относятся к автосемантическим средствам, но они также могут выполнять роль синсемантических средств, например, существительное в предложении является не только субъектно – независимым средством, но и зависимым от дополнения (объекта), синсемантическим средством. Существительные «брат», «отец», «тесть» и другие термины родства сами по себе должны быть признаны синсемантическими средствами, поскольку они выражают связь между объектами. Так что идея Марти имеет очень широкий и глубокий смысл.

Марти пытался доказать что существует различие между лингвистическим выражением и его значением.

Смысл высказывания, скорее, можно сформулировать, только сказав, что собеседник намеревается вызвать аналогичное суждение у слушающего – то, что, по его мнению, должно быть принято. Это так называемое первичное коммуникативное намерение говорящего. Более того, произнося утверждение, говорящий вторично демонстрирует, что он или она судит о том-то. Таким проявлением акта суждения является так называемая вторичная коммуникативная интенция говорящего, служащая средством достижения первичной цели [36, с. 284]. Основная коммуникативная функция выражения (то есть значение) будет варьироваться в зависимости от типа рассматриваемого выражения. Таким образом, необходимо более подробно рассмотреть значение как коммуникативную функцию, исследуя его

разнообразие. Это было сделано им в отношении автосемантики.

Марти говорит, что автосемантика распадается на три класса, а именно: имена (Vorstellungssuggestive), высказывания (Aussagen) и выражение интереса (эмоциональный), каждый из которых соответствует классу психических явлений.

Поскольку Марти рассматривает высказывания как автосемантические, (которые выражают суждения и сообщают собеседнику, что он или она должны судить таким же образом), он характеризует эмоции или выражения, требующие интереса (interesseheischende Ausdrücke – выражения, представляющие интерес), как автосемантические высказывания, которые проявляют не только эмоции, но и волевые действия (которые для него принадлежат к одному и тому же классу) и сообщают собеседнику, что он или она должны чувствовать или хотеть одинаково. Марти очень подробно поддерживает аналогию между утверждениями и суждениями [36, с. 370].

Определенное влияние на перевод внимания ученых с проблемы языка на речь оказала работа Карла Бюлера "Теория языка" (1934; издание на русском языке: 1993) [4]. Карл Бюлер был представителем немецкой школы «Психологии мышления». В своей работе «Теория языка» он обобщил свои идеи и взгляды других немецких ученых – А. Марти, Э. Гуссерль, Э. Косериу – на логику и психологию.

К. Бюлер [33] в 30-х годах XX века создал теорию, которая частично развила идеи Марти. Ученый связал лингвистику с возникшей в то время так называемой «ситуационной психологией», которая исследовала зависимость психики человека, его психологического поведения от конкретной ситуации, в которую поставлен человек. Среди множества возможных ситуаций К. Бюлер выделил коммуникативную ситуацию, то есть ситуацию общения: говорящий – слушающий.

К. Бюлер построил своеобразную модель общения. Например, он называет информацию описанием и доказал, что описание состоит из 2 частей (отправителя и получателя). Он назвал отправителя выражением, а получателя – обращением. Однако суть общения здесь показана не в полной мере. Поэтому языковеды из Азербайджана Ф. Вейсалли, Э. Абдулрагимов и другие в 90-е годы XX века

разработали новую и точную модель общения. В основе созданной ими модели лежит информация, и они делят информацию на 4 части. К ним относятся канал, языковая система, говорящий и слушающий [1, с. 33].

К. Бюлер предложил изучать язык с точки зрения того, как эта ситуация отражается в языковой системе. Например, он исследовал индексное «поле» этой ситуации, то есть систему местоименных слов. Эта система полностью определяется языковой ситуацией. Это очевидно, когда мы обращаемся к личным местоимениям: ich – говорящий, du – слушающий, er – посторонний для говорящего и слушателя: ich – du – er. Но оказывается, что другие местоименные слова отражают ту же ситуацию. Например, местоименные наречия аналогично связаны между собой: hier (здесь) – da (здесь) – dort (там). А поскольку местоименные слова заменяют эквивалентные им слова, их система отражает систему языка в целом и, следовательно, можно построить ситуативную грамматику языка. Более того, поскольку языковая ситуация универсальна, то и эта грамматика также будет универсальной по своей сути (в этом совпадение взглядов с А. Марти).

К. Бюлер, таким образом, акцентирует внимание на роли человека, особенностях его деятельности и ситуациях активности в понимании феномена «язык». По мнению ученого, «каждое выражение может быть истолковано как человеческий поступок/действие, поскольку каждое конкретное высказывание связано с другими сознательными действиями этого человека» [4, с. 53]. В отличие от В. фон Гумбольдта и Ф. де Соссюра, К. Бюлер выделяет не два, а четыре компонента («феномена») речевого процесса, а именно: 1) речевое действие; 2) языковое поведение; 3) речевой акт; 4) языковая структура.

Что касается речевых действий, он пишет, что существуют ситуации, в которых речь используется для решения актуальной на данный момент жизненно важной задачи, поэтому выполняются речевые действия. В речевой деятельности всегда возникает ее результат, и языковая работа, как правило, не зависит от жизненной позиции индивида и опыта автора. Речевой акт определяется К. Бюлер как «субъективное осмысление». Язык, по мнению исследователя, обладает способностью приспосабливаться к неисчерпаемому

богатству фактов, которые подлежат языковой формулировке в каждом конкретном случае. Это то, что обеспечивает определенную степень «свободы осмысления». Языковая структура (языковое образование) является «межсубъективной». К. Бюлер объясняет эту позицию так: «Глагол, артикль и винительный падеж относятся к языковым образованиям точно так же, как «прямоугольный треугольник» относится к «образованиям» элементарной геометрии» [4, с. 61]. В соответствии с этим ученый выделяет три функции языка: репрезентативную, экспрессивную и апеллятивную. Когда языковой знак соотносится с объектами, он действует как символ. Следовательно, берется репрезентативная функция языка. Поскольку знак зависит от говорящего, он является симптомом. Отсюда и берется его выразительная функция. Обращаясь к слушателю, знак становится сигналом. Следовательно, язык выполняет апеллятивную функцию.

Речевая ситуация, по словам К. Бюлер, формируется говорящим, слушателем и объектами речи. Он подчеркивает, что при создании речевой ситуации не только отправитель, но и получатель имеют свои собственные позиции. Они обращаются к языку соглашений, которые регулируются межличностным общением. «Поле действия» обязательно включает в себя два синхронных аспекта: внутреннюю и внешнюю ситуации. Все это в определенной степени определяет характер действий субъектов речевого общения, дает возможность установить, что имеет в виду говорящий.

На наш взгляд, концепции А. Марти и К. Бюлера очень ценны для развития современной психолингвистики. Оригинальным вкладом А. Марти можно признать интенциональную концепцию языка как намеренного (absichtlich) социального действия; проект общей семантики, ориентированный на коммуникативную теорию значения; телелогическую и функциональную модель описания языка. Его концепция языка как средства социальной коммуникации легла в основу инструменталистской модели языка («Organon Modell der Sprache») Карла Бюлера. Карл Бюлер одним из первых предложил теорию речевого акта, отличающуюся от соссюровской речевой деятельности; ввел понятие коннотации, одним из первых начал исследование дейктических единиц языка.

Представители классической психолингвистики Дж. Осгуд [25], Дж. Миллер [24], Дж. Кэрролл [5], Н. Хомский [9], И. Зимняя [36], Р. Фрумкина [11], А. Супрун [33] и другие также исходят из определения языка как деятельности, данное Вильгельмом фон Гумбольдтом [12]. Поэтому в центре их внимания находится говорящий. Для них предметом исследования является не грамматическая и лексическая система употребления языка, не продукт, абстрактный результат деятельности общества, а речевая деятельность носителей языка. Но психолингвисты не растворяют язык в речевой деятельности каждого говорящего. Они считают, что язык является глубоко социальным феноменом, даже когда он выражает себя в индивидуальном речевом акте, что особенно подчеркивают психолингвисты (А. Леонтьев [21], Л. Сахарный [31] и другие).

Психолингвистике интересны не только определенные языковые формы, но и механизмы использования этих форм носителями языка, ментальный механизм их восприятия и осознания слушателями. Это означает, что исследователи не могут ограничиваться описанием наблюдаемых готовых текстов, фиксацией текстовых единиц и их обобщением. Важно воссоздать процесс формирования текстов и языковых единиц. Это подразумевает обращение к описанию не только внешней, но и внутренней речи говорящих. По мнению психолингвистов, например, Н. Жинкина [13], современная психология предоставляет необходимые средства для проникновения во внутренний механизм языка.

Такой способ исследования позволяет дифференцировать сам язык. Поскольку носители родного языка неодинаково усваивают готовые языковые формы и по-разному используют известные правила, психолингвисты приходят к выводу, что глобальное понятие языка должно быть строго дифференцировано. Язык говорящего не идентичен языку слушающего, поскольку в первом случае произносится речь, а во втором случае она распознается. Механизм создания речи и механизм распознавания – это разные понятия. Следовательно, необходимо создать две грамматики: одну для говорящих и одну для слушателей. Понятие «язык» должно быть дифференцировано во многих других отношениях: язык детей – это не то же самое, что язык взрослых; язык книг и науки – это не то же самое, что язык непринужденной беседы.

Заслуга психолингвистов перед лингвистикой заключается в том, что они разработали объективный метод изучения «говорящего человека» – психолингвистический эксперимент, позволяющий делать обоснованные выводы не только об этом индивиде, но и о широком круге носителей родного языка. Особенности применения экспериментальных методов психолингвистического анализа описаны, например, в статьях А. Голуба, М. Иванова [18], Е. Кабановской [14], С. Попова [28].

Выдающимся достижением психолингвистов является то, что им удалось создать надежную экспериментальную базу посредством использования соответствующих работ неограмматиков: Г. Остгофа, К. Бругмана [26], Г. Пауля [27] и др. Если до психолингвистов экспериментально изучалась только фонетика (звуки могут быть записаны с помощью устройств), то психолингвисты экспериментально изучают семантику языка. Суть их экспериментов заключается в том, что они обращаются к определенной массе носителей родного языка, чтобы выяснить оценку определенных языковых явлений каждым носителем языка. Полученные результаты обрабатываются математически (статистически) и служат объективным материалом для лингвистических обобщений.

В последние годы, как отмечают С. Цынк, М. Кузьмина, «интерес к личностному аспекту изучения языка значительно возрос» [8, с. 7], [16, с. 54]. Взаимосвязь «личность – язык и речь» также активно изучается в современной психолингвистике. Изучаются языковые способности индивида, например, способность создавать язык, которая ярко проявляется у многих поэтов и писателей (например, [7, 8]).

ВЫВОДЫ

Концепции А. Марти и К. Бюлера способствовали появлению психолингвистических исследований. Для них характерно представление о речи как о психическом процессе; на них основана современная психолингвистика. Основными положениями современной психолингвистики являются следующие:

1. Язык – это не абстрактная система, а деятельность носителей языка, которая в корне социальна и психологична.

2. Язык изучается с точки зрения условий языкового общения.

3. Принципиально различаются два процесса: говорение и слушание (код говорящего и код слушающего).

4. Язык выражает себя в двух формах: внешней и внутренней речи. Следовательно, возникает интерес к механизмам формирования и функционирования языковых единиц.

5. Психолингвистика – это наука, которая является экспериментальной с точки зрения методологии исследования.

6. В последние годы психолингвистика активно рассматривает актуальную проблему – изучение взаимосвязи «личность – язык и речь».

Мы выявили научные предпосылки и основные тенденции развития современной психолингвистики, ее методы, актуальные проблемы и достижения – описание механизмов речи, языковой личности и т.д., показали методологические основы и историческую преемственность учений лингвистов, осветили работы А. Марти, К. Бюлера и др. с точки зрения значимости их взглядов для сегодняшнего понимания тех же научных проблем.

Психолингвистика – это междисциплинарная область науки о закономерностях формирования в онтогенезе и формируемых процессах речевой деятельности в системе различных видов человеческой деятельности. Психолингвистика изучает следующие аспекты речи: ее процессы, мотивы речи, ее субъект и адресат, речевое намерение, внутренние процессы речи, кодовые переходы, распознавание речи слушателем. В ней исследуется развитие речевых способностей человека на протяжении всей жизни, овладение неродными языками, влияние речи. Современная немецкая психолингвистика во многом базируется на положениях, которые были выдвинуты в 30-е годы ХХ века А. Марти и К. Бюлером.

СПИСОК ИСПОЛЬЗОВАННЫХ ИСТОЧНИКОВ / REFERENCES

1. Arsentyeva, E., & Arsentyeva, Y. (2017). Rasshirennaja metafora kak odin iz tipov okkazional'nogo ispol'zovanija frazeologizmov-jevfemizmov: jeksperimental'noe issledovanie (Extended metaphor as one of the types of occasional use of phraseological units-euphemisms). Vestnik tomskogo gosudarstvennogo universiteta, 50, 5–16 (in Russian).

2. Beljanin, V. (2003). *Psiholingvistika* [Psycholinguistics]. Moscow: Flinta (in Russian).

3. Bühler, K. (1934). *Sprachtheorie: Die Darstellungsfunktion der Sprache*. Jena: Gustav Fischer (in German).

4. Buhler, K. (1993). *The Theory of the Language*. N. d.

5. Carroll, J. (1953). *The Study of Language*. Cambridge: Harvard University Press.

6. Chernova, D., Sljusar', N., Prokopenja, V., Petrova, T., & Chernigovskaja, T. (2016). Jeksperimental'nye issledovanija grammatiki: sintaksicheskij analiz neodnoznachnyh predlozhenij [Experimental studies of grammar: syntactic analysis of ambiguous sentences]. *Voprosy jazykoznanija, 6*, 36–50. (in Russian).

7. Cynk, S. (2013). Leksicheskie okkazionalizmy (imena sushhestvitel'nye) v proizvedenii A. I. Solzhenicyna "Dvesti let vmeste". *Vestnik Moskovskogo gosudarstvennogo oblastnogo universiteta. Serija "Russkaja filologija", 1*, 5–10 (in Russian).

8. Chynk S. V. (2015). O nekotoryh leksicheskih okkazionalizmah istoricheskogo ocherka A. I. Solzhenicyna «Dvesti let vmeste» [On Some Lexical Occasionalisms of A.I. Solzhenitsyn's Historical Essay "Two hundred years together"]. *Vestnik Moskovskogo gosudarstvennogo oblastnogo universiteta. Serija "Russkaja filologija", 2,* 35–39 (in Russian).

9. Chomsky, N. (1965). *Aspects of the Theory of Syntax* (50th ed.). N. d.: The MIT Press.

10. Fedorova, O. (2020). Russian psycholinguistics: Yesterday, today, tomorrow (subjective notes on the study of mechanisms of language production and comprehension). *Voprosy Jazykoznanija, 6*, 105. doi: 10.31857/0373-658x.2020.6.105-129

11. Frumkina, R. (2001). *Psiholingvistika* [Psycholinguistics]. Moscow: Akademija (in Russian).

12. Humboldt, V. (1984). *Izbrannye trudy po jazykoznaniju* [Selected works of general linguistics]. Moscow: Progress (in Russian).

13. Zhinkin, N. (1958). *Mehanizmy rechi* [Speech mechanisms]. Moscow: Akademija pedagogicheskih nauk (in Russian).

14. Kabanovskaya, Y. (2020). Izuchenie verbal'nyh associacij v psiholingvistike [Study of verbal associatives in psycholinguistics]. *Science symbol, 5*, 139-140 (in Russian).

15. Kovshikov, V., & Gluhov, V. (2007). *Psiholingvistika. Teorija rechevoj dejatel'nosti* [Psycholinguistics. Theory of speech activity]. Moscow: ACT (in Russian).

16. Kuz'mina, M. (2010). Podhody k issledovaniju diskursa [Approaches to discourse research]. *Nauchnaja perspektiva, 7*, 5 (in Russian).

17. Gijom, G. (1992). *Principy teoreticheskoj lingvistiki* [The principles of theoretical linguistics]. Moscow: Progress (in Russian).

18. Golub', A., & Ivanov, M. (2020). Jeksperimental'nye metody psiholingvisticheskogo analiza. In *Psihologija lichnosti: aktual'nye issledovanija*. Magnitogorsk: MGTU (in Russian).

19. Gorelov I., Sedov, K. (2001). *Osnovy psiholingvistiki* [The basic course of psycholinguistics]. Moscow: Labirint (in Russian).

20. Lebedeva, N. (2017). Opyt tipologizacii orfograficheskih lichnostej na osnove jeksperimenta «Tri diktanta s vizual'nym izucheniem teksta» [Experience of typologisation of orthographic personalities based on the experiment "Three dictations with visual text study"]. *Vestnik Tomskogo gosudarstvennogo universiteta. Filologija, 45*, 116-125 (in Russian).

21. Leont'ev, A. (2003). *Osnovy psiholingvistiki* [Basics of psycholinguistics]. Moscow: Smysl (in Russian).

22. Marty A. (2021). *Ob otnoshenii grammatiki i logiki* [On the relationship between grammar and logic]. Logos, 1(41) (in Russian).

23. Marty, A. (1908). *Untersuchungen zur Grundlegung der allgemeinen Grammatik und Sprachphilosophie*. Retrieved from https://archive.org/details/untersuchungenzu01martuoft

24. Miller, J. (1968). Psikholinqvisti [Psiholingvisty]. In *Teoriya rechevoy deyatelnosti* (in Russian).

25. Osgood, C. E. (1963). Psycholinguistics. In *Psychology: A Study of a Science. Study II. Empirical Substructure and Relations with Other Sciences. Volume 6. Investigations of Man as Socius: Their Place in Psychology and the Social Sciences* (pp., 244–316). doi: 10.1037/10590-005

26. Ostgorf, G., & Brugman, K. (1964). *Morfologicheskie issledovanija v oblasti indoevropejskih jazykov* [Morphological research in the field of Indo-European languages] (in Russian).

27. Paul, Q. (1960). *Principy istorii jazyka* [Principles of language history]. Moscow: izdatel'stvo inostrannoj literatury (in Russian).

28. Popov, S. (2019). Associativnyj jeksperiment kak osnova formirovanija principov otbora leksicheskogo materiala [Associative experiment as a basis for forming the principles of selecting lexical material]. In *Lingvistika i lingvodidaktika v svete sovremennyh nauchnyh paradigm. Sbornik nauchnyh trudov* (pp. 315–323).Irkutsk (in Russian).

29. Rezanova, Z., & Miklashevskij, A. (2016). Modelirovanie obrazno-perceptivnogo komponenta jazykovoj semantiki pri pomoshhi psiholingvisticheskoj bazy dannyh [Modelling the image-perceptual component of linguistic semantics using a psycholinguistic database]. *Vestnik Tomskogo gosudarstvennogo universiteta. Filologija, 5(43)* (in Russian).

30. Rezanova, Z., & Ershova, E. (2017). Vlijanie grammaticheskogo roda na konceptualizaciju ob#ektov (jeksperimental'noe issledovanie) [The influence of grammatical genus on object

conceptualisation (an experimental study)]. *Vestnik Tomskogo gosudarstvennogo universiteta. Filologija, 50*, 104-124 (in Russian).

31. Saharnyj, L. (1989). *Vvedenie v psiholingvistiku* [Introduction to Psycholinguistics]. Leningrad: Izdatel'stvo Leningradskogo universiteta (in Russian).

32. Sherbakova, M. (2020). Vosprijatie pis'mennogo vyskazyvanija v psiholingvisticheskom aspekte [Perception of a written statement in the psycholinguistic aspect]. *Sciences of Europe, 47*, 38–40 (in Russian).

33. Suprun, A. (1996). *Lekcii po teorii rechevoj dejatel'nosti* [Lectures on the theory of speech activity]. N. d.: Belorusskij fond Sorosa (in Russian).

34. Veysalli, F. (2010). Semiotika [Semiotics]. *Studia Philologica, 4*, 338 (in Azerbaijani).

35. Jakovlev, A. (2019). Jazykovoe soznanie - chast' individual'nogo soznanija ili chast' teorii? [Is linguistic consciousness part of individual consciousness or part of theory?] *Voprosy psiholingvistiki, 4*, 69-73 (in Russian).

36. Zimnjaja, I. (2001). *Lingvopsihologija rechevoj dejatel'nosti* [Linguopsychology of speech activity]. Moscow: Moskovskij psihologo-social'nyj institut (in Russian).

37. Cynk, S. (2016). Izuchenie jazykovoj lichnosti A. I. Solzhenicyna kak avtora nauchno-publicisticheskogo teksta [Study of A.I. Solzhenitsyn's linguistic personality as an author of a scientific-publicistic text] (in Russian).

Linguocultural Features of "Good" and "Bad" Concepts in English Idioms

Sevinj Shukurlu [1]

[1] *Azerbaijan National Academy of Science, Institute of Linguistics named after Nasimi*
115 H. Cavid Avenu, Baku, Azerbaijan

Abstract. Language facilitates communication and helps one to comprehend the culture of the people who speak it. Language and culture interactions are studied with the help of linguoculturology. As a branch of humanitarian science, linguoculturology examines the role of language in the formation of culture and the role of culture in the formation of language.

At the heart of linguoculturology are concepts, the fundamental building blocks connecting national thought with a universal conceptual system. These concepts, reflections of the language's worldview, are instrumental in studying people's outlook. Each country's unique ideas, embedded in its language, offer a glimpse into its distinct cultural characteristics. As linguistic phenomena, concepts manifest in stable word combinations and phraseology, shaping our understanding of language and culture.

Language units such as fixed word combinations, idioms, and proverbs are understood based on concepts. Idioms are formed due to the concerted activity of different tribes and generations and become an integral part of the national culture. To understand the content of the value concepts "good" and "bad" verbalized in idioms in English, it is essential to study the culture of those speakers. The study of idioms with the concepts of "good" and "bad" in English expresses the moral values of English culture. Idioms in English confirm the national authenticity of the mentality of the people at the linguistic level.

Keywords: language; culture; linguoculturology; concept; idioms.

INTRODUCTION

Linguoculturology is one of the most developed fields of linguistics in recent years. Born at the intersection of linguistics and cultural studies, linguoculturology is a field of science that studies the expression of cultural information in linguistic units. Linguoculturology analyzes the relationship between language and people, language and culture. The study of language and culture and their relations, as well as the study of how and in what form culture and thought are reflected in language, are the main research objects of linguoculturology.

The most widespread ideas about the interaction of language and culture belong to V. Humboldt. He emphasized that language is essential in forming the people's national spirit; a society's language is its soul, and its soul is its language [2, 165]. Every culture is national; its national character is expressed in language through a unique worldview. Language has its internal form for each nation and expresses its culture. The connection between a person and the world around him occurs with the help of language. While studying the problem of the relationship between language and culture in the context of ethnocultural specifications, it is necessary to proceed from the analysis of the language picture of the world expressed in fundamental concepts.

"Language does not only serve the field of culture. It is directly related to the field of production" [3,105]. Language influences the culture of the people who use it. Culture is created, developed, preserved, and transmitted from generation to generation through language. Languages, like cultures, are rarely sufficient unto themselves. The necessities of intercourse bring the

speakers of one language into direct or indirect contact with those of neighbouring or culturally dominant languages [5, 11]. As a field of science that investigates the interaction between linguistics and culture, the main research objects of linguoculturalology are the language picture of the world, cultural background, mentality, cultural concepts, and so on. The concept is one of the leading research objects of linguoculturology. Emotional, expressive, and evaluative concepts are complex concepts. For the first time in Russian linguistics, the term "concept" was coined by S.A. Askoldov-Alekseev in 1928. He defined the concept as an essential component of cognitive language and noted it as a mental formation in the thinking process [1, 156]. The concept is an integral part of the collective consciousness, existing in verbal form in the memory of the language speakers. A concept is a mental symbol defined as a unit of knowledge.

In modern linguistics, great importance is attached to the study of the essence of the concept, and at the same time, there are different points of view. Concepts analyzed as linguistic-cultural phenomena, cultural concepts, and the world's language picture are investigated using concepts. V. Karasik, G. Slyshkin, and Y. Stepanov, who investigated the concept from the linguistic and cultural aspects, especially emphasized the value and image aspects of the concept from the point of view of culture. By studying these components, the carriers of any language culture can understand the concepts existing in that language. According to Y.S. Stepanov, the concept is a micromodel of ethnic culture. He notes that "culture creates a concept, and a concept develops through culture. The concept has a complex structure. On the one hand, everything is attributed to it - structural concepts, and on the other hand, cultural and historical etymological factors are attributed to it [7, 48].

The language picture of the world is reflected in the concepts that connect national thinking with the universal conceptual system. Concepts are considered units that allow national mentality and moral peculiarities to be revealed.

RESULTS AND DISCUSSIONS

Concepts in language are realized through phraseological units, idioms, proverbs, and paremies. These language units play a unique role in transmitting national and moral values from generation to generation. Idioms, phraseology, and proverbs reflect the main features of concepts. Idioms manifest the culture and history of different languages. The internal form of idioms, one of the primary units of linguistic culture, often includes national-cultural elements.

When learning any language, you must learn its grammar and idioms. Since the words in idioms lose meaning when translated individually, their translation and understanding are difficult for English as a foreign language learner. But after learning idioms, we perfectly understand the language's carriers and begin to express our thoughts more fluently because idioms are stable expressions that enrich speech and make it colourful. Since idioms were created in connection with the way of life and living, customs, and worldview of each nation, it is possible to understand the history and character of the country more deeply by studying them. Idioms that reflect the specific features of the people's life and history show their originality and national particularity. Idiomatic units preserve human society's national-cultural heritage and give it emotional value. Using those units reveals the concepts' most prominent linguistic and cultural aspects.

The description of concepts verbalized through idioms allows us to get more complete information about their place in the mind of a native speaker, and these concepts are universal. In the linguistic landscape of the world, concepts related to moral evaluations of a person occupy the central place, for example, truth-lie, love-hate, good-bad, etc. In this regard, clarifying the concept of "good" in the national consciousness of English is very important.

As a universal concept, the meaning of the concept of "good" refers to a concept that expresses morally valuable qualities. The moral evaluation is subjective; through the subject's character, needs, tastes, habits, ideals, stereotypes, etc., it is possible to determine the expression. The question of the definition of "good", the question of what is good, led to the emergence of problems with the syntax and pragmatics of evaluative words and their use in live speech. "Good" means proper and correct for a person, environment, and society. The linguistic unit "good" has more than ten shades of meaning in the dictionary: 1) very satisfactory, enjoyable, pleasant, or attractive; 2) giving pleasure and holding attention; 3) kind and helpful; 4) healthy or well; 5) of high

quality or level; 6) used to express praise; 7) successful or able to do something well [4, 668].

Ideas about good are mentioned in many people's ancient mythology and religious beliefs worldwide. Today, "good" is a philosophically normative evaluative category that generally means what is correct and morally positive. Ethically, "good" is classified as one of the most essential categories of ethics, which meets the content of the requirements of morality.

While studying the concept of "good," we can learn more deeply about the inner world, character, language consciousness features, and national culture characteristics. "Good is considered the most basic moral value concept. The English language culture has such signs as truth, honesty, mercy, kindness, health, success, love, conscience, patience, decency, and conscience.

When talking about truth, honesty in English idioms such as *good faith – acting honestly, with pure motives, and without deceiving others; good egg – a trustworthy person, required; straight goods – the complete, unvarnished truth; deliver the goods – do what is go through proper channels – to follow the correct steps to get something done* [6, 136]; a good scout – an honest, reliable person; be as good as one's word – to be reliable and truthful; straight shooter – someone who speaks truth; turn an honest penny – to earn money in an honourable and legitimate way, typically through one's hard work is used. It turns out that expressions with the concept of "good" used in the context of truth or honesty have become an inseparable feature of English culture, meaning the ability not to lie and always to keep one's word.

It is sufficient in idioms where the concept of "good" conveys the context of mercy, benevolence, e.g. *good Samaritan – someone who tries to help people in trouble or need*; *be for a good cause – to have a beneficial, often charitable, armour effect; Lady Bountiful – an exceptionally wealthy and generous woman; glass half full – characterized by a generally optimistic world view;* [6, 138] these idioms reflect an ideological activity that illuminates the valuable aspects of the subject's existence.

In English, in fine fettle – in good physical and mental health; right as rain – feel healthy; in the pink – in good health and spirits; right as a trivet – in good health; such idioms emphasize the importance of a person's health.

A group of units with the concept "good" includes idioms that express a pleasant meaning, for example, a good Joe - a nice, friendly, and respectable male; a good looker - a particular person or thing; a good bet - a person or thing that is certain to be good or successful; good faith - good intentions; good word - positive or favourable information; and good works - acts, actions, or efforts that are charitable, generous, kind, or philanthropic.

The concept of "bad", like its opposition "good", is one of the universal concepts of ethno-cultural significance. Philosophically, evil is the lack of good, the avoidance of good. From a religious point of view, opposing the creator of evil is a theme related to sin. The concept of wrong is also represented in quite a large number of English idioms. The dictionary meaning of the concept of wrong is given as follows: 1) unpleasant and causing difficulties; 2) of low quality, not acceptable; 3) not successful, or not able to do something well; 4) damaging to health; 5) evil or morally unacceptable, and so on [4, 100].

For representatives of the English language culture, the concept of "bad" means lies, hostility, malice, unhappiness, anger, illness, cruelty, rudeness, and hypocrisy. For example, *bad actor – a person that is unreliable, unruly, and prone to troublesome or quarrelsome behaviour; bad egg – a dishonest or ill-behaved person; bad joke – is an event or situation that is absurd or a complete failure (just a joke that is not funny); bad penny – a person with no value; bad news – unpleasant information; bad hair day – a day on which everything seems to go wrong, and so on* [6,27]. Similar to the concept of "good", the idea of "bad" is also studied through language and culture. As a result of research, the characteristics of the thinking, cognition, ideas, moral views, and worldviews of specific people are revealed.

One of the main features of idioms with the concept of "bad" in English is that their components have a stable grammatical form. Applying a lingucultural interpretation can help clarify idioms with this concept. Knowledge of cultural and historical context plays an essential role in understanding idioms.

CONCLUSIONS

Thus, studying "good" and "bad" concepts, such as value concepts, in the English language picture allows us to obtain more complete and compre-

hensive information about the place of these concepts in the mind of a native speaker. In linguistics and cultural studies, concepts are represented by idioms that express the cultural characteristics of any nation. The analysis of the concepts of "good" and "bad" in any society from a linguistic and cultural point of view forms an idea about the national realities of certain people and the ethnic landscape of the world of a person who speaks a specific language and its reflection in the language consciousness. The concepts of "good" and "bad" are verbalized uniquely in each culture, so it is essential to consider the etymological features of those concepts, whether in English or another culture.

REFERENCES

1. Askoldov, S. (1997). *Koncept i slovo* [Concept and word]. Moscow: Academia (in Russian).

2. Gumboltd, V. (1985). *Yazyk i filosofiya kultury* Language and philosphy culture]. Moscow: n. d. (in Russian).

3. Muradov, C. (2019). *Dil və mədəniyyət* (Language and culture). Baku: n. d. (in Azerbaijani).

4. Hornby, A. (Ed.). (1998). *Oxford Advanced Learner's Dictionary* (7th ed.). Oxford: Oxford University Press.

5. Sapir, E. (1921). *Language: An Introduction to the Study of Speech*. New York: Harcourt, Brace& World Inc.

6. Siefring, J. (2004). *English Idioms*. Oxford: Oxford University Press.

7. Stepanov, Yu. (2004). *Konstanty* [Constants] (3rd ed.). Moscow: Akademicheskiy Proekt (in Russian).

Sustainability Practices in Urban Cemetery Management

Olufemi Oyediran Oyeleke [1] **, Grace Oloukoi** [1]

[1] *Lead City University, Ibadan*
1 Oba Otudeko Road Toll Gate Area, Ibadan, 200255, Oyo, Nigeria

Abstract. Death is a natural event that can have negative consequences for humans, psychological in nature, as well as environmental health. Efficient land use management is critical for preparing for the dead in metropolitan settings, particularly in Nigerian cities. The accessibility, sufficiency and efficacy of management solutions for the deceased are crucial, particularly in Nigerian cities with various populations and land uses. This research focused on the long-term viability of urban management systems for the deceased and the facilities and services provided by cemeteries. The scarcity of amenities and services in cemeteries causes problems for urban management systems, such as adequate burying space, upkeep and surveillance. Inefficient methods of handling the demands of city dwellers near cemeteries in city planning should be handled to enhance citizens' quality of life and protect and enhance the urban area. Scientific research papers, journals, conference proceedings and theses were used to review the literature on urban management for the deceased. Critical concerns discussed include managing cities for the dead, rising demand for burying space, ecological methods and balancing the needs of the living with the dead. These strategies include reusing places, promoting cremation, creating green burial grounds, and developing inclusive ecosystems. It is self-evident that as cities grow, so will demand for burial space, prompting a move toward more sustainable and environmentally friendly techniques. Providing services and facilities for mourners can help ease their grieving and foster a sense of solidarity to balance the needs of the living and the dead. Cemeteries must be appropriately incorporated into the city's fabric.

Keywords: Cemetery Management; Effectiveness; Nigeria.

INTRODUCTION

Death is constant, and when appropriate land use management occurs, the dead and living can be managed within metropolitan environments. This is because death as a regular occurrence can jeopardise human health, psychological well-being and environmental well-being if not well and properly managed [1]. According to [2], the majority of fatalities in urban areas are caused by natural factors such as ageing, natural and artificial disasters and dangers, which include diseases, accidents, killings, armed assaults, etc. The accessibility, sufficiency and effectiveness of urban planning solutions for the deceased are critical, particularly in Nigerian urban areas, because diverse populations and land dominate metropolitan areas [3].

Furthermore, it is critical to meet the needs of potential visitors by providing facilities for grieving and remembering, as well as information about the dead and the burial place. Rapidly developing cities have severe environmental issues regarding urban management for the deceased [4]. Authors [5] demonstrated how weak urban governance allows people to bury the dead wherever they are on their property or in the neighbourhood. Cemeteries, whether inside or outside the home, can have an effect on the environment in the following ways: contamination of the soil, environmental deterioration, property value reduction, household accidents and waterborne diseases. As a result, infrastructure such as prayer rooms and purification stations should be accessible in public funerals to assist individuals in performing burial-related rituals [6]. Accord-

ing to [6], contemporary graveyards provide significantly better burial amenities than older cemeteries.

Cemeteries are usually constructed with extensive infrastructure, including compartments for washing and preparation before burial. Though most Nigerians prefer to prepare their dead at home, these facilities would allow funeral rites to be held in the cemetery. This would help the deceased, especially if no surviving relatives were left behind [7]. The author [7] demonstrates that graves are more than just a last burial site for the dead; they also serve as natural preserves, tranquil gardens and parks, and places of preservation for a wealth of archaeological, past and architectural artefacts. For each cemetery, a comprehensive management strategy should be developed, considering strategic factors such as choice, cost, countryside, biodiversity preservation, and capability maximisation [8].

Furthermore, it should be meticulously planned, consider evolving funeral habits, and accommodate varied cultural expectations. Cemeteries should be built with imagination, warmth, and sensitivity. Cemeteries may be utilised to store cultural artefacts, protect biodiversity, and encourage urban greening, which could lead to using headstones as landmarks. As a result, graves should be surrounded by classic fences and fortifications [9]. Urban management strategies for those who passed away may be perpetuated due to these imaginative concepts and features.

According to [9], choosing growth and shift patterns that are better to other plans in terms of society, the economy, and the environment is the goal of managing urban policies for deceased people for environmental sustainability. The author [10] highlighted that comprehending regional traditions and honouring and promoting indigenous cultural norms are required to ensure environmentally deceased management of cities. The author [11] maintained that the primary purpose of urban management is to promote a city's productivity, fairness and long-term viability by working with both private and public sectors to address the most critical concerns that urban citizens face. As a result, when developing sustainable and rewarding urban settings, we must address the requirements of the deceased [12]. Sustained urban management strategies for the cemetery are required to build successful municipal management strategies for the departed in Abuja, Nigeria.

Concept of Urban Management Strategies. According to [12], management entails organising, overseeing, encouraging, and organising, which are all part of the job. Urban management is a system that must be employed at the city's top for it to be recognised as an organisation and manage its business. Urban management should plan for the town, organise urban activities, oversee them, and inspire employees to do their best work. The urban management structure will compound the existing problems in the city, and there is even the possibility of impending doom if it does not provide strategies and answers tailored to the specific demands of the cities. Notwithstanding the reality that death has been unavoidable and will continue to be, preparation for the dead is seldom included in thorough plans [13]. According to [12], the feeling of duty in answering society's demands now and in the future is at the heart of urban management.

It is critical to ensure that urban planning methods for those who passed away are placed in the city to render it a more attractive and lively area since cities constantly strive to build and incorporate plans for living, working, making investments, and enjoying to attract residents and assets. For lifeless management practices to be effective, the goals and outputs of operations must be intimately tied to the city's long-term objectives [14]. Authors [14] submitted that it had been established that a lack of services and amenities in cemeteries is an obstacle to urban management systems for those who have passed away. This challenge has several components, including the need for adequate burial space, the maintenance of cemeteries, and assuring their safety and security. Furthermore, future visitors' requirements must be met by providing amenities for grieving, remembrance, and details about the deceased and burial site [15].

Plans should be developed with two purposes in mind: improving the quality of life for city people near cemeteries and conserving or improving the living standards of the urban environment. Enhancing access to essential utilities such as water and sanitation and improving transportation are two options for enhancing individuals' living conditions. Creating green infrastructure, increasing pedestrianism and public transit use, enforcing zoning limitations that favour mixed-use development, and improving public safety are just a few techniques employed to protect or enhance livability [16].
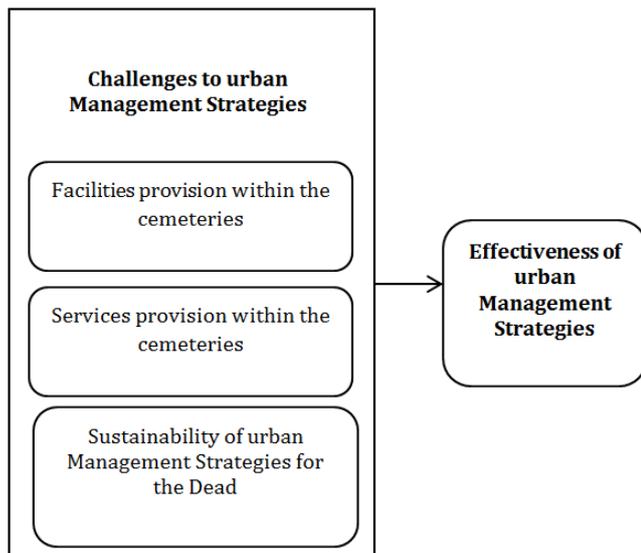
Figure 1 – Conceptual framework

According to the conceptual structure in Figure, obstacles regarding urban management approaches for the deceased based on facility provision within burial grounds, the delivery of services within cemeteries, and the sustainability of urban management strategies for the dead have a direct impact on the successful implementation of urban administration strategies for the dead in the research area.

Perspective on Funeral Planning. Regardless of religious or philosophical views, numerous cultures see burial as an extraordinarily polite and appropriate method to send the deceased and provide the family with a particular gravesite to visit [16]. The most significant issue with the standard funeral method is that it requires a lot of area, which is useless after it is utilised. Since burial grounds are distinct from other land uses by their respective positions, it is essential to understand this while preparing for the dead. Consequently, many assert that several laws regulating the planning and designing of their dead should be developed [17].

The author [18] identified five features or aspects of cemetery systems where fairness theory proves incredibly productive and illuminating. These are, in brief, management, ownership and administration, funding, social infrastructures, and environmental impact. Cemetery systems that are undermined by underdevelopment, corruption, and criminal conduct, where there is no clear accountability for the provision, considerate care is not guaranteed, and corpses are instantly damaged, are signs of a crumbling nation-state. Article 25 of the Universal Declaration of Human Rights states that everybody has a right to "a standard of life sufficient for himself and his family's happiness, including nourishment, clothing, housing, healthcare, and other required social services." In this light, proper waste disposal is a required social function.

According to [19], the administration and planning of the deceased ought to be directed by outlined cultural, religious, humanitarian, social, economic, and environmental standards. These important considerations include the selection of interment sites, the expense of disposal of the deceased, their closeness to commemoration sites, the abundance of free space for natural green areas and habitats, historical aspects, and diversity. Authors [20] also emphasised the importance of organising and handling arrangements for the departed to address longevity by ensuring that cemeteries are viable in every aspect of well-being. As a result, the following concepts were listed: Social refers to a social system's ability to function with a high degree of equilibrium and happiness; societal, which demonstrates social justice and safeguarding traditional beliefs; external factors which provide vast expanses of green the atmosphere; and economic, which includes improving the local economy and reaffirming the local skill base.

Because of land use and zoning regulations, government officials have much say over where new cemeteries should be built and how existing cemeteries can be enlarged. Nevertheless, the elements influencing the design and management of the dead are complex. Because cemeteries are artistic environments, they tremendously impact deeply held values and feelings. Most cemeteries in the United States are owned and operated by private companies. As organisations with a distinctly public function, cemeteries interact with various interest groups, including management, owners, undertakers, pastoral groups, urban planners, political leaders, owners, and the general public. Everybody is concerned about the location of new burial grounds, their design, and how extensions will be handled, making it tough for planners to tackle burial-related challenges [7].

Death can be described in a variety of African words. Some people view death as being beckoned or returning home, ceasing to breathe, bidding farewell, joining their dads, resting or sleeping, etc. According to [21], death, in addition to

reversing living men's links with other people in society, initiates a vicious assault on them. Planning for those who have passed away needs to be prioritised in Nigeria. The author [22] echoed this view when he stated that urban planners have forgotten about it, notably in most African countries.

According to [23], local governments in Nigeria are mandated by the 1999 constitution to provide public cemeteries. Authors [24] believe individuals should be able to choose between burial and cremation when dealing with the deceased. High funeral expenditures should not be used to punish the grieving. An inexpensive cemetery system is based on taxation and subsidy policies [18].

The allocation of place for burial is a service that requires precise calibrating to reach a cost-neutral arrangement, especially when a significant population needs to be served. Land close to urban centres and appropriate for burial tends to be costly; fragile decisions need to be made regarding the rate of grave reuse; and cemetery upkeep expenditures will grow as the ground is utilised since the scenery grows into an increasingly convoluted amalgam. Therefore, cemetery administrations frequently receive direct funding from state governments or municipal taxation. The ratio of public and private sector involvement strongly affects the subsidy amount. Management of cemeteries should keep and improve historic features while considering the surrounding environment's visible historical monuments and artefacts. For ease of access, burial facilities should be placed close to the population that needs them. The creation and usage of cemeteries should protect archaeological remains and come after their inquiry. Management of cemeteries should also preserve and enhance natural resources.

METHODOLOGY

This research was carried out with particular emphasis on existing and current conceptual and theoretical body of knowledge and published in addition to unpublished previous studies on urban management for the deceased. The study reviewed and analysed the literature on sustainability and cemetery management, with the sole purpose of ensuring environmentally conscious and environmentally friendly methods of disposing of the dead, which will, in turn, make the

grieving process easier and promote a sense of solidarity. Strike a balance between the needs of the surviving and the deceased, which has thus attracted much attention in recent years to researchers and research bodies, including corporate or government.

RESULTS AND DISCUSSION

Issues and Realities of Cemeteries in Nigeria. In earlier times, the custom of physically burying those who passed away among the living, either closest to or within their houses, was common among the approximately 450 ethnic groups which make up the present-day Nigerian population [25]. This act had overtones that were spiritual, devotional, and cultural. The belief was that even after they had physically died away, the departed were still assumed to be alive and ready to be associated with by their family members. The rite of home burial is predicated on these concepts. However, as a result of Western influence, the practice of burying the dead on the family property gave place to the public graveyards.

Authors [26] noted that the deceased's final resting place is not typically recognised as an essential issue in urban or landscape planning; how we handle the dead touches on various societal concerns that planners and managers frequently deal with. Many contemporary concerns and difficulties in managing graves have arisen due to the increased human population and advancements. The primary concerns confronting the Gwange cemetery in Maiduguri, Nigeria, are unrest and a lack of enough land [26]. Another major issue for the sector is the need for more land for the use of cemeteries. Cemeteries were constructed on unsuitable terrain, adding to a lack of space and increased need for underground burials. This is owing to ineffective or absent environmental laws governing the soil's suitability and the terrain's slope. The problems are aggravated by failure to comply with burial rules for grave depth in several city cemeteries, which are located near water fountains. The burial facilities sector operates on limited funds. The situation has deteriorated in most Nigerian towns due to the government's budget or commitment to the cemetery business, with cemeteries needing more critical facilities such as workplaces, water, fumigation equipment, houses of worship or meditation, gardening tools, and so on. According to [27], some graves are so situated near

residential areas that the potential for subsurface water contamination is highly significant.

Religious belief and spatial planning. Conflicts over mortality space, such as the place of a burial ceremony, burial ground, memorial, and any geographical activities associated with death, may occur between the sacred and the secular or various religions. Nigerian cemeteries are divided into three types: public (government-owned), privatised (religious and secular) and institution-based [28]. Authors [29] noted that confrontation between the spiritual and secular includes ethnicity, socioeconomic status, and gender. Nevertheless, we may also see it from the state's regulation of religious expression. When the requirement for a spiritual group for a burial ground is contrary to the spatial control established by the secular state, conflict may arise.

Additionally, dispute or contestation of a cemetery combining two distinct religions happens due to divergent comprehensions of what is sacred and profane or the prevailing religion's domination over an area. Various organisations own and manage cemeteries [19]. Mixed economics exists in nearly every nation, and the mix can be highly unique. For instance, the cemetery is still under the control of the state.

CONCLUSIONS

The research makes an essential contribution to the topic of urban management. It presents a comprehensive analysis of the key concerns associated with urban management for the dead and some ideas for addressing these problems. In Nigeria, planning for the deceased has received insufficient attention. The author's [30] research supports that this is particularly prevalent in most developing countries. While creating reliable and fulfilling metropolitan places, urban planners must address the aspirations of the bereaved. For the sake of potential visitors, our cemeteries must provide essential services and conveniences such as collections, landscaping, and utilities. Sustainable urban management methods for graves are required to build effective urban management plans for the departed. The majority of scholarship on how the dead get disposed of has focused on two different viewpoints: cultural and environmental. Even with the difficulty of sustainable urban management plans for the dead, the approach for controlling cemeteries must be adjusted to each city or town's demands. This nation's population has increased from 70 million in 1973 to nearly 200 million in recent years, living in various sectors involving dead planning policies. Government officials are typically mainly concerned with residential, industrial, commercial, and institutional land uses such as stadiums, schools and hospitals when allocating state land directly or through state agencies. Authors [15] noted that eath and burial issues can be handled from a general and an urban management standpoint. In general, when someone dies, their family owes them some responsibilities.

As urban areas become increasingly complicated, developing strategies that address the many layers of a city, from the street level to higher levels where policies are formulated, will be critical. Procedures should also address the many stakeholder groups, such as residents of metropolitan areas near cemetery grounds, organisations and businesses that conduct business in such regions, and government authorities.

As cities keep on expanding, so does the need for burial space. This is a challenge that urban planners and governments must confront. There is a rising trend toward environmentally conscious and environmentally friendly burial methods. It is critical to provide amenities and facilities for mourning. This can make the grieving process more accessible and can also foster a sense of camaraderie. It is essential to strike an equilibrium between the needs of the surviving and the deceased. This involves figuring out how to include a cemetery into the framework of the city while remaining courteous of both the living and the dead. Providing an inviting setting for the deceased's ultimate resting place, correctly burying the deceased's corpse, and ensuring that the final administration and maintenance of the prepared place of rest is reputable and sanitary are all ways to accomplish a sustainable design for the dead. The disposal of the dead is regarded as a critical and mandatory public good by municipalities.

REFERENCES

1. Fernández, Ó., & González-González, M. (2020). The Dead with No Wake, Grieving with No Closure: Illness and Death in the Days of Coronavirus in Spain. *Journal of Religion and Health, 61*(1), 703–721. doi: 10.1007/s10943-020-01078-5

2. Galvin, M., Michel, G., Saintelmond, H.-C., Lesorogol, C., Trani, J.-F., & Iannotti, L. (2023). Exploring the Impact of Crisis and Trauma on the Mental Health and Psychological Well-Being of University Students in Northern Haiti. *International Journal of Mental Health Promotion, 25*(2), 173–191. doi: 10.32604/ijmhp.2023.018800

3. Yusuf, O. L., & Ojewale, O. R. (2023). Implications of urban violence on community security in Ibadan North Local Government Area of Oyo State, Nigeria. *Urban Crime. An international Journal*, *4*(1), 12–39.

4. Beebeejaun, Y., McClymont, K., Maddrell, A., Mathijssen, B., & McNally, D. (2021). Death in the Peripheries: Planning for Minority Ethnic Groups beyond "the City." *Journal of Planning Education and Research*, 0739456X2110432. doi: 10.1177/0739456x211043275

5. Adedeji, L. L., Ibrahim, M. B., & Shittu, A. D. (2021). Assessment of Urban Mosque Facilities and Environmental Issues in Nigeria. *Journal of Religions & Peace Studies*, 5(1), 55–71.

6. Löki, V., Deák, B., Lukács, A. B., & Molnár V., A. (2019). Biodiversity potential of burial places – a review on the flora and fauna of cemeteries and churchyards. *Global Ecology and Conservation, 18*, e00614. doi: 10.1016/j.gecco.2019.e00614

7. Puzdrakiewicz, K. (2020). Cemeteries as (un)wanted heritage of previous communities. An example of changes in the management of cemeteries and their social perception in Gdańsk, Poland. *Landscape Online, 86*, 1–26. doi: 10.3097/lo.202086

8. Sallay, Á., Tar, I. G., Mikházi, Z., Takács, K., Furlan, C., & Krippner, U. (2023). The Role of Urban Cemeteries in Ecosystem Services and Habitat Protection. *Plants, 12*(6), 1269. doi: 10.3390/plants12061269

9. Xu, Q., Zheng, X., & Zheng, M. (2019). Do urban planning policies meet sustainable urbanisation goals? A scenario-based study in Beijing, China. *Science of The Total Environment, 670*, 498–507. doi: 10.1016/j.scitotenv.2019.03.128

10. Badami, A. A. (2022). Management of the image of the city in urban planning: experimental methodologies in the colour plan of the Egadi Islands. *URBAN DESIGN International*. doi: 10.1057/s41289-022-00200-1

11. Stead, D. (2013). Key research themes on governance and sustainable urban mobility. *International Journal of Sustainable Transportation, 10*(1), 40–48. doi: 10.1080/15568318.2013.821008

12. Mirzaei, R. (2023). *Investigation and position of urban management in small cities*. Retrieved from https://www.researchgate.net/publication/369550848_Investigation_and_position_of_urban_management_in_small_cities

13. Naziha, L., & Hassib, R. (2023). La fabricación de la ciudad entre la regulación urbana y el proyecto urbano, caso de la ciudad de Annaba. *ESTOA, 12*(23), 137–147. doi: 10.18537/est.v012.n023.a11

14. Boulton, C., Dedekorkut-Howes, A., & Byrne, J. (2018). Factors shaping urban greenspace provision: A systematic review of the literature. *Landscape and Urban Planning, 178*, 82–101. doi: 10.1016/j.landurbplan.2018.05.029

15. Swensen, G., & Skår, M. (2018). Urban cemeteries' potential as sites for cultural encounters. *Mortality, 24*(3), 333–356. doi: 10.1080/13576275.2018.1461818

16. Parkes, C. M., Laungani, P., & Young, W. (Eds.). (2015). *Death and bereavement across cultures*. N. d.: Routledge.

17. Abd Elrahman, A. S., & Asaad, M. (2021). Urban design & urban planning: A critical analysis to the theoretical relationship gap. *Ain Shams Engineering Journal, 12*(1), 1163–1173. doi: 10.1016/j.asej.2020.04.020

18. Rugg, J. (2020). Social justice and cemetery systems. *Death Studies, 46*(4), 861–874. doi: 10.1080/07481187.2020.1776791

19. Basmajian, C., & Coutts, C. (2010). Planning for the Disposal of the Dead. *Journal of the American Planning Association, 76*(3), 305–317. doi: 10.1080/01944361003791913

20. Enssle, F., & Kabisch, N. (2020). Urban green spaces for the social interaction, health and well-being of older people – An integrated view of urban ecosystem services and socio-environmental justice. *Environmental Science & Policy, 109*, 36–44. doi: 10.1016/j.envsci.2020.04.008

21. Emmanuel, N. U., Paschal, I. I., &Onyinye, R. N. (2021). Modernity and burial rituals in Igbo land: A paranormal communication approach. *British Journal of Mass Communication and Media Research*, *1*(1), 28-38. doi: 10.52589/BJMCMR-OXV49EQI

22. Berrisford, S. (2011). Why It Is Difficult to Change Urban Planning Laws in African Countries. *Urban Forum, 22*(3), 209–228. doi: 10.1007/s12132-011-9121-1

23. Okorie, C. O., Ogba, F. N., Iwuala, H. O., Arua, C., Felix, N., & Nwosumba, V. C. (2022). Decentralisation of South Eastern Nigeria's Local Governments and Achievement of Mandates Enshrined in Nigeria's 1999 Constitution. *SAGE Open, 12*(2), 215824402210899. doi: 10.1177/21582440221089975

24. Grabalov, P., & Nordh, H. (2021). The Future of Urban Cemeteries as Public Spaces: Insights from Oslo and Copenhagen. *Planning Theory & Practice, 23*(1), 81–98. doi: 10.1080/14649357.2021.1993973

25. Gumh, J. I. (2019). *A history of the development of yam economy in TIV land of central Nigeria, 1960-2000* (Doctoral dissertation). Retrieved from https://core.ac.uk/download/322634288.pdf

26. Daya, M. A., Modu, M. A., Butu, H. M., Shehu, B., & Kayode, S. J. (2022). Issues Confronting Management of Grange Cemetery in Maiduguri, Borno State-Nigeria. *International Journal of Sustainable Development, 6*(5), 121–128.

27. Idehen, O. (2020). A Comparative Investigation of Groundwater Contamination in Typical Dumpsites and Cemetery Using Ert and Physicochemical Analysis of Water in Benin Metropolis, Nigeria. *Journal of Geoscience and Environment Protection, 08*(01), 72–85. doi: 10.4236/gep.2020.81005

28. Pliberšek, L., & Vrban, D. (2018). *Cemetery as village tourism development site*. Retrieved from https://www.fthm.uniri.hr/images/kongres/ruralni_turizam/4/znanstveni/Plibersek_Vrban.pdf

29. Ekaputri, A. S., & Sugiarto, B. (2021). Politics of Cemetery: Religious Minority in Local Indonesia. *POLITIKA, 12*(2), 208–221.

30. Adama, O. (2020). Abuja is not for the poor: Street vending and the politics of public space. *Geoforum, 109*, 14–23. doi: 10.1016/j.geoforum.2019.12.012

Physical Education Teacher's Knowledge of ICT-Based Learning Media at Primary School

Misran [1], **Razali** [1], **Syamsulrizal** [1], **Fachrizal Ambia** [1], **Amanda Syukriadi** [1], **Jul Fajrial** [1], **Budi Valianto** [2], **Myrza Akbari** [3], **Rahmati** [3]

[1] *Syiah Kuala University*
Jln. Teuku Nyak Arief, Darussalam, Banda Aceh, Aceh, 23111, Indonesia

[2] *Medan State University*
Jl. William Iskandar Ps. V, Kenangan Baru, Kec. Percut Sei Tuan, Kabupaten Deli Serdang, Sumatra, 20221, Indonesia

[3] *Samudra University*
Jalan Prof. Syarief Thayeb, Meurandeh, Langsa Lama, Aceh, 24416, Indonesia

Abstract. This research aims to determine the level of knowledge of Physical Education teachers regarding ICT-based learning media. This type of research is descriptive research with a quantitative approach. The subjects of this research were 56 elementary school physical education teachers in Pidie Jaya Regency. The instrument used in this research is a knowledge test instrument, which contains multiple-choice test questions. Data analysis uses completeness level and percentage formulas. Based on the results of data analysis, it can be concluded that 1) The level of knowledge of Physical Education teachers regarding ICT-based learning media in elementary schools as a whole with an average of 72.54% is in the medium category; 2) The level of mastery of indicator 1 in designing learning media in the form of images with an average of 81.91% is in the excellent category; 3) Level of mastery of indicator two regarding making learning media in audio form with an average of 74.01% in the sufficient category; 4) Level of mastery of indicator three regarding making learning media in audiovisual form with an average of 65.17% in the medium category; 5) Level of mastery of indicator four regarding projecting learning media in visual form with an average of 67.09% in the poor category; 6) Level of mastery of indicators 5 in internet browsing-based learning media with an average of 73.66% in the medium category.

Keywords: ICT; Physical Education; Primary School.

INTRODUCTION

The challenges of a teacher in the Industrial Revolution 4.0 era are getting bigger; education in the 4.0 era must be oriented towards using digital technology in learning. Every teacher is required to have competencies related to the use of technology. UNESCO's Information and Communication Technology (ICT) competency framework for teachers (ICT-CFT) seeks to help countries develop comprehensive national teacher ICT competency policies and standards and integrate ICT holistically in education plans [1].

Successful integration of ICT into the teaching and learning process requires rethinking the role of teachers in planning and implementing ICT to improve and transform learning [2]. Furthermore, integrating ICT into education can make it easier for teachers to carry out their duties and functions and for students to achieve the expected competencies [3]. The national education system must ensure that all teachers can utilize technology.

The digital era is a fusion of the Industrial Revolution 4.0 era, where there are rapid changes in society regarding accessing information, politics,

business economics and even the world of education [4]. The digital era must not be resisted or avoided but must be balanced and accepted by society, including teaching staff in the teaching and learning process. Many changes have occurred in people's lives due to the development of technology in this digital era, from the economic, social, and business world to education [5]. Technological advances in education support educators in creating, adapting, utilizing and sharing online learning media content in planning and implementing learning.

The concept of "freedom of learning" continues to be intensified by the Ministry of Education to prepare a reliable generation for the future. One of the programs being intensified by the Ministry of Education is about independent learning, which provides freedom for educators and students to innovate and be creative through the PembaTIK (Information and Communication Technology-Based Learning) program from the Ministry of Education. According to [6], implementing the 21st-century curriculum must combine knowledge, thinking, innovation skills, media and Information and Communication Technology (ICT) literacy. Teachers must be motivated to know and understand the importance of using ICT-based learning media.

Using learning media will make the learning process more effective [7]. ICT can make teachers more innovative and creative in packaging learning so that students absorb every material presented. ICT can convey information or messages to students while transferring knowledge to them. With good use of ICT, students and educators will benefit from the technology [8].

The Learning Implementation Plan must include ICT in the form of learning media. Every learning process must start with planning and following the goals to be achieved. Physical Education, Sports, and Health are among the most essential school subjects. It is even one of the subjects in Law No 3 of 2005 concerning the national sports system.

Sports education is physical education, and sports are part of a regular and sustainable educational process to acquire knowledge, personality, skills, health, and physical fitness [9].

In general, physical education lessons at school aim to improve students' physical fitness through cognitive and affective psychomotor activities. Physical Education teachers must be creative and

innovative in teaching and learning, including creating learning media so students can easily understand them. For students still studying in elementary school, it is easier to understand learning if it is taught using media that is more interesting and follows reality, such as displaying audiovisual press [10].

In the technological era, teachers must use ICT in the learning process. From the observations, researchers found that there are still Physical Education teachers who do not understand the use of ICT and are not yet able to create emails and operate computers [11]. Data that researchers found from the education office from 2018 to 2022 showed that only one physical education teacher passed the teacher competency exam to take part in the professional teacher education program.

From the description above, the author wants to know the extent of elementary school physical education teachers' understanding of the use of ICT-based learning media through research entitled "Primary school Physical Education Teachers' Knowledge of ICT-Based Learning Media.

METHOD

This research uses a quantitative approach with a descriptive type. This research was conducted with a sample size determined based on the existing population.

This study's population was 73 elementary school physical education teachers in Pidie Jaya Regency, Aceh Province, Indonesia. Because the population is less than 100 people, this research does not use a research sample; the entire population will be studied (total sampling).

The general steps for compiling/developing tests are as follows [12].

1. Determining the test objectives. The first step in developing a test instrument is to determine its objectives. The test objectives must be formulated clearly to provide direction and scope for further test development.

2. Preparation of the test grid. The purpose of preparing the grid is to determine the scope and as a guide in writing questions. Grids can be either format or matrix. The test grid describes the scope and content of what will be tested and provides details about the questions required by the test. The grid generally contains 1) details of

the learning material/aspect to be evaluated, 2) the behaviour to be measured along with a description of the indicators, 3) the proportion and number of questions, and 4) the form of the questions.

3. Writing questions. When writing questions, the writer must pay attention to the rules for writing questions. Writing questions translate competency indicators to be measured into questions whose characteristics correspond to the grid.

4. Study the questions. Question review is reviewing the test questions that have been prepared. This study was carried out by examining three aspects: material, construction, and language. Usually, when reviewing questions, other people check and revise them.

5. Test questions, including analysis. The questions that have been created and have been reproduced or increased are tested on a predetermined number of samples. The test sample must have characteristics that are more or less the same as the characteristics of the actual test participants. Based on the data from the test results, analysis was carried out, especially analysis of the items, which included the difficulty level, item validity, and distractor function.

6. Assembling the questions into a test set. When assembling tests, it is necessary to group the items according to their form rather than according to the type of material or according to the level of knowledge to be measured.

7. Test presentation. After obtaining the standardized test, the test script is ready to be given or presented to the test taker. Things that need to be considered when giving a test are the time of presentation, clear instructions on how to answer or take the test, and the room and seat of the test taker.

8. Scoring. Scoring is done according to the form of the test or questions.

9. Reporting test results. After carrying out the test and scoring, the test results need to be reported, for example, to the student concerned, to the student's parents/guardians, to the principal, and so on.

10. Utilization of test results. Test results, which are only measurement results, can be used to improve systems, methods, or teaching and learning strategies and to determine policy.

The grid of the elementary physical education teacher knowledge test regarding ICT-based learning media is as follows:

Table 1 - Research Instrument Grid

Variable	Indicator
Physical Education Teacher's Knowledge Of ICT-Based Learning Media At Primary School	Designing learning media in the form of images
	Creating learning media in audio form
	Create learning media in audiovisual form.
	Projecting learning media in visual form
	Exploring Internet-based learning media

Before this test instrument is used, it is first tested in two stages: validity and reliability. Researchers carried out these two stages using a trial sample of 17 people who were not included in the research sample. The knowledge test instrument used during the trial consisted of 50 questions. The trial results found that 40 questions were declared valid, and 10 were declared invalid/invalid.

Based on the data collection results in Table 4.1, which were carried out using a knowledge test instrument of 40 questions regarding the knowledge of Physical Education teachers, results were obtained using the following (1).

$$\text{Knowledge level} = \frac{\sum \text{correct answer}}{\sum \text{to Questions}} \times 100 \qquad (1)$$

After the data is collected, the data is interpreted using the percentage assessment norms in Table 2.

Table 2 – Knowledge Level Norms

No	Knowledge level, %	Predicate of Success
1	90-100	Very Good
2	80–89	Good
3	70–79	Medium
4	< 70	Poor

Using the following formula, calculate the percentage classification of Physical Education

teachers' knowledge of ICT-based media at the elementary school level.

$$P = \frac{F}{N} \text{ x } 100\%$$

where P – Percentage; F – Frequency; N – Sample; 100% – Fixed number.

Very Good $P = \dfrac{18}{56} \ x \ 100\% = 32{,}14\%$

Good $P = \dfrac{15}{56} \ x \ 100\% = 26{,}78\%$

Medium $P = \dfrac{7}{56} \ x \ 100\% = 12{,}51\%$

Poor $P = \dfrac{16}{56} \ x \ 100\% = 28{,}57\%$

Table 2 – Recapitulation of Overall Knowledge Percentage Calculation Results

Category	Frequency	%
Very Good	18	32,14
Good	15	26,78
Medium	7	12,51
Poor	16	28,57
Total	56	100

RESULTS AND DISCUSSION

From the results of the calculations above, it can be stated that the percentage of knowledge of Physical Education teachers regarding ICT-based media in Pidie Jaya district elementary schools, with an average of 72.54%, is in the sufficient category, with the following details: 1) excellent category, as many as 18 people (32.14%), 2) good category as many as 15 people (26.78%), 3) medium category, as many as seven people (12.51%), 4) category poor, as many as 16 people (28.57%).

Next, analyze the data on the level of mastery and knowledge of Physical Education teachers based on the indicators that have been prepared, which consist of 5 indicators, namely

1) Designing learning media in the form of images,

2) Creating learning media in the form of audio,

3) Creating learning media in the form of audio-visual,

4) Projecting learning media in visual form,

5) Exploring internet-based learning media.

The data analysis of the level of mastery and knowledge of Physical Education teachers is based on indicators that have been prepared, which consist of 5 indicators, namely

1) Designing learning media in the form of images,

2) Creating learning media in the form of audio,

3) Creating learning media in the form of audio-visual,

4) Projecting learning media in visual form,

5) Exploring internet-based learning media.

Furthermore, the results of research and data analysis of Physical Education teachers' knowledge about ICT-based media in elementary schools using a percentage formula based on categories, namely excellent, good, medium, and poor with a range of values:

1) the level of knowledge in the excellent category is at 90-100%,

2) the level of knowledge in the excellent category is 80–89%,

3) the level of knowledge in the medium category is 70–79%,

4) the poor category's knowledge level is <70%.

The results of data analysis calculations on Physical Education teachers' knowledge about ICT-based media in Pidie Jaya Regency Elementary Schools can be grouped based on the following indicators:

a) the level of mastery and knowledge of Physical Education teachers in indicator one regarding designing learning media in the form of images is in the excellent category,

b) Physical Education teachers' mastery level and knowledge in indicator two regarding creating learning media in audio form is in the medium category.

c) the level of mastery and knowledge of Physical Education teachers in indicator three regarding creating learning media in audiovisual form is in the medium category,

d) the level of mastery and knowledge of Physical Education teachers in indicator four regarding

projecting learning media in visual form is in the poor category,

e) Physical Education teachers' mastery level and knowledge in indicator five regarding exploring internet-based learning media is in the medium category.

Furthermore, the results of data analysis calculations on the level of knowledge of Physical Education teachers regarding ICT-based media in elementary schools show that the average is 72.54% in the medium category. This means that it can be concluded that Physical Education teachers' knowledge about ICT-based learning media is still in the medium category; they still need support from stakeholders from the government to increase Physical Education teachers' knowledge about ICT-based learning media so that they can reach a percentage level above 95%, to support educational progress.

Industrial Revolution 4.0 is a change in society regarding accessing information, politics, business economics, and even the world of education. Technological advances in education support educators in creating, adapting, utilizing, and sharing online learning media content in planning and implementing learning.

CONCLUSIONS

Based on the results of the research that the authors obtained, it can be concluded that the achievement motivation level of football players is 131.68 (in the medium category) with the following details: as many as three respondents (13.63%) are in a low type, six respondents (27.28%) are in the medium category, and the remaining 13 respondents (59.09%) are in the high class.

This follows the [13] statement, which explains that achievement motivation is a fundamental mental skill that athletes need. The motivation that athletes need to have is achievement motivation cause athletes who have achievement motivation will race with excellence, both self-advantage and other people's excellence, even to achieve performance in training tasks and competitions.

REFERENCES

1. Hinojo Lucena, F. J., López Belmonte, J., Fuentes Cabrera, A., Trujillo Torres, J. M., & Pozo Sánchez, S. (2019). Academic Effects of the Use of Flipped Learning in Physical Education. *International Journal of Environmental Research and Public Health, 17*(1), 276. doi: 10.3390/ijerph17010276

2. Moreno-Guerrero, A.-J., Alonso García, S., Ramos Navas-Parejo, M., Campos-Soto, M. N., & Gómez García, G. (2020). Augmented Reality as a Resource for Improving Learning in the Physical Education Classroom. *International Journal of Environmental Research and Public Health, 17*(10), 3637. doi: 10.3390/ijerph17103637

3. Rocu Gómez, P., Blández Ángel, J., & Sierra Zamorano, M. Á. (2019). Construyendo aprendizajes en Expresión Corporal a través de WebQuest: un estudio de caso múltiple. *Revista Complutense de Educación, 30*(4), 1013–1029. doi: 10.5209/rced.59905

4. Hutabarat, H. H., Razali., Ahadin., & Akbari, M. (2021). Implementation of Management Functions in Football Clubs. *Journal of Physical Education, Sport, Heals and Recreation, 10*(3), 109–112.

5. Meng, J. (2021). College Physical Education Teaching Aided by Virtual Reality Technology. *Mobile Information Systems, 2021*, 1–11. doi: 10.1155/2021/3052895

6. Liu, S., & Chen, Q. (2022). College Sports Multimedia Network Based on Wireless Communication and Deep Learning Network Environment. *Wireless Communications and Mobile Computing, 2022*, 1–12. doi: 10.1155/2022/3267639

7. Rodriguez, R., & Avila, C. (2022). Digital competences in university students and teachers in the area of Physical Education and Sports. *Retos, 43*, 1065–1072.

8. Killian, C. M., Espinoza, S. M., Webster, C. A., Long, B., Urtel, M., Mays Woods, A., & D'Agostino, E. M. (2022). Flipping the Script: An Initial Exploration of Flipped Learning as an Enhanced Alternative to Traditional Physical Education Lessons. *International Journal of Environmental Research and Public Health, 19*(22), 15188. doi: 10.3390/ijerph192215188

9. Said, L. R., Anisah, H. U., Firdaus, M. R., Rusniati, R., & Rachman, M. K. (2022). The Impact of Perceived Benefits of Corporate Social Responsibility Initiatives on Wetland Farming Communities in Indonesia. *Wseas Transactions On Business And Economics, 19*, 402–413. doi: 10.37394/23207.2022.19.36

10. Long, N. J. (2022). Afterlives and Alter-lives. *Social Analysis, 66*(4), 112–133. doi: 10.3167/sa.2022.660406

11. Pomportes, L., Brisswalter, J., Hays, A., & Davranche, K. (2016). Effect of Carbohydrate Intake on Maximal Power Output and Cognitive *Performances. Sports, 4*(4), 49. doi: 10.3390/sports4040049

12. Zhang, H., Liu, X., Xie, Y., Gou, Q., Li, R., Qiu, Y., Hu, Y., & Huang, B. (2022). Assessment and Improvement of Urban Resilience to Flooding at a Subdistrict Level Using Multi-Source Geospatial Data: Jakarta as a Case Study. *Remote Sensing, 14*(9), 2010. doi: 10.3390/rs14092010

13. Szajna, G., Bak, R., & Kulasa, J. (2019). *Application of conflict algebra in the analysis of fencing and tactical preparation methods*. Retrieved from https://www.proquest.com/openview/afaf2f900c45674c315323e266032013/1?pq-origsite=gscholar&cbl=5371637

Optimised Condition Catalytic Upgrading of Agbabu Bitumen in the Presence of Rice Husks

Yunusa Mohammed Oseni [1, 2]**, Umar Omeiza Aroke** [2]**, Baba Jibril Yakubu** [3]

[1] *Bayero University Kano*
Nigeria Gwarzo Road, P. M. B. 3011, Kano, Nigeria

[2] *Abubakar Tafawa Balewa University*
Dass road, P. M. B. 0248, Bauchi, Nigeria

[3] *Ahmadu Bello University*
Zaria, 810211, Nigeria

Corresponding Author:
Yunusa M. Oseni
yunusamohammedoseni@gmail.com
ymoseni.cpe@buk.edu.ng

Abstract. In this study, the optimisation of bitumen collected from Agbabu Ondo State, Nigeria, was upgraded in the presence of rice husks in a nitrogen environment using a 100 ml autoclave batch reactor with the aid of the design expert software. Response surface methodology (*RSM*) was used to determine the optimum conditions for the bitumen upgrading in the presence of rice husks using the Box-Behnken Designed Experiment (BBD). Three mesoporous aluminosilicate catalysts (NiMo/ZSM-5, CoMo/HZSM-5 and Mo/HZSM-5) were used to upgrade the bitumen at the obtained optimised point. The bitumen sample was characterised by saturates (53.48 wt.%), aromatics (12.84 wt.%), resins (15.37 wt.%), asphaltenes (8.86 wt.%) and an initial viscosity of 86.78 Pa.s, API gravity of 7.87 $^\circ$ and density of 1.0153 kg/l. The GC-MS result revealed that there were 42 chemical compounds present in the raw bitumen. The XRF result for the rice husks revealed that the silica to Alumina (SiO_2/Al_2O_3) ratio was 11.89:1. RSM optimisation of the experimental runs with the autoclave reactor gave an optimum condition (Temperature of 345.716 $^\circ$C, Reaction time of 30 min, and Rice husks of 1.0 wt.%) without employing any of the three mesoporous aluminosilicate catalysts. The responses obtained for the upgraded oil were viscosity 8.34 Pa.s, API gravity 24.520 $^\circ$, residue yield 22.39 w/w% and light oil yield 50.064 w/w%. The experimental run with NiMo/ZSM-5 catalyst at the optimum conditions was observed to be more effective in the catalytic thermal cracking of the bitumen upgrading process, as the light oil yield was 70.42 w/w%, viscosity of 2.060 Pa.s, API gravity of 29.826° and residue yield of 10.66 w/w% compared to what was obtained from CoMo/HZSM-5 and Mo/HZSM-5 mesoporous aluminosilicate catalysts. The FT-IR and GC-MS of the upgraded Agbabu bitumen testified that the level of upgrade of the bituminous oil was satisfactory as the raw Agbabu bitumen had an initial viscosity of 86.780 Pa.s, API gravity of 7.87 $^\circ$ and density of 1.0153 kg/l in which all the initial core properties of the bitumen have shifted satisfactorily after the bitumen upgrade to produce light oil that fell within the acceptable range of refinery feedstock specifications for refining processes in the vacuum distillation unit (VDU).

Keywords: Heavy Oil; Bitumen; Bitumen Upgrading; Rice Husks; Mesoporous Aluminosilicate Catalysts

INTRODUCTION

The growing global demands for fossil fuels due to the worldwide increase in human population and technological advancement has led to the fast depletion of conventional crude oil and thus the need to seek and adopt a viable means to which the provision for the fossil fuels demands could be sustained, gave rise to the keen interest by researchers and oil industry based researchers to look onto unconventional oils – mainly heavy oils, extra-heavy oils and bitumen as an alternative source for the fossil fuels provision. Over half of the world's oil reserves are recoverable oils such as heavy oil, extra heavy oil, bitumen, etc. However, there are many challenges governing the recovery and using these oil sources in regular refinery routes to process them into valuable fuels. Figure 1 shows the world oil reserves [1].
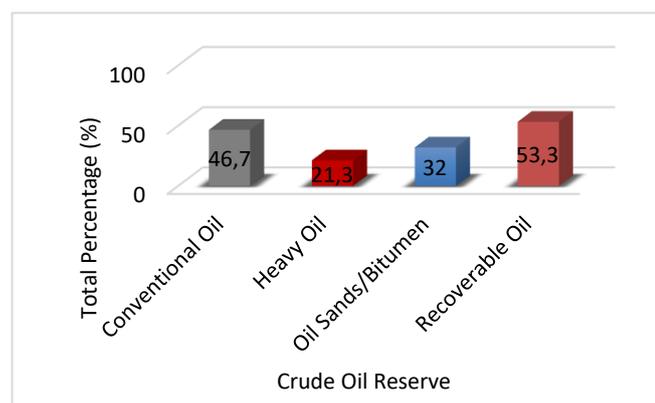
Figure 1 – Total World Oil Reserve

Bitumen constitutes mainly hydrocarbons possessing low hydrogen-to-carbon ratio (H/C) with high molecular weights that result in high boiling points, and most bitumen have a typical carbon atom greater than 15 in their molecular structures. Their components can be classified as saturates, aromatics, resins, and asphaltenes (SARA), concerning their polarizability and polarity [2]. The bitumen is characterised and determined mainly by the amount of asphaltenes followed by resins present in the bitumen. Thus, the viscosity of the bitumen is a function of asphaltenes content in the bitumen such that the greater the volume percentage of the asphaltenes, the greater the viscosity of the bitumen. The bitumen has an average range of values for H/C (1.0–1.2), density (1.1–1.20 Kg/l), and at an ambient condition of solubility (19–24 Mpa). Natural bitumen has API gravity in the range of

7–14°, high viscosity in the range of 5–100 Pa.s, and high content of sulphur, oxygen, nitrogen, and heavy metals such as nickel and vanadium. The structure of bitumen is condensed polynuclear aromatic rings containing branched chains of the alkyl group. The number of these polynuclear atomic rings may be present in the proportion ranging from 6–15 in the case of asphaltenes [2, 3].

The combination of bitumen with other resources, such as catalysts and biomass after bitumen production, has been growing in interest by researchers and oil industry-based researchers globally for upgrading the bitumen to light oil. Biomass is a renewable, carbon iv oxide (CO_2) free energy source with low sulphur content. It can be mixed with bitumen over a mesoporous aluminosilicate catalyst for chemical modification to produce light oil [4]. Rice husks are biomass with low density and less commercial interest by the public, so their handling and transportation become problematic, creating disposal and serious environmental problems. Thus, the need to properly dispose of rice husks in waste utilisation gave rise to its usage in bitumen upgrading for fossil fuel supply and sustainability [5].

Lots of heavy oil/bitumen upgrading methods used were observed as remarked that the viscosity of the upgraded heavy oils or bitumens seems to backslide as time goes by, resulting in greater viscosities as there is the presence of heteroatoms such as oxygen, nitrogen and sulphur and regeneration of free radicals. Thermal upgrading of heavy oil/bitumen in the presence of a catalyst and biomass is believed to show a notable promise in heavy oil/bitumen upgrading if exploited as with the noteworthy accomplishment obtained from thermal upgrading with catalyst alone [5]. In this context, catalytic thermal cracking of natural bitumen with rice husks to produce a stabilised light oil using a mesoporous aluminosilicate catalyst at optimum conditions will be investigated, hence this study. In this light, this research work aims to upgrade the natural bitumen collected from the Agbabu Ondo State of Nigeria at optimum conditions (optimum conditions obtained first from upgrading the Agbabu bitumen using rice husks only without employing any nano-catalysts at the initial stage of the bitumen upgrade to find the optimum conditions

for upgrade)[1] over three separate mesoporous aluminosilicate catalysts (NiMo/ZSM-5, Co-Mo/HZSM-5, and Mo/HZSM-5) to see the effects of the upgrade by a combination of rice husks and catalysts at different experimental runs with the ambition to find a mean to ensure a constant future fuel supply and away of proper disposal/utilisation of rice husks waste.

METHOD

Materials/Chemicals. Bitumen was collected from Agbabu bituminous field, Ondo State, Nigeria. Table 1 lists the properties of the bitumen - different laboratories have conducted and collated analyses of the bituminous oil.

Table 1 – Agbabu, Ondo State Bitumen

Parameter	Value
Viscosity @ 70 °C (Pa.s)	86.780
Density @ 60 °C (Kg/l)	1.0153
API gravity (º)	7.870
Sulfur (wt.%)	6.33
Hydrogen to Carbon (H/C) ratio	1.19
Water in Crude (Karl Fisher ASTM D4928);	
Initial Crude	23.94
Dehydrated Crude	3.26
Micro-Elemental Composition (%);	
Carbon (C)	76.64
Hydrogen (H)	7.67
Nitrogen (N)	0.25
Sulfur (S)	4.51
Oxygen (O)	37.1
Metal Composition (ppm)	
Nickel (Ni)	800
Vanadium (V)	2000
SARA Composition (wt.%);	
Saturates	53.48
Aromatics	12.84
Resins	15.37
Asphaltenes	8.86

Notes: Analyses conducted at different laboratories and collated

The rice husks were collected from a local rice mill in Kano State, Nigeria. They were dried in an oven to ensure minimal moisture content, and their physicochemical properties were characterised.

The following chemicals were used: Toluene (Sigma-Aldrich), n-Hexane (Fisher Scientific),

Nitrogen (99.82%), Silica gel, and Attapulgus clay were obtained from a local supplier.

The three catalysts employed were mesoporous aluminosilicate catalysts: NiMo/ZSM-5, CoMo/HZSM-5, and Mo/HZSM-5. Each catalyst was characterised.

Characterisation of Raw Bitumen, Rice Husks and Mesoporous Aluminosilicate Catalysts. The raw bitumen (Agbabu bitumen), rice husks and mesoporous aluminosilicate catalysts were characterised, and their physiochemical properties were recorded under the following headings.

Characterisation of Raw Agbabu Bitumen. Characterisations (viscosity, API gravity, density, etc.) of the Agbabu bitumen were carried out to determine the properties of the raw bitumen, as shown in Table 1. FT-IR, GC-MS, XRF, and micro elemental analysis were also carried out to further determine the raw bitumen's properties.

Characterisation of Rice Husks. The rice husk was collected from a local rice mill in Kano State, Tofa Local Government of Nigeria. Characterisations such as the oxide and elemental analysis were carried out to determine the properties of the rice husks using XRF and XRD machines.

Characterisation of Modified Aluminosilicate Catalysts. The three mesoporous aluminosilicate catalysts (NiMo/ZSM-5, CoMo/HZSM-5, and Mo/HZSM-5) employed in the heavy oil upgrade were characterised using X-ray powder diffraction (XRD), scanning electron microscope (SEM), and BET analysis machines.

Optimisation of Agbabu Bitumen Upgrading in the Presence of Rice Husks. Using response surface methodology (RSM), the Agbabu bitumen was optimised to obtain the optimum conditions. The Box-Behnken Design experiment was used as the design template for the optimisation reaction experiment.

Catalytic Thermal Cracking Experiment at the Optimum Conditions. Now, applying the optimum conditions obtained from the optimisation of Agbabu bitumen for the upgrade, the bitumen catalytic thermal cracking experiment was carried out in an autoclave 100 ml batch reactor. Explicitly, a total of 50 g of (Raw Agbabu bitumen + 1.0 wt.% rice husks + 0.5 wt.% catalyst) amounting to 49.25 g of raw bitumen, 0.5 g of rice husks and 0.25 g of mesoporous aluminosilicate catalyst were mixed in the reactor, indicat-

---

[1] The optimisation of Agbabu bitumen in the Presence of Rice Husks was performed to obtain the optimum condition

ing a 0.0051 catalyst-to-oil (C/O) ratio for the bituminous catalytic thermal experiment.

The reactor was closed but with the gas exit valve opened (and later, the gas exit valve was closed to air tighten the reactor before the reaction), then nitrogen gas was passed through the reactor and made to exit through the gas exit valve of the reactor for few seconds before air tighten of the reactor to drive away any trapped gases in the reactor. The reactor was pressurised with nitrogen gas at a pressure of 6 bar, followed by a leakage test before the reaction. The stirrer was set at a rotational speed of 500 rpm, and the reaction time began nearly 120 min after the heating element of the autoclave reactor was switched on. The reaction temperature was ensured to be stabilised at 345.716 °C. The reaction was permitted for 30 min as setup, after which the reactor system was automatically switched off, and the reactor was allowed to cool over time. The gas was vented out and trapped through a gas board analyser (Gasboard 3100P), and the resulting light oil was separated from the residue oil. The light oil and the residue oil were weighed separately - the light crude was measured for viscosity and API gravity. Figure 2 shows the experimental method and analytical scheme of bitumen upgrading.
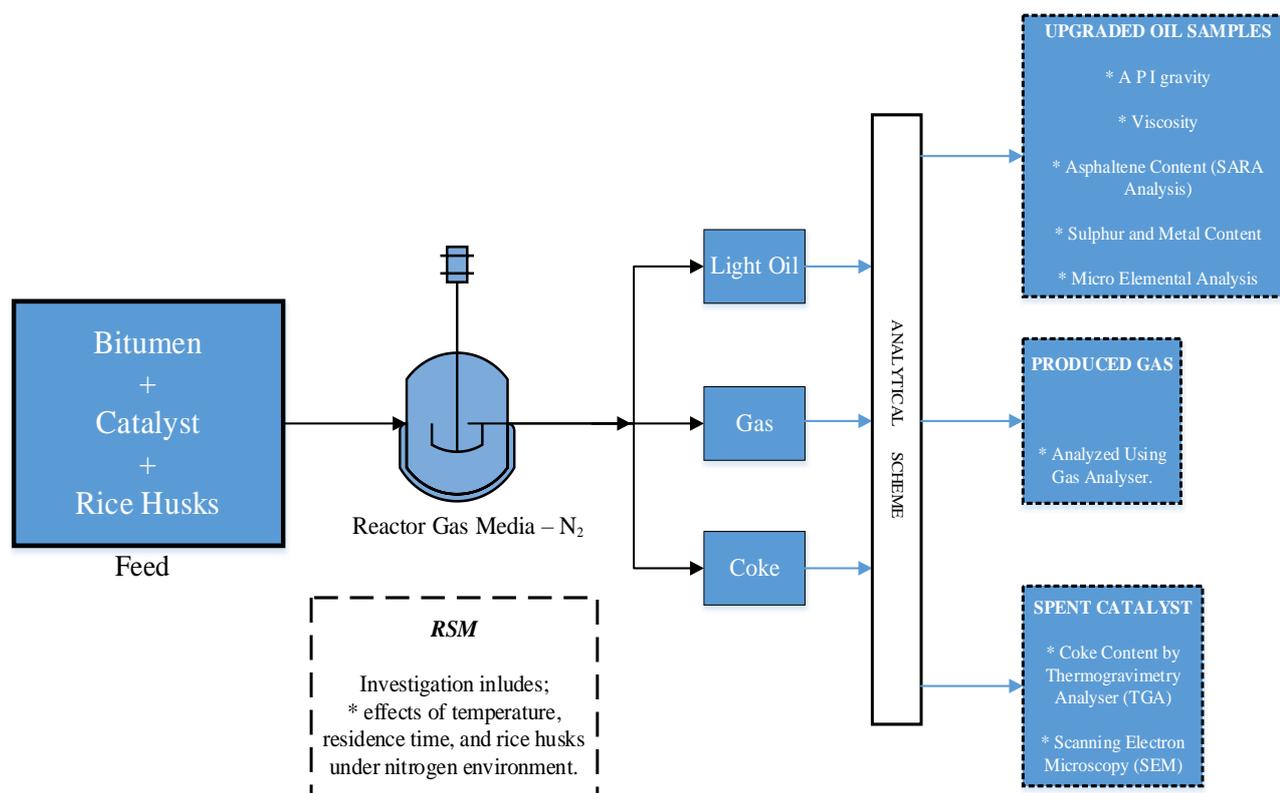
Figure 2 − Experimental Method and Analytical Scheme of Bitumen Upgrading

Four experimental runs were carried out by employing three different mesoporous aluminosilicate catalysts and optimal crude (without catalyst) to validate the optimum conditions known as the validation point. In this experiment, 0.5 wt.% mesoporous aluminosilicate catalysts of NiMo/ZSM-5, CoMo/HZSM-5 and Mo/HZSM-5 were employed respectively at a total weight of 50 g feed to further upgrade the bituminous oil at the optimum conditions (temperature of 345.716 °C, reaction time of 30.0 minutes and 1.0 wt.% of rice husks) to ascertain the effects of each catalyst on the optimised upgraded Agbabu bitumen to obtain optimised catalytically upgraded Agbabu bitumen. The composition of the four experimental runs at optimum conditions are:

1. Raw Bitumen + 1.0 wt.% Rice Husks (Optimal Crude).

2. Raw Bitumen + 1.0 wt.% Rice Husks + 0.5 wt.% NiMo/ZSM-5 (NiMo/ZSM-5 Catalyzed Crude).

3. Raw Bitumen + 1.0 wt.% Rice Husks + 0.5 wt.% CoMo/HZSM-5 (CoMo/HZSM-5 Catalyzed Crude).

4. Raw Bitumen + 1.0 wt.% Rice Husks + 0.5 wt.% Mo/HZSM-5 (Mo/HZSM-5 Catalyzed Crude).

RESULTS AND DISCUSSIONS

Physicochemical Properties of Raw Agbabu Bitumen. The physicochemical properties of the Agbabu bitumen are shown in Table 1.

FT-IR Analysis of Raw Agbabu Bitumen. This was performed to determine the functional group compositions of the Agbabu bitumen, as shown in Figure 3.
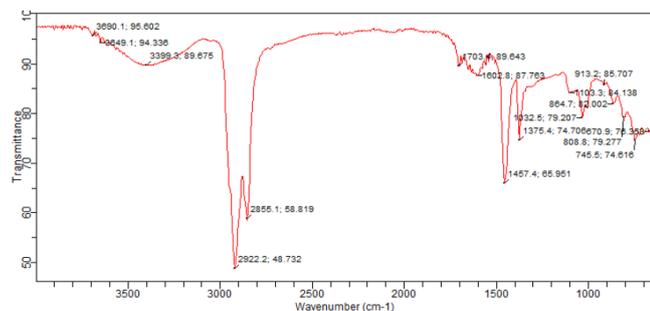
Figure 3 – FT-IR Spectrum of Raw Agbabu Bitumen

The FT-IR result obtained for the raw Agbabu bitumen in Figure 3 revealed that there were 3 broad peaks, 3690.1 cm^{-1}, 3649.1 cm^{-1}, and 3399.3 cm^{-1} observed in the range of 3700–3400 cm^{-1} absorption bands. This range (3700–3400 cm^{-1}) of absorption bands indicates hydrogen bonding and confirms the existence of hydrate (H_2O), hydroxyl (–OH), ammonium, or amino, phenolic, alcoholic and carboxylic compounds. The 3399.3 cm^{-1} absorption band is assigned to the hydrogen-bonded O–H group (intermolecular H bond) in phenolic, alcoholic, and carboxylic acid compounds in the asphaltenes [6]. The two intense peaks (2855.1 cm^{-1} and 2922.2 cm^{-1}) are assigned to –CH stretching bands for long-chain linear aliphatic compounds [7]. There were no observable peaks between the range (2800–1800 cm^{-1}) of absorption bands. But this absorption range is assigned to different functional groups; peaks between 2700 cm^{-1} and 2800 cm^{-1} are specific to aldehydes; (2500–2000 cm^{-1}) are the triple (C≡C) bond region and transition metal carbonyls. The peak 1703.4 cm^{-1} indicated simple amides, carbonyl compounds like ketones, aldehydes, esters or carboxylates functional group [8]. The medium peak 1602.8 cm^{-1} indicated the presence of double bond (C = C) stretching or olefinic compounds. 1457.4 cm^{-1} and 1375.4 cm^{-1} peaks were attributed to the bending vibration of C–H in methylene and methyl, respectively. The peak observed at 1103.3 cm^{-1} band was likely for esters linkages in asphaltene molecules. The band attributed to 1032.5 cm^{-1} was assigned S=O in alkane-substituted sulfoxides and also ester linkages present in asphaltene molecules, vinyl–related compounds found in resins, C-H bending in aromatics and C-O-C in mixed ethers [9]. The 913.2 cm^{-1} band was assigned to aliphatic fluoro compounds, C-F stretch, vinyl C-H out-of-plane bend and cyclohexane ring vibrations. The range of bands (870–730 cm^{-1}) was assigned to aromatic C-H out-of-plane bend [8].

GC-MS Analysis of Raw Agbabu Bitumen. GC-MS of the raw Agbabu bitumen was carried out to determine the chemical compounds present in the raw Agbabu bitumen. Asphaltenes, as one of the significant characteristics of heavy oil or bitumen, are non-volatile complex compounds consisting of different polymeric compounds with higher molecular weights. They are challenging to detect and analyse by merely GC-MS methods as GC-MS works on a chemical compound's volatility principle. Thus, in the GC-MS spectra of the raw bitumen and upgraded heavy oil or bitumen in this work, the GC-MS machine was able to detect and analyse aliphatics (saturates, cycloalkanes, alkenes, cycloalkenes, etc.), aromatic compounds, resins (low to no volatile compounds or semi-volatile), ester and polar compounds. There are 42 chemical compounds present in the raw bitumen obtained from the GC-MS spectra, as shown in Table 2.

The raw bitumen shown in Table 2 contains aliphatic compounds. These aliphatic compounds consist mainly of different $C_8 - C_{20}$ paraffinic hydrocarbons (saturates), alicyclic compounds in small amounts, and alkene. However, not all the chemical compounds present in GC-MS spectra could be identified, thus showing the nature and complexity of those that could not be determined.

The aromatic compounds in the raw bitumen shown in Table 2 consist of monochromatic, polycyclic aromatic hydrocarbons and heterocyclic hydrocarbons containing sulphur and nitrogen. Pyrene, naphthalene, biphenyl, anthracene, indene, and phenanthrene derivatives are included in polycyclic aromatic hydrocarbons. While heterocyclic hydrocarbons containing sulphur consist of mainly thiophenes derivatives, the heterocyclic hydrocarbons containing nitrogen contain derivatives such as indole, pyridine, quinolone, etc. [10].

Table 2 – Chemical Composition of Raw Agbabu Bitumen from the GC-MS Analysis

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
1	Vestitenone	069401-36-1	$C_{12}H_{18}O$	178.27	Aromatic
2	4-Methylundecane	002980-69-0	$C_{12}H_{26}$	170.34	Saturate
3	Undecane	001120-21-4	$C_{11}H_{24}$	156.31	Saturate
4	2-Methyltridecane	001560-96-9	$C_{14}H_{30}$	198.39	Saturate
5	Tridecane	000629-50-5	$C_{13}H_{26}$	184.36	Saturate
6	Tetradecane	000629-59-4	$C_{14}H_{30}$	198.39	Saturate
7	Spiro[2,4,5,6,7,7a-hexahydro-2-oxo-4,4,7a trimethylbenzofuran]-7,2'-(oxirane)	1000197-10-9	$C_{12}H_6O_3$	208.25	Aromatic
8	Sclareoloxide	051553-92-4	$C_{18}H_{30}O$	262.43	Resin
9	Oxalic acid, 6-ethyloct-3-yl hexyl ester	1000309-34-4	$C_{18}H_{34}O_4$	314.50	Aromatic
10	4-Ethyloctane	015869-86-0	$C_{10}H_{22}$	142.28	Saturate
11	2,6-dimethyloctane	002051-30-1	$C_{10}H_{22}$	142.28	Saturate
12	Methyl 2-oxo-5,6,7,8-tetrahydro-1H-quinoline-3-carboxylate	125031-45-0	-	-	-
13	2,4-Dimethylhexane	000589-43-5	C_8H_{18}	114.23	Saturate
14	Ethyl 5-(furan-2-yl)-1,2-oxazole-3-carboxylate	33545-40-3	$C_{10}H_9O_4$	207.18	Aromatic
15	E-11-Methyl-12-tetradecen-1-ol acetate	1000130-80-7	$C_{17}H_{32}O_2$	268.44	Aromatic
16	E-10-Methyl-11-tetradecen-1-ol acetate	1000130-79-0	$C_{17}H_{32}O_2$	268.44	Aromatic
17	4-Methyldodecane	006117-97-1	$C_{13}H_{28}$	184.37	Saturate
18	3-Methyldodecane	017312-57-1	$C_{13}H_{28}$	184.37	Saturate
19	Dodecane	000112-40-3	$C_{12}H_{26}$	170.33	Saturate
20	D-Homoandrostane, (5.alpha.,13.alpha.)-	054482-31-4	$C_{20}H_{34}$	274.49	Aromatic
21	2-Methyldecane	006975-98-0	$C_{11}H_{24}$	156.31	Saturate
22	2,9-Dimethyldecane	001002-17-1	$C_{12}H_{26}$	170.33	Saturate
23	2,4-Dimethyldecane	002801-84-5	$C_{12}H_{26}$	170.33	Saturate
24	Decane	000124-18-5	$C_{10}H_{22}$	142.29	Saturate
25	Cyclopropane carboxamide, 2-cyclopropyl-2-methyl-N-(1-cyclopropylethyl)-	331416-19-4	$C_{13}H_{21}NO$	207.16	Aromatic
26	Cyclopentanecarboxaldehyde, 2-methyl-3-methylene-	1000154-24-0	$C_8H_{12}O$	124.18	Aromatic
27	Cyclohexene, 4-pentyl-1-(4-propylcyclohexyl)-	108067-17-0	$C_{20}H_{36}$	276.50	Saturate
28	Cyclohexene, 4-(4-ethylcyclohexyl)-1-pentyl-	301643-32-3	$C_{19}H_{34}$	262.48	Saturate
29	Androstane, (5.alpha.)-	000438-22-2	$C_{19}H_{32}$	260.46	-
30	Cyclohexanebutanoic acid,2,2-dimethyl-6-methylene-, methyl ester	081752-87-6	$C_{11}H_{18}O_2$	182.26	Aromatic
31	Cholestan-3-ol, 4,4-dimethyl-, (3.beta.,5.alpha.)-	002550-84-7	$C_{29}H_{52}O$	416.72	-
32	Carbonic acid, nonyl vinyl ester	1000383-25-6	$C_{12}H_{22}O_3$	214.30	Resin
33	Carbonic acid, eicosyl vinyl ester	1000382-54-3	$C_{23}H_{44}O_3$	368.60	Resin
34	Androstane-2,11-dione, (5.alpha.)-	001449-57-6	$C_{19}H_{28}O_2$	288.42	-
35	3-Trifluoroacetoxypentadecane	1000245-47-8	$C_{17}H_{31}F_3O_3$	324.40	-
36	2-Bromononane	002216-35-5	$C_9H_{19}Br$	207.16	Saturate
37	1H-Indene, 5-butyl-6-hexyloctahydro-	055044-36-5	$C_{19}H_{36}$	264.49	Aromatic
38	1H-Indene, 2-butyl-5-hexyloctahydro-	055044-33-2	$C_{19}H_{36}$	264.49	Aromatic
39	10-Methylnonadecane	056862-62-5	$C_{20}H_{42}$	282.56	Saturate
40	1,1,6-trimethyl-3-methylene-2-(3,6,9,13-tetramethyl-6-ethenye-10,14-dimethylene-pentadec-4-enyl)cyclohexane	1000373-94-5	$C_{33}H_{56}$	452.80	Aromatic
41	1(3H)-Isobenzofuranone,6,7-dimethoxy-3-[2-(2-methoxyphenyl)-2-oxoethyl]-	1000350-76-1	$C_{19}H_{18}O_6$	342.34	Aromatic
42	(1S,4aS,4bS,7S,8aS,10aS)-7-Isopropyl-1,4a-dimethyltetradecahydrophenanthrene	002221-95-6	$C_{19}H_{34}$	262.48	Saturate

The ester compounds present in the raw bitumen in Table 2 contain furan, aldehyde, ketone acid, etc – oxygen-containing compounds. Some of these ester compounds also contain aromatic groups containing sulphur and nitrogen and are called aromatics. Thus, the nature of chemical compounds present in Table 2 was only identified as saturate, aromatic, and resin, as the as-

phaltenes in the raw bitumen cannot be detected by merely direct GC-MS spectrum due to the complex nature of asphaltenes. Figure 4 shows the GC-MS spectra for the raw Agbabu bitumen.

Figure 4 – GC-MS Spectrum for Raw Agbabu Bitumen

X-ray Florescence (XRF) Analysis of the Rice Husks. XRF analysis for the rice husks was performed to know the composition of the minerals in the rice husks. The elemental and oxide composition presented in Table 3 shows that the rice husks consist mainly of silica and silica oxide, with metallic oxides such as Fe_2O_3, MnO, ZnO and TiO_2 present as minor mineral compositions.

Silica and Alumina and their oxides are the main mineral compositions for the heavy oil upgrade as they support the mesoporous aluminosilicate catalysts. From Table 3, the oxide of silica (SiO_2) is 47.80 w/w%, and that of Alumina (Al_2O_3) is 6.82 w/w%.

Table 3 – XRF Analysis of Rice Husks

Oxide Composition	Value (w/w%)	Elemental Composition	Value (w/w%)
SiO_2	47.80	Si	22.35
P_2O_5	13.71	P	5.98
K_2O	12.48	K	10.36
MgO	7.20	Mg	4.40
Al_2O_3	6.82	Al	3.61
SO_3	4.93	S	1.97
CaO	2.80	Ca	2.00
Fe_2O_3	1.52	Fe	1.07
TiO_2	0.64	Ti	0.39
MnO	0.34	Mn	0.27
Rb_2O	0.11	Rb	0.10
ZnO	0.10	Zn	0.08
ZrO_2	0.08	Zr	0.06

At the same time, for elemental composition, silicon (Si) is 22.35 w/w%, and that of aluminium is 3.61 w/w% for the rice husks, which is an indication of an excellent precursor to the aluminosilicate catalysts. Thus, the XRF result for the rice husks revealed that the silica to Alumina (SiO_2/Al_2O_3) ratio is 11.89:1, and the silicon to aluminium (Si/Al) ratio is 5.95:1.

X-ray Diffraction (XRD) Analysis of the Rice Husks. X-ray Diffraction (XRD) analysis of the rice husks was performed to determine the silica and alumina phase of the rice husks sample. It was scanned by an X-ray diffractometer using CuKα radiation at 40 mA/45 kV and λ = 1.5406 Å, PSD length [2θ] of 3.35°, scan step time [s] of 29.07 sec., and scan position [2θ] at an angle/position from 5–78°. Figure 5 shows the XRD pattern of the rice husks.

Figure 5 – X-Ray Diffraction Spectrum of Rice Husks

According to JCPDS Card Number 021-1272 of rice husks XRD pattern, the rice husks have mainly silicon (Si) in the form of SiO_2 and is indicating the Si is in amorphous form due to the broad peak on 2θ at an angle of 22°. The following three sharp prominent peaks observed on the XRD spectrum 2θ at an angle of 25.5°, 36° and 49.5° show the presence of cristobalite (SiO_2) as the only crystalline phase present in the rice husks sample. The X-ray diffractometer pattern of the rice husks also conforms to what is obtainable in the literature [11].

XRD Analysis of the Modified Aluminosilicate Catalysts. XRD analysis of the three modified aluminosilicate catalysts was carried out to determine the phase composition of the aluminosilicate catalysts. Figure 6 shows the XRD patterns of the three aluminosilicate catalysts.

The three synthesised aluminosilicate catalysts displayed peaks along the axis 2θ at an angle of 7.2°, 8.5°, 23.1°, 26° and 27.6°, which correspond to [011], [020], [051], [332], and [343] planes respectively.
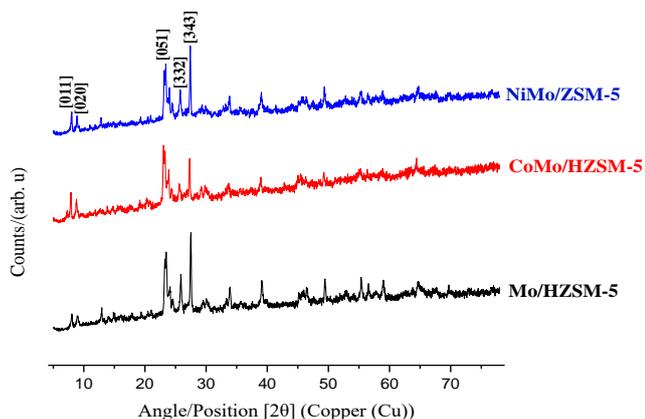
Figure 6 – X-Ray Powder Diffraction (XRD) Patterns of the Mesoporous Aluminosilicate Catalysts

The XRD patterns of all the aluminosilicate catalysts showed the characteristics of diffraction peaks of the mordenite framework inverted (MFI) crystalline structure, confirming the formation of ZSM-5 and HZSM-5 catalysts. Furthermore, the intensities of the peaks in the three aluminosilicate catalysts, as observed, are very similar, an indication that the gel used in the synthesis of the aluminosilicate catalysts did not affect the crystalline structure of the synthesised ZSM-5 and HZSM-5 catalysts [12, 13].

SEM Analysis of the Modified Aluminosilicate Catalysts. The three micrograph images (a), (b), and (c) of the aluminosilicate catalyst shown in Figure 7 show the presence of particles with agglomerated, well-defined, varied morphology. Thus providing good evidence that implies mesoporous heterogeneous surface morphology with a surface area of 705-809 m^2/g and pore volume of 0.75-0.87 cm^3/g, as evident in the BET analysis (Table 4) [14].
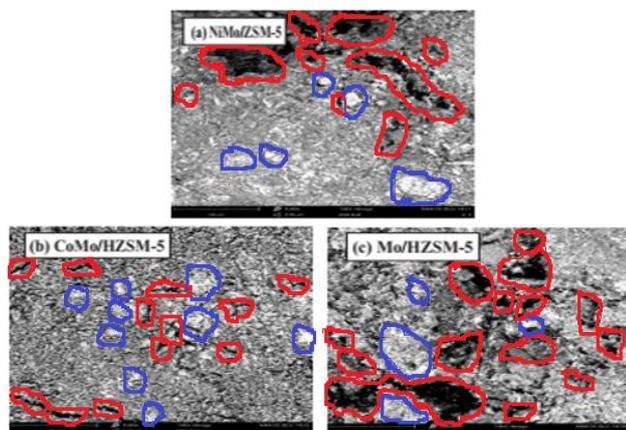

Figure 7 – SEM Micrographs of the Modified Aluminosilicate Catalysts (NiMo/ZSM-5, CoMo/HZSM-5, & Mo/HZSM-5).

The dark parts or patches on the SEM images are the pores of each catalyst, while the white spots are the solid materials of the catalyst. The catalyst becomes poisoned and deactivated when the pores are too large to accommodate the heavy crude oil's bulky molecules [13].

Table 4 – BET Properties of Mesoporous Aluminosilicate Catalysts

Catalyst	Surface area (m^2/g)	APD (nm)	Pore Volume (cm^3/g)
NiMo/ZSM-5	809	3.8	0.87
CoMo/HZSM-5	705	3.4	0.63
Mo/HZSM-5	798	3.6	0.75

Thus, mesoporous catalysts with larger pore volumes and active sites were used to upgrade bitumen.

BET Analysis of the Modified Aluminosilicate Catalysts. Brunauer Emmett Teller (BET) analysis of NiMo/ZSM-5, CoMo/HZSM-5, and Mo/HZSM-5 shown in Table 4, indicates that the aluminosilicate catalysts used in the upgrade of the bitumen showed high values for their surface area and pore volume, with average pore diameter in the mesopore range (2-50 nm) [15, 16]. Thus, each catalyst displayed a structure corresponding to a mesoporous aluminosilicate catalyst [17].

Summary of Optimised Agbabu Bitumen (Optimum Conditions). The numerical optimisation method involved setting a goal for each response to generate the optimal conditions while each factor selected was in default set goal – 'in range'. The optimisation goal was to minimise the viscosity, maximise the API gravity, minimise the residue yield and maximise the light oil yield as the responses. At the same time, the ranges of the factors (temperature, reaction time, and rice husks) are set as presented in Table 5.

Table 5 – Optimisation Criteria

Name	Goal	Lower Limit	Upper Limit
A: Temperature	is in range	300	350
B: Residence Time	is in range	30	180
C: Rice Husks	is in range	0.6	1
Viscosity	Minimise	20.63	68.924
API gravity	Maximise	19.99	24.52
Residue	Minimise	25.36	58.68
Light oil yield	Maximise	21.72	63.16

Table 5 shows the criteria used for the optimisation of Agbabu bitumen upgrading. While Table 6 shows some of the predicted optimisation results. The predicted responses under these conditions were 8.34 Pa.s, 24.52 °, 22.391 w/w% and 50.064 w/w% of viscosity, API gravity, residue yield and light oil yield.

Table 6 – Some of the Predicted Optimization Results

No	Temp. (°C)	Residence Time (min)	Rice Husks (%)	Viscosity (Pa.s)	API gravity (°)	Residue yield (w/w%)	Light oil yield (w/w%)	Desirability (Unity)	
1	345.716	30.000	1.000	8.340	24.520	22.391	50.064	0.909	Selected
2	345.935	30.007	1.000	8.160	24.559	22.407	49.870	0.908	
3	344.963	30.000	1.000	8.963	24.389	22.353	50.705	0.908	
4	345.825	30.703	1.000	8.611	24.520	22.487	49.844	0.908	
5	349.434	179.999	1.000	18.816	24.520	19.144	49.786	0.907	

Validation of the Optimum Conditions. The Agbabu bitumen upgrade was conducted at the optimum conditions (temperature of 345.716 °C, reaction time of 30.0 min and rice husks of 1.0 wt.%) to validate the result obtained from the Design Expert software. Table 7 compares the optimum value and validation value of the responses for the Agbabu bitumen upgrade after conduction at the optimum conditions.

Table 7 – Validation of the Optimum Conditions (Temp., 345.716 °C, Residence time of 30 Minutes and 1.0% of Rice husks)

No	Responses	Predicted value	Experimental Value	% Error
1	Viscosity	8.340	8.280	0.719
2	API gravity	24.520	24.351	0.689
3	Residue yield	22.390	22.56	0.759
4	Light oil yield	50.064	50.100	0.072

The result in Table 7 implied that variation between the optimum and validation value responses was minimal (this can be observed from the % error). Hence, this ascertains the accuracy of the results obtained from the optimisation.

Upgraded Agbabu Bitumen Analysis. The four experimental runs investigated in this work can be classified explicitly under thermal cracking (without catalyst) and catalytic thermal cracking (with catalyst). However, the parameter of interest is the effect of the three mesoporous catalysts (NiMo/ZSM-5, CoMo/HZSM-5 and Mo/HZSM-5) on the upgrading process at the optimum condition (temperature of 345.716 °C, residence time of 30.0 minutes and 1.0 wt.% of rice husks). The FT-IR and GC-MS analysis of each experimental run was conducted to ascertain the upgrade level by comparing and contrasting the heavy oil or bitumen before the upgrade and the upgraded oil after the upgrade or reaction. The results of employing the three mesoporous aluminosilicate catalysts were compared with the responses (viscosity, API gravity, residue and light oil yield) obtained at the optimum conditions (validation point/value) without catalysts, as shown in Table 8. Table 8 implies that bituminous oil was upgraded more when the catalyst was used. The performance of the upgrading process was measured through the following headings.

Viscosity, API gravity, and Light oil yield of optimised and upgraded Agbabu bitumen. The comparison of the viscosity, API gravity and light oil yield among the experimental runs with catalyst NiMo/ZSM-5 was observed to perform better in upgrading compared with catalysts CoMo/HZSM-5, Mo/HZSM-5 and optimal crude as shown in Table 8.

This can be attributed to the fact that the catalyst NiMo/ZSM-5 has more pore volume and surface area distribution than the other catalysts (CoMo/HZSM-5 and Mo/HZSM-5), thus more upgrade and yield. In addition, such catalysts are very effective in the catalytic transformations of bulk molecules of the bitumen due to the efficient transportation and diffusion of the reactants to the active sites and the reverse diffusion of the resulting reaction products [18].

Table 8 – Catalytic Optimised Agbabu Bitumen at Optimum Conditions

No	Experimental run	Responses			
		Viscosity (Pa.s)	API gravity (°)	Residue yield (w/w%)	Light oil yield (w/w%)
1	Optimal Crude	8.280	24.351	22.56	50.10
2	NiMo/ZSM-5 Catalyzed Crude	2.060	29.826	10.66	70.42
3	CoMo/HZSM-5 Catalyzed Crude	3.780	26.652	12.48	65.08
4	Mo/HZSM-5 Catalyzed Crude	3.160	27.984	12.12	68.66

From Table 8, the API gravity of the upgraded Agbabu bitumen falls within the range of medium crude oil (API gravity 22.3–31.1°) compared to conventional light crude oil of API gravity greater than 31.1° API. In some literature, medium crude oil is light crude oil with API gravity greater than 22° API [19].

Asphaltenes Reduction and Sulfur Removal. Saturates, Aromatics, Resins, and Asphaltenes (SARA) analysis is used to determine the organic components in crude oil based on the components above (SARA) according to their solubility and polarity. However, as an analytical technique, it is used to determine the quality of bitumen. Asphaltenes component is mainly responsible for the highly viscous nature of the bitumen. So, asphaltenes reduction is significant in determining the quality of bitumen in the oil industry. The decrease in asphaltenes in bitumen usually takes place through solvent deasphalting and bond cleavage to form lower molecular structures such as saturates, naphthenes, olefins, aromatics, and resins etc, through a general process known as organic cracking [2].

Desulphurisation is a significant reaction in upgrading heavy oil or bitumen. As a reaction, desulphurisation removes sulphur contained in the bitumen as heteroatoms. The less sulphur in the bitumen, the higher its price value in the global petroleum market. It is affirmed that dispersed mesoporous nano-catalyst has high tendencies of sulphur removal in desulphurisation reactions as the active sites of the catalyst can access and accommodate the bulky molecules of the bitumen [20, 21].

Table 9 shows the asphaltenes and sulfur reduction of Agbabu raw bitumen, optimal crude and catalytically upgraded Agbabu bitumen.

Table 9 – Asphaltenes Reduction and Sulfur Removal of Upgraded Agbabu Bitumen

No	Experimental Run	SARA (wt.%)			Sulfur (wt.%)	
		Saturates	Aromatics	Resins	Asphaltenes	Sulfur
1	Raw Bitumen	53.48	12.84	15.37	8.86	4.51
2	Optimal Crude	59.28	17.15	13.46	3.14	2.26
3	NiMo/ZSM-5 Catalyzed Crude	70.12	19.25	3.87	1.65	1.26
4	CoMo/HZSM-5 Catalyzed Crude	60.45	14.34	12.33	2.86	1.54
5	Mo/HZSM-5 Catalyzed Crude	67.53	16.41	4.85	2.10	1.89

NiMo/ZSM-5 catalysed crude has the lowest asphaltenes content of 1.65 wt.%, amounting to 81.38% reduction in asphaltenes; likewise, the sulfur content was observed to be 1.26 wt.%, amounting to 72.06% sulfur removal. The amount of sulfur it contains makes a particular crude sour or sweet. Sweet crude has deficient levels of sulfur, well under 1 wt.%, while sour oil has as much as 1-2 wt.% of sulfur [19]. Thus, all the Agbabu bitumen presented in Table 9 is sour crude.

H/C Ratio. The H/C ratio is one of the main characteristic properties used to measure the extent of upgrading. During hydrocracking, heavy molecules such as asphaltenes and resins are expected to break down into saturates and aromatics fragments, with some smaller molecules, partly associating with each other, increasing H/C ratio [22]. Table 10 shows that the H/C ratio of the raw Agbabu bitumen was 1.19:1, with an increment of 1.73:1, with catalyst NiMo/ZSM-5 as the highest H/C amongst the runs.

From an established work by [25] in which they employed Fe/ZSM-5, glycerol and biomass for the heavy oil upgrade, the upgraded oil has Carbon 65.22 wt.% and Hydrogen 9.13 wt.% which gave H/C ratio of 1.68:1.

Table 10 – Hydrogen to Carbon (H/C) Ratio of Upgraded Agbabu Bitumen

Experimental Run	Carbon (wt.%)	Hydrogen (wt.%)	Hydrogen/Carbon (H/C Ratio)
Raw Bitumen	76.64	7.67	1.19:1
Optimal Crude	73.53	7.58	1.23:1
NiMo/ZSM-5 Catalyzed Crude	87.7	12.71	1.73:1
CoMo/HZSM-5 Catalyzed Crude	67.32	7.11	1.26:1
Mo/HZSM-5 Catalyzed Crude	78.45	9.66	1.47:1

Figure 8 – FT-IR Spectrum of Upgraded Agbabu Bitumen at Optimum Conditions

The initial raw heavy crude employed by [25] has Carbon 85.45 wt.% and Hydrogen 11.19 wt. %, which gave H/C ratio of 1.57:1 and, hence, an increase of H/C ratio from 1.57:1 to 1.68:1. Thus, by comparison, this shows the extent of achievement in this research work. The H/C ratio for the raw heavy crude (raw Agbabu bitumen) and upgraded NiMo/ZSM-5 catalysed crude oil at optimum conditions increases from 1.19:1 to 1.73:1, respectively.

FT-IR Analysis of Upgraded Agbabu bitumen. The FTIR spectrum of the Agbabu bitumen after the upgrade was used to analyse and identify variation in the functional group of the active components present (saturates, aromatics, resins, and asphaltenes) based on the peak value in the infrared radiation region.

1. FT-IR Analysis of Upgraded Agbabu Bitumen at Optimum Conditions. However, the spectra of the other four runs showed a visible remarkable change when compared to the spectrum of the raw Agbabu bitumen as there was chemical bond cleavage such that from the raw Agbabu bitumen spectrum (Figure 3) showing the peaks (3690.1 cm^{-1}, 3649.1 cm^{-1} and 3399.3 cm^{-1}) had all disappeared (the observable contour or bulge from the raw Agbabu bitumen spectrum) indicating that the asphaltenes content has decreased in the raw Agbabu bitumen thus converted to or broken down to lighter components like saturates, aromatics and in some cases resins [23]. Several peaks, such as 2370.6 cm^{-1}, 2050.0 cm^{-1}, 1889.8 cm^{-1}, 1699.7 cm^{-1}, 1453.7 cm^{-1}, 965.4 cm^{-1}, and 812.6 cm^{-1} absorption bands, appeared in Figure 8 that were not in Figure 3, which is an indication of bond cleavage to lower molecular fractions such as saturates and aromatics [24].
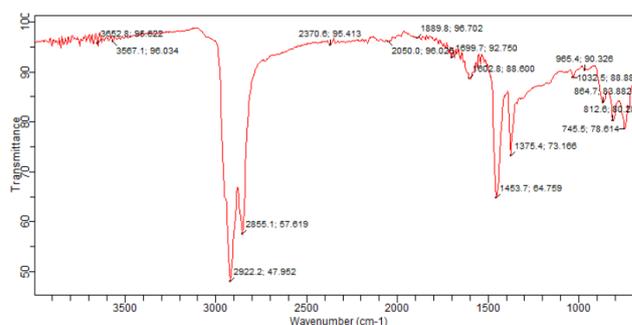
The FT-IR spectrum of the upgraded Agbabu bitumen at optimum conditions, as shown in Figure 9, indicates that there were more observable peaks than the FT-IR of the raw Agbabu bitumen.

2. FT-IR Analysis of NiMo/ZSM-5 Catalyzed Upgraded Agbabu Bitumen. There are more observable peaks on the FT-IR of the upgraded Agbabu bitumen using NiMo/ZSM-5 at the optimum conditions when compared to the FT-IR of the raw Agbabu bitumen (Figure 9), indicating bond breakage from asphaltenes to resins and other lower oil components.
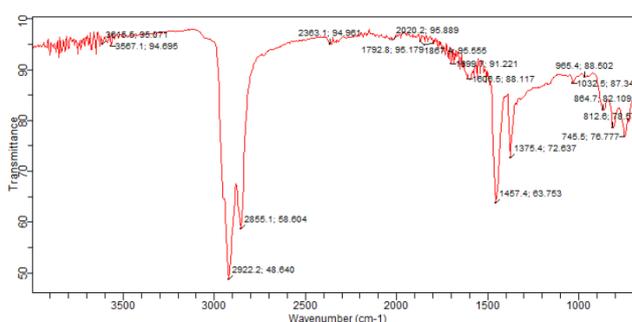
Figure 9 – FT-IR of NiMo/ZSM-5 Catalyzed Upgraded Agbabu Bitumen

Furthermore, the peaks 2363.1 cm^{-1}, 2020.2 cm^{-1}, 1867.4 cm^{-1}, 1792.8 cm^{-1}, 1699.7 cm^{-1}, and 1606.5 cm^{-1} absorption bands are primarily assigned to aliphatic saturated and unsaturated compounds, esters, and aromatics which is an indication of the bitumen upgrade [6].

3. FT-IR Analysis of CoMo/HZSM-5 Catalyzed Upgraded Agbabu Bitumen. There was not much upgrade on the Agbabu bitumen using CoMo/HZSM-5 catalyst as the peaks shown in the FT-IR spectrum in Figure 10 indicate lesser peaks compared to the FTIR spectrum obtained for the upgraded Agbabu bitumen at the optimum conditions and that of the catalysed NiMo/ZSM-5 upgraded Agbabu bitumen.

Figure 10 – FT-IR of CoMo/HZSM-5 Catalyzed Upgraded Agbabu Bitumen

Thus, there is lesser conversion to lower compounds of the functional group. The only differences in the peaks are 2050.0 cm^{-1}, 1871.1 cm^{-1}, and 1602.8 cm^{-1} absorption bands, which are assigned to (aromatic combination bands, transition metal carbonyls), five-membered ring aldehyde and (alkenyl C=C stretch, conjugated C=C) respectively [9].
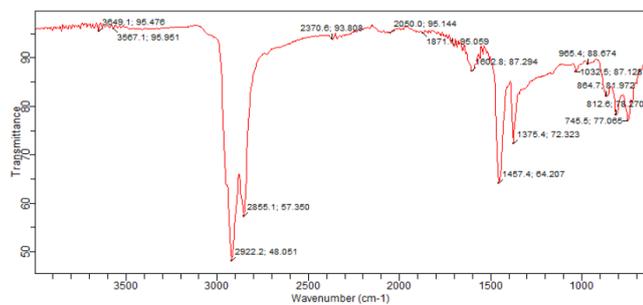
4. FT-IR Analysis of Mo/ZSM-5 Catalyzed Upgraded Agbabu Bitumen. There were visible absorption bands shown in Figure 11, and most of the bond cleavage ends in the aromatics group.
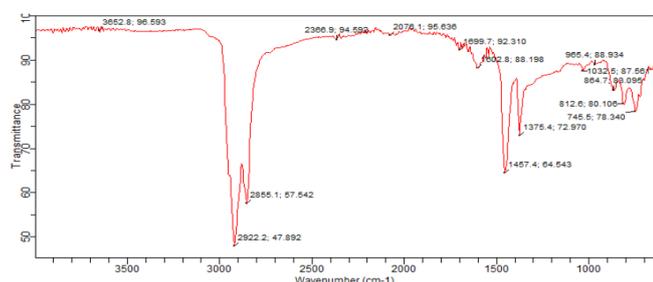

Figure 11 – FT-IR of Mo/HZSM-5 Catalyzed Upgraded Agbabu Bitumen

The visible absorption bands in Figure 11, different from all the FTIR discussed earlier, are 2366.9 cm^{-1}, 2076.1 cm^{-1}, and 1699.7 cm^{-1} absorption bands, and are assigned to (C≡C group, NH component), Isothiocyanate (-NCS), and C=O in aromatic carboxylic acids), respectively [6]. Amongst the three catalysts employed (NiMo/ZSM-5, CoMo/HZSM-5, and Mo/HZSM-5) in carrying out the Agbabu bitumen upgrade, catalyst Mo/HZSM-5 has the minor conversion to lower molecules as most of its' aromatics not converted to lower compounds but rather the asphaltenes were converted to more aromatics resulting to more aromatics peaks on the FT-IR spectrum [8]. This effect of Mo/HZSM-5 catalyst on the Agbabu bitumen upgrade can be much felt or understood from the GC-MS spectrum of the upgraded Agbabu bitumen using Mo/HZSM-5 at optimum conditions.

A cascaded graph of the FT-IR spectrum of the raw Agbabu bitumen, optimal crude, NiMo/ZSM-5 catalysed crude, CoMo/HZSM-5 catalysed crude and Mo/HZSM-5 catalysed crude run are displayed on a single graph shown in Figure 12 for contrast and comparison. The spectra of the other four runs showed a visible remarkable change when compared to the spectrum of the raw Agbabu bitumen, as there was chemical composition shift/bond cleavage such that the asphaltenes region from the raw bitumen spectrum showing the peak (3849.1 cm^{-1}, 94.336%) and (3399.3 cm^{-1}, 89.675%) have all disappeared (the observable contour or bulge from the raw bitumen spectrum) indicating that the asphaltenes content has decreased in the raw Agbabu bitumen thus converted to or broken down to lighter components like saturates, aromatics and in some cases resins.
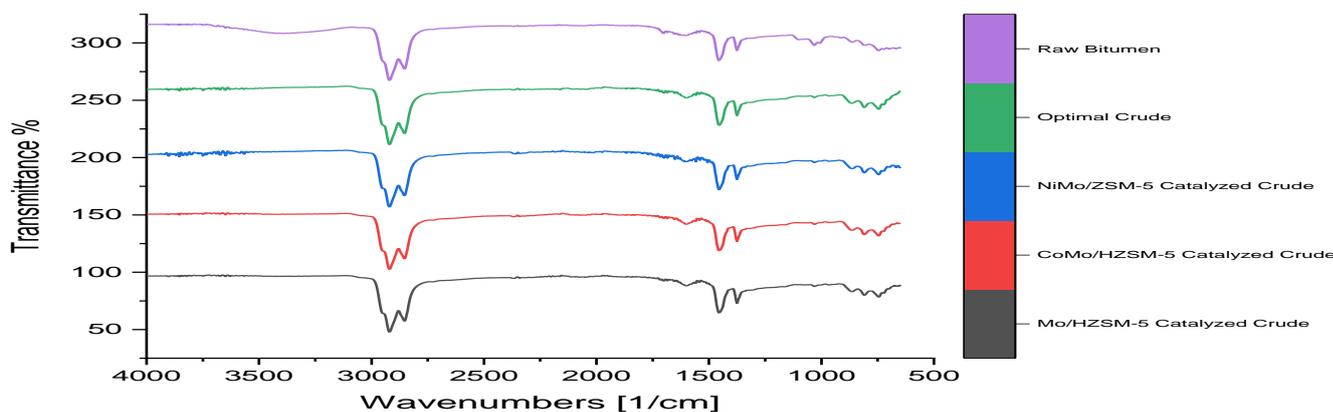

Figure 12 – FT-IR Spectrum of the Raw Agbabu Bitumen Before and After Upgrade

GC-MS Analysis of Agbabu Bitumen. The results of the GC-MS analysis led to the identification of several compounds from the GC fractions of the raw bitumen after the upgrade. These compounds were identified through mass spectrometry attached to the GC.

1. GC-MS Analysis of Optimised Agbabu Bitumen. From GC-MS analysis of the run "optimal crude" without catalyst – (Raw bitumen + 1.0 wt.% Rice husks @ 345.716 °C, 30 min), 21 different compounds were identified as shown in Table 11 and Figure 13 shows the GC-MS spectrum for the run "optimal crude" without catalyst.

2. GC-MS Analysis of NiMo/ZSM-5 Catalyzed Agbabu Bitumen. From GC-MS analysis of the run "NiMo/ZSM-5 catalysed crude", 73 different compounds were identified, as shown in Table 12, and Figure 14 shows the GC-MS spectrum of NiMo/ZSM-5 catalysed Agbabu bitumen. The NiMo/ZSM-5 catalysed Agbabu bitumen has more chemical compounds than the GC-MS spectrum of the raw Agbabu bitumen, with only 42 chemical compounds identified. This indicates an upgrade from higher molecular fractions to lower molecular fractions.

3. GC-MS Analysis of CoMo/HZSM-5 Catalyzed Agbabu Bitumen. From GC-MS analysis of the run "CoMo/HZSM-5 catalysed crude", ten different compounds were identified, as shown in Table 13, and Figure 15 shows the GC-MS spectrum of CoMo/HZSM-5 catalysed Agbabu bitumen. From the spectrum, the CoMo/HZSM-5 catalyst does not favour the bitumen upgrade, as most of the asphaltene components were only broken down to resins rather than aromatics and saturates.

4. GC-MS Analysis of Mo/HZSM-5 Catalyzed Agbabu Bitumen. From GC-MS analysis of the run "Mo/HZSM-5 catalysed crude," 61 different compounds were identified, as shown in Table 14. Figure 16 shows the GC-MS spectrum of Mo/HZSM-5 catalysed Agbabu heavy crude oil. There was also a noticeable upgrade of the Agbabu bitumen with the Mo/HZSM-5 catalysed reaction, as the asphaltenes bond cleavage mostly ends to form aromatic compounds, a few resins, and saturates.

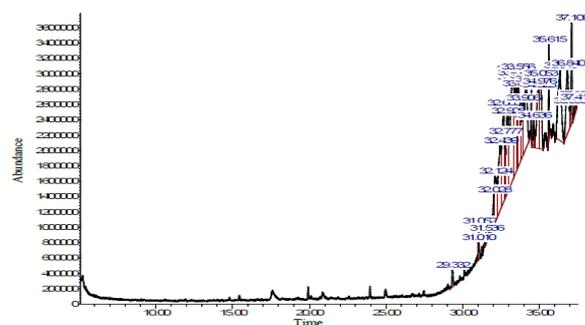Figure 13 – GC-MS Spectra of Optimised Agbabu Bitumen

Figure 14 – GC-MS Spectrum of NiMo/ZSM-5 Catalyzed Agbabu Bitumen

Figure 15 – GC-MS Spectrum of CoMo/HZSM-5 Catalyzed Agbabu Bitumen

Figure 16 – GC-MS Spectrum of Mo/HZSM-5 Catalyzed Agbabu Bitumen

Table 11 – Chemical Composition of Optimised Agbabu Bitumen from GC-MS Analysis

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
1	Z,Z-6,24-Tritriacontadien-2-one	1000111-38-8	$C_{33}H_{64}O$	476.90	-
2	trans-2-Ethyl-2-hexen-1-ol	1000139-52-3	$C_8H_{16}O$	128.21	-
3	Pentatriacontane, 13-docosenylidene-	1000156-09-1	$C_{47}H_{94}$	659.20	-
4	Pentadecanoic acid, 13-methyl-, methyl ester	005487-50-3	$C_{17}H_{34}O_2$	270.45	Aromatic
5	n-Tridecan-1-ol	000112-70-9	$C_{13}H_{28}O$	200.36	-
6	Lup-20(29)-en-3-ol, acetate, (3.beta.)-	001617-68-1	$C_{32}H_{52}O_2$	468.75	-
7	Hexadecanoic acid, 2-hydroxy-, methyl ester	016742-51-1	$C_{17}H_{34}O_3$	286.40	Aromatic
8	Cyclotriacontane	000297-35-8	$C_{30}H_{60}$	420.80	Saturate
9	Cyclononasiloxane, octadecamethyl-	000556-71-8	$C_{18}H_{54}O_9Si_9$	667.40	Resin
10	Cyclohexane, (1-hexadecylheptadecyl)-	055517-75-4	$C_{39}H_{78}$	547.04	Saturate
11	Carbamic acid, N-(4-chlorophenyl)-, 4-nitrophenyl ester	003848-41-7	-	-	Aromatic
12	Borane, 2,3-dimethyl-2-butyl- (dimer)	1000159-64-3	$C_{12}H_{30}B_2$	196.00	-
13	benzenesulfonyl fluoride, 4-(hexadecyloxy)-3-nitro-	1000402-84-4	$C_{22}H_{36}FNO_5S$	445.60	Aromatic
14	9,19-Cyclolanostan-3-ol, 24,24-epoxymethano-, acetate	1000190-57-2	$C_{33}H_{54}O_3$	498.80	Resin
15	7,10-Octadecadienoic acid, methyl ester	056554-24-6	$C_{19}H_{34}O_2$	294.47	Aromatic
16	4-Trifluoroacetoxytetradecane	1000245-47-6	$C_{16}H_{29}F_3O_2$	310.39	-
17	1-Heptadecanamine	004200-95-7	$C_{17}H_{37}N$	255.48	-
18	1,3,5,7,9,11-Hexavinyl-3,5,9,11-tetrabutoxybicyclo[5.5.1]hexasiloxane	110991-14-5	-	-	Resin
19	1,22-Docosanediol	022513-81-1	-	-	-
20	1,1,1,5,7,7,7-Heptamethyl-3,3 bis(trimethylsiloxy)tetrasiloxane	038147-00-1	$C_{13}H_{39}O_5Si_6$	443.96	Resin
21	.alpha.-d-Glucose, 4,6-O-isopropylidene-1-O-methyl-6-O-[4-bromobenzenesulfonate]	1000127-18-3	$C_{22}H_{36}BrO_8S$	453.30	Aromatic

Table 12 – Chemical Composition of NiMo/ZSM-5 Catalyzed Agbabu Bitumen from GC-MS Analysis

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
1	Z-8-Hexadecene	1000130-87-5	$C_{16}H_{32}$	224.43	-
2	trans-13-Octadecenoic acid	000693-71-0	$C_{18}H_{34}O_2$	282.46	-
3	17-hexadecyltetratriacontane	055256-07-0	$C_{50}H_{102}$	703.34	Saturate
4	Phthalic acid, pentyl 2,4,6-trichlorobenzyl ester	1000382-87-9	-	-	Aromatic
5	Phenanthrene-10-ethanamine, 3-bromo-.beta.-hydroxy-N,N-diheptyl-, hydrosulfate	049647-04-3	-	-	-
6	Pentadecanoic acid, 13-methyl-, methyl ester	005487-50-3	$C_{17}H_{34}O_2$	270.45	Aromatic
7	13-Undecylpentacosane	055517-89-0	$C_{47}H_{74}$	506.58	Saturate
8	Pennogenin diacetate	065380-31-6	$C_{31}H_{46}O_6$	514.7	-
9	Palmitoleic acid	000373-49-9	$C_{16}H_{30}O_2$	254.41	-
10	Ttetradecyloxirane	007320-37-8	$C_{16}H_{32}O$	240.43	Resin
11	Oleic Acid	000112-80-1	$C_{18}H_{34}O_2$	282.46	-
12	Nickel, bis[bis(2-methylpropyl) carbamodithioato-S,S']-, (SP-4-1)-	015317-78-9	$C_{18}H_{36}N_2NiS_4$	467.45	Resin
13	Methyl 8-methyl-decanoate	1000336-49-1	$C_{12}H_{24}O_2$	200.32	Aromatic
14	Methyl 2-hydroxy-pentacosanoate	118745-42-9	$C_{26}H_{52}O_3$	412.70	Aromatic
15	Hexadecanoic acid, methyl ester	000112-39-0	$C_{17}H_{34}O_2$	270.50	Aromatic
16	Hexadecanenitrile	000629-79-8	$C_{16}H_{31}N$	237.42	-
17	Hexadecane	000544-76-3	$C_{16}H_{34}$	226.44	Saturate
18	Heptylcyclohexane	005617-41-4	$C_{13}H_{26}$	182.35	Saturate
19	Heptadecanoic acid, 16-methyl-, methyl ester	005129-61-3	$C_{19}H_{38}O_2$	298.50	Aromatic

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
20	Estra-1,3,5(10)-trien-17.beta.-ol	002529-64-8	$C_{18}H_{24}O$	256.39	Aromatic
21	E-14-Hexadecenal	330207-53-9	$C_{16}H_{30}O$	238.41	-
22	E-11-Hexadecenal	1000130-86-1	$C_{16}H_{30}O$	238.41	-
23	Dodecanoic acid, methyl ester	000111-82-0	$C_{13}H_{26}O_2$	214.34	Aromatic
24	Diethyl Phthalate	000084-66-2	$C_{12}H_{14}O_4$	222.40	Aromatic
25	Decanoic acid, ethyl ester	000110-38-3	$C_{12}H_{24}O_2$	200.32	Aromatic
26	Cyclohexanol, 2-(2-propynyloxy)-, trans-	007229-32-5	$C_9H_{14}O_2$	154.21	-
27	Undecylcyclohexane	054105-66-7	$C_{17}H_{34}$	238.45	Saturate
28	Cyclohexane, 1,1'-(1-methyl-1,3-propanediyl)bis-	041851-35-8	$C_{16}H_{30}$	222.41	Saturate
29	cis-9-Hexadecenal	056219-04-6	$C_{16}H_{30}O$	238.41	Aromatic
30	cis-13-Octadecenoic acid, methyl ester	1000333-58-3	$C_{19}H_{36}O_2$	296.50	Aromatic
31	cis-11-Hexadecenal	053939-28-9	$C_{16}H_{30}O$	238.41	Aromatic
32	Bicyclo[10.8.0]eicosane, (E)-	1000155-85-0	$C_{20}H_{38}$	275.50	Saturate
33	Benzene, 1,2,3-trifluoro-4-nitro-	000771-69-7	$C_6H_2F_3NO_2$	177.08	Aromatic
34	Allopregan-3,16-diol, O,O'-diacetyl-20-s-[3-methylpyrid-6-yl]-	1000214-17-9	-	-	-
35	Acetyl chloride, chloro-	000079-04-9	$C_2H_2Cl_2O$	112.94	-
36	9-Tetradecenal, (Z)-	053939-27-8	$C_{14}H_{26}O$	210.36	-
37	9-Octadecenoic acid, methyl ester, (E)-	001937-62-8	$C_{19}H_{36}O_2$	296.50	Aromatic
38	9-Octadecenoic acid, (E)-	000112-79-8	$C_{18}H_{34}O_2$	282.50	-
39	9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	000111-03-5	$C_{21}H_{40}O_4$	356.50	Aromatic
40	9-Octadecenal	005090-41-5	$C_{18}H_{34}O_2$	266.5	-
41	9-Nonadecene	031035-07-1	$C_{19}H_{38}$	266.51	-
42	9-Heptadecanone	000540-08-9	$C_{17}H_{34}O$	254.50	-
43	9,19-Cyclolanostan-3-ol, 24,24-epoxymethano-, acetate	1000190-57-2	$C_{33}H_{54}O_3$	498.80	Resin
44	8-Cyclohexadecen-1-one	003100-36-5	$C_{16}H_{28}O$	236.39	-
45	8,11-Octadecadienoic acid, methyl ester	056599-58-7	$C_{19}H_{34}O_2$	294.26	Aromatic
46	7-Oxabicyclo[4.1.0]heptane, 1,5-dimethyl-	162239-52-3	$C_8H_{14}O$	126.20	-
47	7-Hexadecene, (Z)-	035507-09-6	$C_{16}H_{32}$	224.42	-
48	5-Octadecene, (E)-	007206-21-5	$C_{18}H_{36}$	252.48	-
49	4-Trifluoroacetoxypentadecane	1000245-47-9	$C_{17}H_{31}F_3O_2$	324.40	-
50	4-n-Hexylthiane, S,S-dioxide	070928-52-8	$C_{11}H_{22}O_2S$	218.36	-
51	4-Hydroxyphenyllactic acid, 3TBDMS derivative	1000221-80-2	$C_{27}H_{52}O_4Si_3$	524.96	Resin
52	4-Androsten-4-chloro-3.alpha.-ol-17-one, di-trimethylsilyl	1000412-24-8	$C_{26}H_{43}ClO_2Si_2$	479.20	Resin
53	4-(Diethylphosphoryl)-4-methylpentan-2-one	015090-36-5	$C_{10}H_{21}O_2P$	204.25	-
54	3-Nonenoic acid, ethyl ester	091213-30-8	$C_{11}H_{20}O_2$	184.28	Aromatic
55	3'H-Cycloprop(1,2)-5-cholest-1-en-3-one, 1'-carboethoxy-1'-cyano-1,2-dihydro-	075857-80-6	$C_{32}H_{49}NO_3$	495.37	Resin
56	3-Aza-2-oxabicyclo[2.2.2]oct-5-ene, 3-acetyl-7-endo,8-exo-dimethoxy-	102724-50-5	-	-	-
57	2-Methyl-Z,Z-3,13-octadecadienol	1000130-90-5	$C_{19}H_{36}O$	280.50	-
58	2-Hexyldecyl isobutyrate	1000368-55-3	$C_{20}H_{40}O_2$	312.50	-
59	2-Dodecen-1-yl(-)succinic anhydride	019780-11-1	$C_{16}H_{26}O_3$	266.38	Aromatic
60	2,5-Furandione, 3-dodecyl-	059426-46-9	$C_{16}H_{26}O_3$	266.38	Aromatic
61	2,3-Di[p-chlorophenyl]-5,8-dimethoxy-6-acetamidoquinoxaline	056393-33-0	-	-	-
62	1-Hexadecanol	036653-82-4	$C_{16}H_{34}O$	242.44	-
63	1-Eicosene	003452-07-1	$C_{20}H_{40}$	280.53	-
64	1-Decyloxy-2-nitrobenzene	098311-79-6	$C_{16}H_{25}NO_3$	279.38	Aromatic
65	13-Octadecenoic acid, methyl ester	056554-47-3	$C_{19}H_{36}O_2$	296.50	Aromatic

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
66	12-Methyl-E,E-2,13-octadecadien-1-ol	1000130-90-4	$C_{19}H_{36}O$	280.50	-
67	11-Dodecen-1-ol trifluoroacetate	128792-46-1	$C_{14}H_{23}F_3O_2$	280.33	-
68	1-[3,3-Difluoro-1-(pentafluoroethyl)-2-(trifluoromethyl)prop-2-en-1-ylidene]-2-[2,2,2-trifluoro-1-(trifluoromethyl)ethylidene]hydrazine	1000394-35-5	-	-	-
69	1,3-Dimethyl-4,8-dioxatricyclo[5.1.0.0(3,5)]octane-2,6-diol	1000186-19-0	-	-	-
70	1,3,5,7,9,11-Hexavinyl-3,5,9,11-tetrabutoxybicyclo[5.5.1]hexasiloxane	110991-14-5	-	-	-
71	1-(3-Acetamidophenyl)-3-(2,2,2-trichloro-1-isovaleramidoethyl)-2-thiourea	294658-29-0	-	-	-
72	[2-Acetyl-3-(2,4-dichlorophenyl)-5-(2,4-dichlorostyryl)-3,4-dihydrophenoxy]difluoroborane	1000223-62-4	-	-	-
73	(S)-(+)-Epichlorohydrin	067843-74-7	C_3H_5ClO	92.52	Resin

Table 13 − Chemical Composition of CoMo/HZSM-5 Catalyzed Agbabu Bitumen from GC-MS Analysis

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
1	Pyridine-3-carboxamide, oxime, N-(2-rifluoromethylphenyl)-	288246-53-7	$C_{13}H_{10}F_3N_3O$	281.23	-
2	Morphine, 2TMS derivative	055449-66-6	$C_{23}H_{35}NO_3Si_2$	429.70	Resin
3	Hexasiloxane, tetradecamethyl-	000107-52-8	$C_{14}H_{42}O_5Si_6$	458.99	Resin
4	Dodecyl propyl ether	1000406-27-7	$C_{15}H_{32}O$	228.41	Aromatic
5	Dihydrophytol, TMS derivative	078695-20-2	$C_{23}H_{50}OSi$	370.70	-
6	Cyclononasiloxane, octadecamethyl-	000556-71-8	$C_{18}H_{54}O_9Si_9$	667.36	Resin
7	3-Isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(trimethylsiloxy)tetrasiloxane	071579-69-6	$C_{18}H_{52}O_7Si_7$	577.2	Resin
8	3'H-Cycloprop(1,2)-5-cholest-1-en-3-one, 1'-carboethoxy-1'-cyano-1,2-dihydro-	075857-80-6	$C_{32}H_{49}NO_3$	495.70	Resin
9	3-Bromo-N-(3,5-dichlorophenyl)benzamide, TMS derivative	1000331-99-9	$C_{16}H_{16}Br_2Cl_2NOSi$	417.2	Resin
10	1,1,1,5,7,7,7-Heptamethyl-3,3 bis(trimethylsiloxy)tetrasiloxane	038147-00-1	$C_{13}H_{40}O_5Si_6$	444.97	Resin

Table 14 − Chemical Composition of Mo/HZSM-5 Catalyzed Agbabu Heavy Bitumen from GC-MS Analysis

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
1	Z-6,17-Octadecadien-1-ol acetate	086252-73-5	$C_{20}H_{36}O_2$	308.50	-
2	Z,E-2-Methyl-3,13-octadecadien-1-ol	1000131-10-5	$C_{19}H_{36}O$	280.50	-
3	Undec-10-ynoic acid, tridec-2-yn-1-yl ester	1000406-96-9	$C_{24}H_{40}O_2$	360.60	Aromatic
4	Trimyristin	000555-45-3	$C_{45}H_{86}O_6$	723.16	Aromatic
5	trans-2-Hexenoic acid, 5-methyl-2-isopropyl-, methyl ester	1000139-87-5	$C_{11}H_{20}O_2$	184.27	Aromatic
6	Thiourea, 2-cyano-1,3-dihexyl-	056342-27-9	$C_{14}H_{26}N_2S_2$	286.50	-
7	Tetracosanoic acid, heptyl ester	1000405-21-9	$C_{20}H_{40}O_2$	312.50	Aromatic
8	Sulfurous acid, 2-propyl undecyl ester	1000309-12-2	$C_{14}H_{30}O_3S_2$	278.45	Aromatic
9	Succinic acid, 4-chloro-3-methylphenyl tetrahydrofurfuryl ester	1000390-72-4	-	-	-
10	Spiro[2,4,5,6,7,7a-hexahydro-2-oxo-4,4,7a-trimethylbenzofuran]-7,2'-(oxirane)	1000197-10-9	$C_{12}H_6O_3$	208.25	Aromatic
11	Sclareolide	000564-20-5	$C_{16}H_{26}O_2$	250.38	Aromatic

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
12	1-(2-furanylcarbonyl)piperazine	040172-95-0	$C_9H_{12}N_2O_2$	180.20	Aromatic
13	Phenanthrene-10-ethanamine, 3-bromo-.beta.-hydroxy-N,N-diheptyl-, hydrosulfate	049647-04-3	$C_{30}H_{42}BrNO_4S$	592.63	Aromatic
14	Oxirane, tetradecyl-	007320-37-8	$C_{16}H_{32}O$	240.42	Resin
15	2-methyloctane	003221-61-2	C_9H_{20}	128.26	Saturate
16	N-Pyrrylcarbinol	092776-61-9	C_5H_7NO	97.12	-
17	N-Benzyl-N-ethyl-p-isopropylbenzamide	015089-22-2	$C_{19}H_{23}NO$	281.40	Aromatic
18	N-(3-Amino-1,4-dioxo-1,4-dihydronaphthalen-2-yl)-N-phenylacetamide	004497-84-1	$C_{18}H_{14}N_2O_3$	306.30	Aromatic
19	Muscimol	002763-96-4	$C_4H_6N_2O_2$	114.10	-
20	Isopulegol	000089-79-2	$C_{10}H_{18}O$	154.25	Aromatic
21	Tetradecamethylhexasiloxane	000107-52-8	$C_{14}H_{42}O_5Si_6$	458.99	Resin
22	Hexadecanoic acid, methyl ester	000112-39-0	$C_{17}H_{34}O_2$	270.50	Aromatic
23	Eicosyl isobutyl ether	1000406-33-0	$C_{23}H_{48}O$	340.60	-
24	E-8-Methyl-9-tetradecen-1-ol acetate	1000130-81-4	$C_{17}H_{32}O_2$	268.40	-
25	E-10-Octadecen-1-ol acetate	002195-92-8	$C_{20}H_{38}O_2$	310.50	-
26	Diethyl[[3-octylsulfonyl]-4-n-butylanilinomethylene]malonate	1000214-51-0	-	-	-
27	Decyl heptyl ether	1000406-39-1	$C_{17}H_{36}O$	256.50	Aromatic
28	Cyclopropane, 1-chloro-1-ethyl-2,2,3-trimethyl-	061142-56-1	$C_8H_{15}Cl$	146.66	-
29	1,2,4,5-tetraethylcyclohexane	061142-00-5	$C_{14}H_{28}$	196.37	Saturate
30	1-aminomethylcyclododecanol	000832-29-1	$C_{13}H_{27}NO$	213.36	-
31	Cyclodisilazane-2,2,4,4-tetramine, N,N,N',N'-tetramethyl-1,3-bis[tris(methylamino)silyl]-	034665-55-9	$C_{10}H_{40}N_{12}Si_4$	440.84	Resin
32	Borane, isopropyldipropyl-	010325-43-6	$C_9H_{21}B$	140.07	-
33	Bicyclo[2.2.1]heptane-1-carboxylic acid, 7,7-dimethyl-2-oxo-, (3,4-difluorophenyl)amide	1000315-99-0	-	-	-
34	Bicyclo[2.2.1]heptane-1-carboxylic acid, 4,7,7-trimethyl-3-oxo-2-oxa-, (4-trifluoromethylphenyl)amide	1000315-86-8	-	-	-
35	9-Undecenal, 2,6,10-trimethyl-	000141-13-9	$C_{14}H_{26}O$	210.36	-
36	9-Tetradecen-1-ol, (E)-	052957-16-1	$C_{14}H_{28}O$	212.37	-
37	9,12-Octadecadienoic acid, methyl ester, (E,E)-	002566-97-4	$C_{19}H_{34}O_2$	294.50	Aromatic
38	8-Heptadecene	002579-04-6	$C_{17}H_{34}$	238.50	-
39	8,8,9-Trimethyl-deca-3,5-diene-2,7-dione	1000194-25-9	$C_{13}H_{20}O_2$	208.30	-
40	6-Bromohexanoic acid, 2-bromo-4-fluorophenyl ester	1000293-66-9	$C_9H_{13}Br_2FO_2$		Aromatic
41	6-Amino-1,3,5-triazine-2,4(1H,3H)-dione	000645-93-2	$C_3H_4N_4O_2$	128.09	-
42	5-Hydroxy-1-(4-methoxy-phenyl)-5-phenyl-pyrrolidine-2,3-dione	1000296-82-7	$C_{17}H_{15}NO_4$	297.31	Aromatic
43	4-Methyl-trans-3-thiabicyclo[4.4.0]decane	1000215-94-1	-	-	-
44	3H-Cyclodeca[b]furan-2-one, 4,9-dihydroxy-6-methyl-3,10-dimethylene-3a,4,7,8,9,10,11,11a-octahydro-	1000310-90-7	$C_{15}H_{20}O_4$	264.32	Aromatic
45	3,5-Dimethyl-4-chloroisoxazole	010557-86-5	C_5H_6ClNO	131.56	Aromatic
46	3,4-Diiodo-3,4-dedioxy-1,2:5,6-diacetone dulcitol	1000129-83-6	-	-	-
47	2-Pentadecanone, 6,10,14-trimethyl-	000502-69-2	$C_{18}H_{36}O$	268.48	-
48	2-Methyl-Z,Z-3,13-octadecadienol	1000130-90-5	$C_{19}H_{36}O$	280.50	-
49	2H-Inden-2-one, octahydro-3a-methyl-, trans-	020379-99-1	$C_{10}H_{16}O$	152.23	Aromatic

No	Chemical Compound	CAS No	Mol. Formula	Mol. Wt. (g/mol)	Nature of Compounds
50	2H-Bisoxireno[2,3:8,8a]azuleno[4,5-b]furan-7(3aH)-one, octahydro-3a,8c-dimethyl-6-methylene-, (1aR,2aR,3aS,5aS,8aS,8bS,8cS)-	139343-89-8	$C_{15}H_{18}O_4$	262.12	Resin
51	2,5-Dihydroxybenzoic acid, 3TMS derivative	003618-20-0	$C_{16}H_{30}O_4Si_3$	370.66	Resin
52	2,4-Hexadienoic acid, ethyl ester, (2E,4E)-	002396-84-1	$C_8H_{12}O_2$	140.18	Aromatic
53	1-methyl-4-(prop-1-en-2-yl)-7-oxabicyclo[4.1.0]heptan-2one	1000365-66-7	-	-	-
54	1H-Indene, 2-butyl-5-hexyloctahydro-	055044-33-2	$C_{19}H_{36}$	264.50	Saturate
55	1H-Inden-1-one, 2,3-dihydro-3,3,5,6-tetramethyl-	054789-22-9	$C_{13}H_{16}O$	188.27	Aromatic
56	1-Ethyl-3,trans-(1,1-dimethylethyl)-4,trans-methoxycyclohexan-1-ol	1000215-62-5	$C_{13}H_{26}O_2$	214.34	-
57	1-Chloroeicosane	042217-02-7	$C_{20}H_{41}Cl$	316.99	
58	17-(1,5-Dimethylhexyl)-10,13-dimethyl-4-vinylhexadecahydrocyclopenta[a]phenanthren-3-ol	1000210-86-9	$C_{29}H_{50}O$	414.70	Resin
59	1,3,5,7,9,11-Hexavinyl-3,5,9,11-tetrabutoxybicyclo[5.5.1]hexasiloxane	110991-14-5	-	-	Resin
60	[1,2,4]Triazolo[1,5-a]pyrimidine, 2-butylsulfanyl-5,7-dimethyl-	1000304-65-4	-	-	-
61	[1,2,3,4]Tetrazolo[1,5-a]pyridin-8-amine	073721-28-5	$C_5H_5N_5$	135.13	Aromatic

Produced Gases from Upgraded Agbabu Bitumen. The composition of gases produced during the catalytic upgrading process was analysed using a natural gasboard gas analyser (Gasboard 3100P) to determine the volume percentage of CH_4 and H_2. Table 15 shows the volume percentage of the gases produced in each experimental run. From an overview of all the experimental runs, as shown in Table 15, methane (CH_4) gas represents the highest volume percentage of gas produced compared to H_2. The NiMo/ZSM-5 catalysed reaction produced the highest volume percentage of 54.82% CH_4 gas and 7.24% H_2 gas.

Table 15 – Volume Percentage of Gases Produced from Upgraded Agbabu Bitumen

No	Experimental run	Produced gases (vol.%)	
		CH_4	H_2
1	Optimal crude	39.93	5.71
2	NiMo/ZSM-5 catalyzed crude	54.82	7.24
3	CoMo/HZSM-5 catalyzed crude	45.46	5.05
4	Mo/HZSM-5 catalyzed crude	51.23	6.41

It is expected to have no CO and CO_2 as the reaction occurs without oxygen because the reactor was airtight and took place in an inert medium (N_2 medium). Thus, the rate of the oxidation process was limited due to the absence of oxygen [25].

The Extent of Upgrade of Upgraded Agbabu Bitumen. The extent of upgrading of the Agbabu bitumen was calculated or carried out to know the degree to which the Agbabu bitumen was upgraded. The parameters used were viscosity, API gravity, asphaltenes, sulfur, and H/C. Table 16 shows the properties of raw, optimal and catalysed upgraded Agbabu bitumen.

From all the upgrades carried out with and without catalyst at the optimum conditions, NiMo/ZSM-5 catalysed crude exhibits highest percentage upgrade in all the parameters with 97.63% viscosity reduction, 278.98% API gravity increase, 81.38% asphaltenes reduction, 72.06% sulfur removal, 45.38% H/C ratio increase as presented in Figure 17 which shows the summary in bar chart representation of the extent of upgrade of the upgraded Agbabu bitumen.

Table 16 – Properties of Raw, Optimal and Catalyzed Upgraded Agbabu Bitumen

Raw Bitumen / Upgraded Oil	Parameter				
	Viscosity (Pa.s)	API Gravity (°)	Asphaltenes (wt.%)	Sulfur (wt.%)	H/C
Raw bitumen	86.780	7.870	8.86	4.51	1.19
Optimal crude	8.280	24.351	3.14	2.26	1.23
NiMo/ZSM-5 catalyzed crude	2.060	29.826	1.65	1.26	1.73
CoMo/HZSM-5 catalyzed crude	3.780	26.652	2.86	1.54	1.26
Mo/HZSM-5 catalyzed crude	3.160	27.894	2.10	1.89	1.47
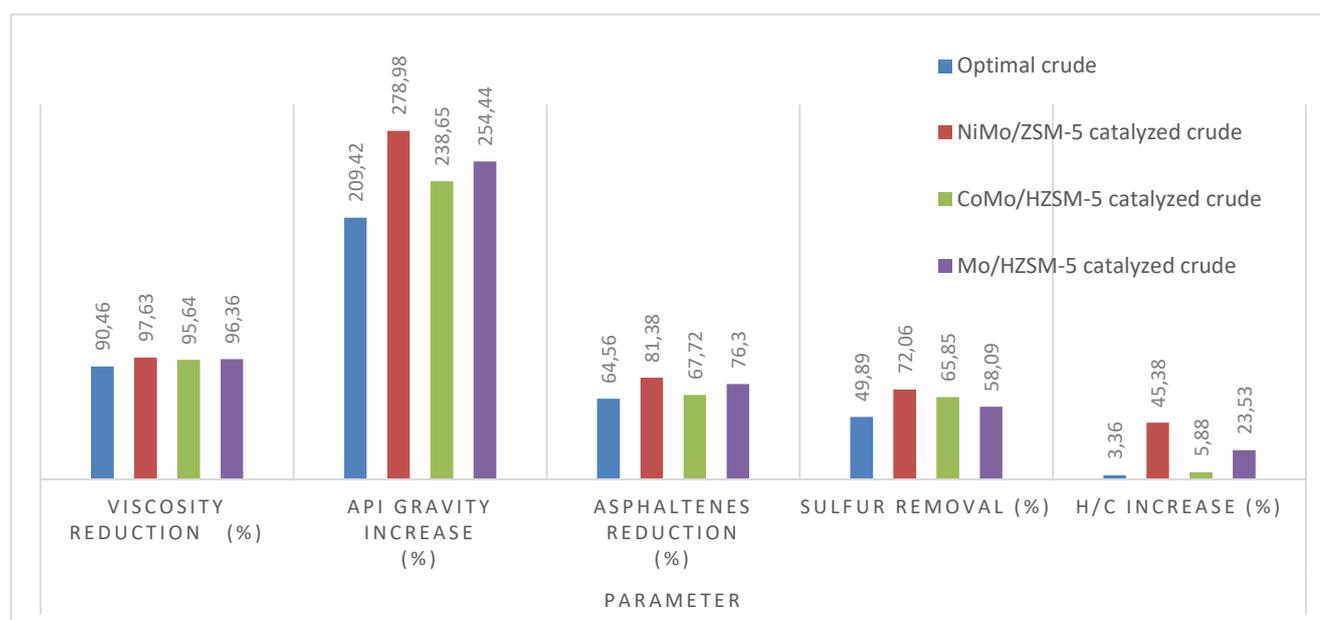
Figure 17 – Extent of Upgrade of Upgraded Agbabu Bitumen

CONCLUSIONS

Three mesoporous catalysts (NiMo/ZSM-5, Co-Mo/HZSM-5, and Mo/HZSM-5) were used to test and thus further upgrade Nigeria Agbabu bitumen in an autoclave batch reactor operating at optimum conditions (Temp., 345.716 °C, Residence time 30 min and 1.0 wt.% Rice husks) and a pressure of 32 bar nitrogen to investigate the effect of the three mesoporous aluminosilicate catalysts in the presence of rice husks on the Agbabu bitumen upgrade. This effect was studied with the viscosity reduction, API gravity increase, micro-carbon residue, light oil yield, asphaltenes reduction, sulphur removal/reduction, SARA wt.%, produced gas, and H/C ratio increase. The Agbabau bitumen before upgrade and after the upgrade was characterised for FT-IR and GC-MS, where the observable contour, specifically the peaks (3690.1 cm^{-1}, 3649.1 cm^{-1} and 3399.3 cm^{-1}) at the region of the FT-IR spectrum of all the upgraded Agbabu bitumen compared with the FT-IR spectrum of the raw Agbabu bitumen were noticed to disappear almost completely, indicating heavy molecular bond breakage to smaller bonds (such as saturates, aromatics and resins in some cases). The GC-MS spectrum of the upgraded Agbabu bitumen showed more chemical compounds available in the upgraded Agbabu bitumen than presented in the GC-MS of the raw Agbabu bitumen. However, this scenario was exceptional in the application of the CoMo/HZSM-5 catalyst for the bitumen upgrade, which has fewer chemical compounds in its GC-MS spectrum of the upgraded Agbabu bitumen and maybe because the CoMo/HZSM-5 catalyst has less pore volume and active sites compared to the other catalysts (NiMo/ZSM-5, and Mo/HZSM-5) employed, with NiMo/ZSM-5 catalysed upgraded Agbabu bituminous crude oil having the most chemical compounds present in its GC-MS spectrum. Also, NiMo/ZSM-5 catalysed upgraded bituminous oil has the API gravity and H/C ratio higher, viscosity, asphaltenes and sulphur contents lower and more produced gas (CH$_4$ and H$_2$ gas) compared to the other CoMo/HZSM-5 and Mo/HZSM-5 catalysed upgraded bituminous crude oil.

REFERENCES

1. Demirbas, A., Bafail, A., & Nizami, A.-S. (2016). Heavy oil upgrading: Unlocking the future fuel supply. *Petroleum Science and Technology, 34*(4), 303–308. doi: 10.1080/10916466.2015.1136949

2. Spiecker, P. M., Gawrys, K. L., Trail, C. B., & Kilpatrick, P. K. (2003). Effects of petroleum resins on asphaltene aggregation and water-in-oil emulsion formation. *Colloids and Surfaces A: Physicochemical and Engineering Aspects, 220*(1–3), 9–27. doi: 10.1016/s0927-7757(03)00079-7

3. Speight, J. G. (2007). *The chemistry and technology of petroleum* (4th ed.). Boca Raton: CRC Press.

4. Li, J., Wang, X., Tang, X., Zhang, M., Zheng, X., Wang, C., & Tang, Z. (2019). Upgrading of heavy oil by thermal treatment in the presence of alkali-treated Fe/ZSM-5, glycerol, and biomass. *Fuel Processing Technology, 188*, 137–145. doi: 10.1016/j.fuproc.2019.02.010

5. Babaso, P. N., & Sharanagouda, H. (2017). Rice Husk and Its Applications: Review. *International Journal of Current Microbiology and Applied Sciences, 6*(10), 1144–1156. doi: 10.20546/ijcmas.2017.610.138

6. Nandiyanto, A. B. D., Oktiani, R., & Ragadhita, R. (2019). How to Read and Interpret FTIR Spectroscope of Organic Material. *Indonesian Journal of Science and Technology, 4*(1), 97. doi: 10.17509/ijost.v4i1.15806

7. Abdulkadir, I., Uba, S., Salihu A., A., & Almustapha, M. N. (2016). A Rapid Method of Crude Oil Analysis Using FT-IR Spectroscopy. *Nigerian Journal of Basic and Applied Sciences, 24*(1), 47. doi: 10.4314/njbas.v24i1.8

8. Ahmad, I., Sohail, S. M., Khan, H., Khan, R., & Ahmad, W. (2108). Characterisation of Petroleum Crude Oils by Fourier Transform Infrared (FT-IR) and Gas Chromatography-Mass Spectrometry. *Petroleum and Petrochemical Engineering Journal, 2*(2), 1–7.

9. Coates, J. (2000). Interpretation of Infrared Spectra, A Practical Approach. *Encyclopedia of Analytical Chemistry*. doi: 10.1002/9780470027318.a5606

10. Jiang, J., Wang, Q., Wang, Y., Tong, W., Xiao, B., & Xiao, B. (2007). GC/MS Analysis Of Coal Tar Composition Produced From Coal Pyrolysis. *Bulletin of the Chemical Society of Ethiopia, 21*(2). doi: 10.4314/bcse.v21i2.21202

11. Bosio, A., Gianoncelli, A., Zacco, A., Borgese, L., Rodella, N., Zanotti, D., Depero, L. E., Siviero, G., Cinosi, A., Bingham, P. A., & Bontempi, E. (2013). A new nanotechnology of fly ash inertization based on the use of silica gel extracted from rice husk ash and microwave treatment. *Proceedings of the*

Institution of Mechanical Engineers, Part N: Journal of Nanoengineering and Nanosystems, 228(1), 27–32. doi: 10.1177/1740349913490683

12. Treacy, M. M., & Higgins, J. B. (2001). *Collection of Simulated XRD Powder Patterns for Zeolites (*4th ed.). New York: Elsevier.

13. Pavlačková, Z., Košová, G., Žilková, N., Zukal, A., & Čejka, J. (2006). Formation of Mesopores in ZSM-5 by Carbon Templating. *Scientific Bases for the Preparation of Heterogeneous Catalysts*, 905–912. doi: 10.1016/s0167-2991(06)80996-1

14. Yan, Y., Guo, X., Zhang, Y., & Tang, Y. (2015). Future of nano-/hierarchical zeolites in catalysis: gaseous phase or liquid phase system. *Catalysis Science & Technology, 5*(2), 772–785. doi: 10.1039/c4cy01114g

15. Zhang, K., & Ostraat, M. L. (2016). Innovations in hierarchical zeolite synthesis. *Catalysis Today, 264*, 3–15. doi: 10.1016/j.cattod.2015.08.012

16. Fernandez, C., Stan, I., Gilson, J., Thomas, K., Vicente, A., Bonilla, A., & Pérez-Ramírez, J. (2010). Hierarchical ZSM-5 Zeolites in Shape-Selective Xylene Isomerization: Role of Mesoporosity and Acid Site Speciation. *Chemistry – A European Journal, 16*(21), 6224–6233. doi: 10.1002/chem.200903426

17. Chou, Y. H., Cundy, C. S., Garforth, A. A., & Zholobenko, V. L. (2006). Mesoporous ZSM-5 catalysts: Preparation, characterisation and catalytic properties. Part I: Comparison of different synthesis routes. *Microporous and Mesoporous Materials, 89*(1–3), 78–87. doi: 10.1016/j.micromeso.2005.10.014

18. Agliullin, M. R., Talzi, V. P., Filippova, N. A., Bikbaeva, V. R., Bubennov, S. V., Prosochkina, T. R., Grigorieva, N. G., Narender, N., & Kutepov, B. I. (2018). Two-step sol–gel synthesis of mesoporous aluminosilicates: highly efficient catalysts for the preparation of 3,5-dialkylpyridines. *Applied Petrochemical Research, 8*(3), 141–151. doi: 10.1007/s13203-018-0202-0

19. Guo, K., Li, H., & Yu, Z. (2016). In-situ heavy and extra-heavy oil recovery: A review. *Fuel, 185*, 886–902. doi: 10.1016/j.fuel.2016.08.047

20. Scott, D. S., Radlein, D., Piskorz, J., Majerski, P., & deBruijn, Th. J. W. (2001). Upgrading of bitumen in supercritical fluids. *Fuel, 80*(8), 1087–1099. doi: 10.1016/s0016-2361(00)00174-5

21. Ates, A., Azimi, G., Choi, K.-H., Green, W. H., & Timko, M. T. (2014). The role of catalyst in supercritical water desulfurisation. *Applied Catalysis B: Environmental, 147*, 144–155. doi: 10.1016/j.apcatb.2013.08.018

22. Avbenake, O. P., Al-Hajri, R. S., & Jibril, B. Y. (2019). Catalytic upgrading of heavy oil using NiCo/γ-Al2O3 catalyst: Effect of initial atmosphere and water-gas shift reaction. *Fuel, 235*, 736–743. doi: 10.1016/j.fuel.2018.08.074

23. Yusuf, A., Al-Hajri, R. S., Al-Waheibi, Y. M., & Jibril, Baba. Y. (2016). In-situ upgrading of Omani heavy oil with catalyst and hydrogen donor. *Journal of Analytical and Applied Pyrolysis, 121*, 102–112. doi: 10.1016/j.jaap.2016.07.010

24. Kumar, S., & Mahto, V. (2016). Emulsification of Indian heavy crude oil in water for its efficient transportation through offshore pipelines. *Chemical Engineering Research and Design, 115*, 34–43. doi: 10.1016/j.cherd.2016.09.017

25. Li, J., Wang, X., Tang, X., Zhang, M., Zheng, X., Wang, C., & Tang, Z. (2019). Upgrading of heavy oil by thermal treatment in the presence of alkali-treated Fe/ZSM-5, glycerol, and biomass. *Fuel Processing Technology, 188*, 137–145. doi: 10.1016/j.fuproc.2019.02.010

Building Future Psychologists' Art Therapy Competence While Professional Training in Higher Education Institutions

Halyna Khyman [1]

[1] *Oleksandr Dovzhenko Hlukhiv National Pedagogical University*
24 Kyiv street, Hlukhiv, Sumy, Ukraine, 41400

Abstract. The article considers the issue of building future psychologists' art therapy competence during professional training in higher education institutions. The author analyzes scientists' views on the essence of the competence approach in education. The author's vision determines the interpretation of "competence" and "future psychologists' art therapy competence."

Keywords: competence approach; art therapy competence; future psychologists; professional training; higher education institution.

INTRODUCTION

The beginning of the twenty-first century has been marked by the spread of integration processes in all spheres of modern society. European country's integration in politics and economy has recently significantly impacted the education sector. Therefore, the globalization of society creates new requirements for the national education system.

The requirement of training students not only as specialists with the appropriate knowledge but also as individuals capable of effectively performing professional tasks, self-development, and self-education specifies the widespread implementation of the competence-based approach into the Ukrainian educational space. This process consecutively should facilitate the specialists' rapid adaptation to the changing conditions of professional activity and increase their competitiveness and mobility in the domestic and international labour market.

Ukrainian higher education is currently at a new reform stage, aiming to modernize the entire system of future professionals' training. From this perspective, it is necessary to completely abandon the previous higher education system and move to a new one that can meet today's requirements. One of the priority areas of development in the education sector is the widespread implementation of a competency-based approach. Significant changes in the legal regulation of educational activities and new provisions and requirements for organizing and implementing the educational process have increased the categorical and conceptual apparatus in the academic environment. The new definitions and concepts have also been marked.

METHOD

Scientists O. Antonova, V. Bader, I. Bekh, V. Bolotov, L. Biriuk, O. Dubaseniuk, V. Kurok, R. Kurok, V. Lugovyi, O. Pometun, V. Radkevych, V. Riabchenko, and others have made an essential contribution to solving the problematic issues of implementing the competence approach in the national educational space.

Simultaneously, despite the increased attention of Ukrainian scientists to topical issues of applying the competence approach provisions in educational activity, the problems of how to implement it in future psychologists' training in higher education institutions and building their art therapy competence has remained insufficiently studied [1, 2].

The article aims to analyze how to build future psychologists' art therapy competence during professional training in higher education institutions.

RESULTS AND DISCUSSION

The analysis of regulatory legal acts on education states that the leading concept of reforming the educational system in Ukraine is to implement a competence-based approach to academic activities. Therefore, it can permit the training of future specialists who can make optimal professional decisions independently.

Introducing a competence-based approach in education becomes the readiness subject of scientific research and regulatory documents that have formed the basis for reforming the European education system. The official UNESCO documents "Convention on the Recognition of Qualifications Concerning Higher Education in the European Region," "Convention on Technical and Vocational Education," Recommendations of the European Parliament and the Council of the European Union "On Key Competences for Lifelong Learning" outline the range of key competences to built during the educational process in higher education. They indicate future specialists' readiness to perform professional duties successfully, enabling them to develop, fulfil their potential, and be actively involved in social life.

Having analyzed the scientific works, we can state that the issue of building future psychologists' art therapy competence has not had sufficient attention. In this regard, we should highlight the absence of a scientifically-based approach to the definition and its content. To eliminate the identified gaps, we will analyze the scientists' views on interpreting the competence approach in the context of future psychologists' training during their professional training in higher education institutions.

In S. Honcharenko's dictionary, the concept of "competence" (from Latin competent - appropriate, capable) is considered as a set of knowledge and skills necessary for effective professional activity: the ability to analyze, predict the consequences of professional activity, use information [3, p. 311].

In the Encyclopedia of Education, edited by V. Kremen, competence in learning is described as "a personality's acquired characteristic that contributes to the successful entry of a young person into the life of modern society." Furthermore, this concept is interpreted as "an integrated result that involves a shift from accumulating normatively defined knowledge, skills and abilities to the formation and development of students' skills to operate practically, and apply the experience of successful activities in a particular area" [4, p. 408].

Thus, the competence approach ensures the implementation of building future psychologists' art therapy competence in current conditions. Consequently, the mentioned approach directs the educational process to form and develop an individual's key and subject competencies and promotes their social defence through professional mobility. The scientists note that "one of the competence approach features is the carrying of the attention from the learning process to its results" [5, p. 111; 6]. The Bologna Process expert S. Adam from the UK emphasizes the importance of reforming curricula, which can result in building qualifications that meet the needs of the labour market and further education. "The qualifications framework is important to help higher education institutions develop modules and curricula based on learning outcomes and credits" [7, p. 299].

"The competence approach focuses on the final result of the educational process, how to build the future teacher's or psychologist's skill to effectively use their potential (knowledge, skills, abilities, values, psychological characteristics) and external resources" [8, p. 26]. The unity of scientists' views on the decisive role of the competence approach in building competencies and competitiveness of modern teachers (psychologists) in the educational service market has been confirmed in scientific works by I. Halushchak [9], V. Kurok, [10], and by the Bologna Process expert S. Adam [6].

O. Shcherbak states that "competence characterizes the ability to solve a task effectively while activating knowledge, skills, experience, behavioural attitudes and values. The category of "ability to operate" comes to the forefront as the ability to apply knowledge in practical activities" [11].

According to H. Selevko, competence is "an integral personality's ability that manifests in his/her general ability and readiness for activity. It is based on knowledge and experience acquired in learning and socialization and focused on independent and successful participation in activities" [12, p. 140]. S. Bondar agrees with this opin-

ion and notes that "no one will act if they are not personally interested in it. The nature of competence is such that it can be manifested only in organic unity with human values, in other words, in conditions of deep personal interest in a particular type of activity" [13].

According to the Law of Ukraine "On Higher Education," the concept of "competence" is characterized as the "ability of a personality to successfully socialize, learn, and perform professional activities, which arises based on a dynamic combination of knowledge, skills, abilities, ways of thinking, views, values, and other personal qualities" [14].

The analysis of scientific interpretations of the concept "competence" by specialists in various fields makes it possible to state that different scholars consider it as "a set of knowledge and skills," "an acquired characteristic of a personality," "the ability to solve a task effectively," "an integral ability of a personality," etc.

Driven by the interpretation of the concept "competence," legally enshrined in the Law of Ukraine "On Higher Education," this definition will understood as "the ability of a personality to perform certain activities", as it most accurately reflects the focus of the competence approach on training specialists who can operate effective while performing professional functions.

We consider the future psychologist's art therapy competence as the ability of a personality to successfully perform art therapy activities, characterized by the presence of a set of knowledge on art therapy, skills and abilities to use art therapy technologies, and a value attitude to this activity that meets the requirements of a professional standard.

CONCLUSIONS

During the study, based on the analysis of the scientists' views on the sense of the competence approach, the interpretation of the concept of "future psychologist's art therapy competence" is defined. Thus, the future psychologist's art therapy competence enables him/her to perform functional duties properly and implement high-quality professional activities using the acquired art therapy knowledge and skills. This ability relies on many factors, including personal qualities, professional characteristics, education, etc.

We consider studying the structure and content of future psychologists' art therapy competence as prospects for further scientific research.

REFERENCES

1. Kurok, V., & Khyman, H. (2022). *Analiz riznykh naukovykh pidkhodiv do vyznachennia art-terapii* [Analysis of scientific approaches to defining art therapy]. *Visnyk Hlukhivskoho NPU im. O. Dovzhenka, 3*(50), 252–259 (in Ukrainian).

2. Khyman, H. (2023). Obgruntuvannia pryntsypiv formuvannia artterapevtychnoi kompetentnosti maibutnikh psykholohiv [Substantiation of the principles of forming art therapy competence of future psychologists]. *Profesiine stanovlennia osobystosti: problemy i perspektyvy* (pp. 76–77). Khmelnytskyi: Khmelnytskyi natsionalnyi universytet (in Ukrainian).

3. Goncharenko, S., Zyazyun, I., & Nichkalo, N. (2000*). Profesiina osvita* [Professional education]. Kyiv: Vischa shkola (in Ukrainian).

4. Kremen, V. (2021). *Entsyklopediia osvity* [Encyclopaedia of Education]. Kyiv: Yurinkom Inter (in Ukrainian).

5. Korotkova, L., Lukianenko, H., Lukianova, L., Melnyk, S., & Savchenko, I. (2011). *Profesiini standarty: teoriia i praktyka rozroblennia* [Professional standards: theory and practice of development]. Kyiv: NAPN Ukrainy (in Ukrainian).

6. Adam, S. (2004, July 1–2). *Using Learning Outcomes.* Retrieved from https://www.aic.lv/bolona/Bologna/Bol_semin/Edinburgh/S_Adam_Bacgrerep_presentation.pdf

7. Adam, S. (2008, February 21–22). *Learning outcomes current developments in Europe.* Retrieved from https://www.academia.edu/32806775/Learning_Outcomes_Current_Developments_in_Europe_Update_on_the_Issues_and_Applications_of_Learning_Outcomes_Associated_with_the_Bologna_Process

8. Lukianova, L. (2010). Kontseptualni zasady formuvannia ekolohichnoi kompetentnosti maibutnikh fakhivtsiv [Conceptual bases of formation of future specialists' environmental competence]. In N. Nychkalo, L. Lukianova, V. Anishchenko, *Teoriia i praktyka profesiinoho navchannia doroslykh u PTNZ i na vyrobnytstvi*. Kyiv (in Ukrainian).

9. Halushchak, I. (2018*). Teoriia i tekhnolohii formuvannia pravovoi kompetentnosti maibutnikh ekonomistiv v umovakh neperervnoi universytetskoi osvity [Theory and technologies of future economists legal competence forming in continuous university education]* (Doctoral thesis). Retrieved from http://dspace.pdpu.edu.ua/bitstream/123456789/1653/1/Galushchak%20Iryna%20Yevgenivna.pdf (in Ukrainian).

10. Kurok, V., & Lytvynova, N. (2019). *Profesiina kompetentnist maibutnikh pedahohiv profesiinoho navchannia budivelnoho profiliu: teoriia i praktyka formuvannia v protsesi vyrobnychoi praktyky* [Professional competence of future teachers of vocational education of construction profile: theory and practice of formation in the process of industrial practice]. Sumy: Vinnychenko M. D. (in Ukrainian).

11. Shcherbak, O. (2014). *Teoretyko-metodychni zasady pidhotovky i pidvyshchennia kvalifikatsii pedahoha profesiinoho navchannia dlia osvity doroslykh* [Theoretical and methodological bases of training and advanced training of a vocational teacher for adult education]. Kyiv: KPPK imeni Antona Makarenka (in Ukrainian).

12. Selevko, H. (2004). Kompetentnosti ta yikh klasyfikatsiya [Competences and their classification]. *Narodnoe obrazovanye 4,* 138–143 (in Russian).

13. Bondar, S. (2003). Kompetentnist osobystosti – intehrovanyi komponent navchalnykh dosiahnen uchniv [Competence of the personality as an integrated component of students' academic achievements]. *Biolohiia i khimiia v shkoli, 2*, 8–9 (in Ukrainian).

14. Pro vyshchu osvitu [On Higher Education] (Ukraine), 01.07.2014, No 1556-VII. Retrieved April 1, 2024, from https://zakon.rada.gov.ua/laws/show/1556-18#Text (in Ukrainian).

Antifertility Efficacy of n-Hexane Seed Extract of Ricinus communis Var Minor in Wistar Rats Uterus In Vitro

Ayuba Clagba Sanni [1], **Olusayo Moritiwon** [1], **Timothy Olugbenga Ogundeko** [2],
Seljul Mamzhi Crown Ramyil [2], **Paul Amos Bassi** [2], **Francis Kanayo Okwuasaba** [1]

[1] *University of Jos*
P. M. B 2084, Jos, Nigeria

[2] *Bingham University*
P. M. B 005, KM 26 Abuja-Keffi Expressway Kodope, Karu, Nasarawa State, Nigeria

Abstract. The seed of Ricinus communis var minor (RICOM 1013-J) is a popular contraceptive among the tribal women in Bassa Local Government Area of Plateau State, Nigeria. Several reports have confirmed the efficacy and safety of different fractions of RICOM 1013-J, particularly the n-Hexane fraction. RICOM 1013-J appears to possess a unique contraceptive effect. This study aimed to provide further insight into the impact of RICOM 1013-J on the reproductive organs compared with the activity profile of some uterotonic drugs. A total of 20 adult albino rats (15 females and five males) weighing 150-200 g were initially divided into five groups of 3 female rats each with treatments via the oral route as follows: Groups A (2ml olive oil), others n-Hexane extract of Ricinus communis seeds (RICOM 1013-J) B (5 mg/kg), C (10 mg/kg), D (20 mg/kg) and E (30 mg/kg). After three days, the five male rats were introduced into each group (ratio of 3 females to 1 male per cage) till the end of experiments for mating. The effect of the pretreatment with the n-hexane extract of RICOM 1013-J on the rat uterus was evaluated after days 10, 30, 60 and 90. RICOM 1013-J (20 mg/kg and 30 mg/kg) demonstrated potent anti-conceptive effects, protecting female Wister albino rats against pregnancy for over five gestational periods. RICOM 1013-J statistically altered the regular basal activity of the uterus in a time-dependent manner (10, 30, 60 and 90 days pretreatment). Furthermore, pretreatment with RICOM 1013-J decreased the reactivity of the uterus to some uterotonic drugs, including oxytocin (2×10^{-3} iu/ml), ergometrine (1×10^{-3} mg/ml), misoprostol (2×10^{-3} mg/ml), Ach (1×10^{-5} gm/ml) and potassium chloride (1×10^{-3} gm/ml). The contraction to misoprostol and potassium chloride in the uterus was abolished on day 90 of pretreatment. This study has demonstrated the dose-dependent efficacy of RICOM 1013-J in protecting against pregnancy for over five gestation periods in rats. This protective effect may be due to the alterations in the activity profile of smooth muscle quiescence and inertia in the uterus. In addition, the changes in the responsiveness of the uterus to the uterotonic drugs further confirm the anti-conceptive effects of RICOM 1013-J.

Keywords: Peucicap culture; interpretation; breastfeeding mothers.

INTRODUCTION

The increase in population growth worldwide, with a decreased standard of living, increased desertification, decrease in agricultural food production, and increase in movement from rural regions to urban areas, has greatly caused a rise in population in the metropolitan cities, leading to high rate of crime due to low job opportunities coupled with global economic recession in a country with over 1.8 million people [1]. The world population presently stands at about 8 billion people [2], and its socio-economic impacts cannot be overestimated, particularly in most developing nations. In Africa, particularly Nigeria, the ever-increasing population has

negatively impacted the total health care delivery system and the people's standard of living. Nigeria's population is about 220 million, projected to be over 440 million by 2050 [3]. However, it is noteworthy that decades ago, the Rukuba-speaking people of Bassa Local Government Area of Plateau State in North Central Nigeria used the seeds of *Ricinus communis var minor* (RICOM 1013-J) for family planning by exploiting its anti-conceptive properties. Several researchers evaluated such efficacy [4-7], and [4] demonstrated the novel effects of RICOM 1013-J in that administration of 3-4 seeds once orally protected women volunteers against pregnancy for 9-12 months. *Ricinus communis* L. popularly known as the castor oil plant, taxonomically belongs to the family of Euphorbiaceae, native to India and Africa (Ethiopia), though widely distributed in tropical, subtropical, and warm temperate climates of the world also having It is the following local names: Endi (Hindi), Errandi (Marathi), Zurma (Hausa), Jada (Oriya), Kherwal (Saudi Arabia), Diveli (Guajarati) [8-13]. *R. communis* is highly adaptable and can grow in various climates, from warm temperate to tropical regions, including Nigeria [9, 13-15]. Various studies have revealed the rich biological activities of *Ricinus communis,* which authenticates its medicinal properties, including antibacterial [18], Antifungal [18, 9], antioxidants [8, 18],) anti-cancer activity [20], antidiabetic activity [17, 19], anti-ulcer properties [6]. The exact mechanism of action of RICOM 1013-J remains elusive, although several mechanisms have been postulated. Authors [4, 21, 22] demonstrated that estrogenic activity altered uterine responsiveness to drugs, histological changes in the ovaries, including atretic ovaries and a disruption of the delicate oestrogen-progesterone balance in the ovaries and uterus as a possible ant-conceptive effect of RICOM 1013-J.

The present study was designed to provide further insight into the possible mechanism of action of RICOM 1013-J by evaluating its effects on the rat uterus and rabbit fallopian tube.

The *study aims* to provide further insight into the effect of RICOM 1013-J on the reproductive organs and the activity profile of some uterotonic drugs.

Figure 1 – Image of the castor-oil plant [23]

METHODS

Collection and Preparation of Plant Materials. The seeds of RICOM 1013-J were collected from the wild shrubs in Jebbu Bassa, Bassa LGA, Plateau State, Nigeria, between January and March 2016. The seeds were authenticated at the Department of Plant Science University of Jos and the Federal Forestry Research Institute Jos, and the voucher specimen (Voucher No UJ/PCG/HSP/95E25) was deposited in the herbarium of the Department of Pharmacognosy, University of Jos, Nigeria.

Seed Extract Preparation. The dried seeds of RICOM 1013-J were dried and finely grounded with porcelain mortar and pestle. About 130 g was soaked in 250 ml of n-Hexane in a conical flask and agitated using a Gyromax 800-Series Open-Air shaker (medium), Amerex Instruments, Inc., for 96 hours. The mixture was filtered through a glass funnel with filter paper (Whatman No.1), and the residue was soaked in n-Hexane (250 ml) with further continuous agitation for another 96 hours until exhaustive extraction was achieved at room temperature (22 ± 3 °C) [24]. The solvent was evaporated in a fume chamber, and the extract was transferred into a clean, dried specimen bottle and stored at 4-8 °C in a refrigerator before use. The percentage yield was calculated as below:

Percentage yield (%) = 30.6 g/130 x 100 = 23.4%

Acute Toxicity Studies. Determination of Lethal Dose (LD_{50}). The author [25] described the method for determining LD_{50} using 12 matured female Wistar rats in two phases. For phase I,

nine rats weighing between 200 g and 250 g were divided into three groups with three animals each and orally administered with 10 mg/kg, 100 mg/kg and 1000 mg/kg body weight RICOM 1013-J – extract, respectively while for the phase II, three animals of same weight range in phase I were grouped into three different cages of one animal each and administered with 1500 mg/kg, 3000 mg/kg and 5000 mg/kg of RICOM 1013-J – extract respectively. The rats were usually fed, allowed access to clean water *ad libitum*, and observed for 24 hours. The animals were monitored for toxicological symptoms and mortality rate within the same period.

The LD$_{50}$ was calculated using the formula:

$$LD_{50} = \sqrt{D_0 x D_{100}}$$

No mortality was, however, recorded in both phases, indicating the safety of RICOM 1013-J – extract ≤5000 mg/kg.

Phytochemical Screening. RICOM 1013-J extract was screened for secondary metabolites such as flavonoids, alkaloids, tannins, saponins, carbohydrates, anthraquinones and cardiac glycosides according to the methods of [26].

Test for alkaloids. Aliquot of 500 mg of extract was stirred with 3 ml of 1 % aqueous hydrochloric acid on a steam bath and filtered; 1 ml of the filtrate was treated with drops of the following reagents: Mayer's reagent, Picric acid solution and Dragendroff reagent. Precipitation with either of these reagents was taken as preliminary evidence of the presence of the alkaloids.

Test for saponins. An Aliquot of 500 mg extract was shaken with water in a test tube. Frothing that persists during warming was taken as preliminary evidence of the presence of saponins.

Test for tannins. An Aliquot of 500 mg of the extract in a test tube and Ferric chloride solution was added to the test tube. A blue-black, green, or blue-green precipitate was taken as evidence of tannins' presence.

Test for anthraquinones. An Aliquot of 500 mg of extract was put in a dry test tube, and 5 ml of chloroform was added and shaken for 5 minutes.

The filtrate was filtered and shaken with an equal 100% ammonia solution volume. The pink, violet or red colour in the ammoniacal layer (lower layer) indicated the presence of free anthraquinones.

Test for cardiac glycosides (Keller Killani test). An Aliquot of 100 mg of extract in 1 ml of glacial acetic acid containing one drop of Ferric chloride solution and 1 ml of concentrated sulphuric acid was added gently by the side of the test tube. A brown ring formed at the interphase indicated the deoxy sugar characteristics of cardenolides.

Test for steroids (steroidal ring). An Aliquot of 100 mg of the extract was dissolved in 2 ml of chloroform; sulphuric acid was carefully added to form a lower layer. A reddish brown colour at the interphase indicated the presence of a steroidal ring.

Test for flavonoids. 200 mg of the extract was detained with acetone. The sample was placed in a hot water bath for all acetone to evaporate. Boiling distilled water was added to the sample arrested. The mixture was filtered while hot. The filtrate was cooled, and 5 ml of 20% sodium hydroxide was added to equal the filtrate volume. A yellow solution indicates the presence of flavonoids.

Test for carbohydrates. Aliquot of 500 mg of the extract was heated with dilute hydrochloric acid. The mixture was neutralized by adding sodium hydroxide solution, and Fehling's solutions 1 and 2 were added and boiled on a hot plate. A brick-red precipitate formed, indicated the presence of flavonoids.

Experimental Animals Procurement and Preparation. A total of 20 adult albino rats (15 females and five males) weighing 150-200 g were obtained from the Animal House Unit of the University of Jos, Nigeria. The rats were housed in plastic cages with stainless steel mesh tops according to groups, maintained under favourable laboratory conditions in a cross-ventilated room (22± 3 °C), lighting (12 hrs light and 12 hrs dark cycle), conducive beddings, fed with standard rat pellets from Grand Cereal Mills, Jos, Nigeria and allowed access to water *ad libitum*. All animals were allowed to acclimatize for 14 days.

Anti-conceptive Studies on RICOM 1013-J. A total of 15 Adult female rats weighing 150-200 g shown to have regular oestrus cycles determined daily by vaginal smear analysis with at least two

successive four days estrus cycles were selected. The rats were randomly divided into five groups (A, B, C, D and E) consisting of 3 rats, each with different treatments as follows:

Group A: administered with olive oil orally using the orogastric tube.

Group B: administered with 5 mg/kg n-Hexane extract of *Ricinus communis* seeds (RICOM 1013-J) orally.

Group C: orally administered with n-Hexane extract of 10 mg/kg Ricinus communis seeds (RICOM 1013-J).

Group D: administered with 20 mg/kg n-Hexane extract of *Ricinus communis* seeds (RICOM 1013-J) orally.

Group E: administered with 30 mg/kg n-Hexane extract of *Ricinus communis* seeds (RICOM 1013-J) orally.

Fertile and sexually active male rats were introduced on day three after administration of RICOM 1013-J into each group (ratio of 3 females to 1 male per cage) till the end of experiments for mating according to the methods of [10]. Mating was confirmed by the presence of a whitish vaginal plug with the presence of spermatozoa and is considered to be day '1' of conception [27, 28]. The male rats were in contact with the female rats for the seven gestation periods of the study. The fertility rate was calculated as the number of rats littered per group divided by the total number.

Invitro Study on Rat Uterus. A control group was used.

Control Group. The control Rats were administered olive oil orally at a dose of 30 mg/kg body weight. The effect of the pretreatment with the n-hexane extract of RICOM 1013-J on the rat uterus was evaluated after days 10, 30, 60 and 90. The rats were exsanguinated. The abdomen was dissected, the uterus cut to a size of about 3 cm, placed in a petri dish containing De-Jalon's solution and bubbled with air (oxygen 95% and carbon dioxide 5%) until used.

The tissue was then mounted in a bath containing 25 ml of De-Jalon's solution at 37 °C and aerated using an aerator (student physiograph). A sensitivity of 50 microvolt/cm and speed of 2 mm/sec was used throughout the experiment. The contractible activity of the uterus was recorded via isometric force-displacement transducer model 707 connected to a 3-way channel student physiograph recorder (model Medicaid, 7013).

The following drugs were used to study the activity and response of the uterine muscle to drugs (Acetylcholine $1x10^{-5}$ g/ml, Oxytocin $2 x 10^{-3}$ iu/ml, Misoprostol $2 x10^{-6}$ g μ/ml, Ergometrine $1 x 10^{-3}$ g/ml and KCl $1x10^{-3}$ g/ml).

Statistical Analysis. Data were expressed as mean ± SEM.

RESULTS AND DISCUSSION

Phytochemical Screening. The phytochemical screening of the n-Hexane extract of RICOM 1013-J revealed the presence of steroids and carbohydrates only, while alkaloids, saponins, tannins, flavonoids, anthraquinones and cardiac glycoside were not detected (Table 1).

Table 1 − Phytochemical Analysis of RICOM 1013-J

Chemical Constituent	Result
Alkaloid	-
Saponins	-
Tannins	-
Flavonoids	-
Carbohydrates	+
Steroids	+
Anthraquinones	-
Cardiac Glycoside	-

Notes: "−" Not Detected; "+" Detected

Anti-conceptive activity. RICOM 1013-J (20 and 30 mg) protected treated rats against pregnancy for over six weeks following a single oral administration in a dose-dependent manner (Table 2).

Table 2 − Anti-conceptive Activity of RICOM 1013-J in Female Rats

Dose of RICOM 1013-J	Pregnancy Occurrence	Duration of Protection (months)	Fertility Rate
Control	3/3	0	1
5 mg/Kg	2/3	5.00 ± 1.70*	0.6
10 mg/Kg	2/3	5.67 ± 1.39*	0.6
20 mg/Kg	1/3	6.33 ± 1.16*	0.3
30 mg/Kg	0/3	6.67 ± 0.58*	0.0

Notes: n = 3; * − P < 0.05

The results obtained from the phytochemical study have demonstrated the presence of steroids and carbohydrates in the n-Hexane extract of RICOM 1013-J.

This agrees with the earlier report [22] that *Ricinus Communis* oil contains some steroidal compounds. These findings are significant since some conventional oral contraceptives are of estrogen-progestin combination, and this may contribute in part to the anti-conceptive effect of RICOM 1013-J. Moreover, it is known that plant steroids are converted into animal steroid hormones through synthetic pathways involving steroidogenic enzymes [29].

Effect of RICOM 1013-J pretreatment on the rat uterus. Pretreatment of rats and rabbits with a single oral dose of RICOM 1013-J (30 mg/kg) altered the contractile profiles of the rat uterus in a time-dependent manner (Figure 2).

There was complete quiescence of basal rhythmic contraction on days 10 and 90 (Figure 6) post-treatment. Post-treatment on the rat uteri day 90 (Figure 6) resulted in complete inactivity of the basal rhythmic contraction. There was a marked increase in the frequency of basal rhythmic contraction on days 30 and 60 of the post-treatment Figure 8 and 9, respectively.

Effect of RICOM 1013-J pretreatment on the contractile activity of uterotonic drugs on the rat uterus. Pretreatment with RICOM-1013J altered the uterus response to standard uterotonic agonists [acetylcholine, prostaglandin E₂ (PGE₂), ergometrine and potassium chloride (KCl)]. The responsiveness of the uterus to the uterotonic agonists varied significantly and depended on the pretreatment duration with RICOM 1013-J. The contractile activity of the agonists (Ach, Oxy, Miso, ergot and KCl) was abolished on day 30 of pretreatment with RICOM 1013-J (Figure 4). However, there was recovery of contractile activity on day 60 (Figure 5), while the contractions to misoprostol and KCl were abolished again on day 90 (Figure 6).

The administration of RICOM 1013-J protected the animals against conception in a dose-dependent manner for six gestational periods. This also bolsters the earlier finding of [4], where he administered different doses of petroleum ether (PE) extract of RICOM 1013-J (5-20 mg/kg), which induced a dose-dependent contraceptive effect over five gestational periods.
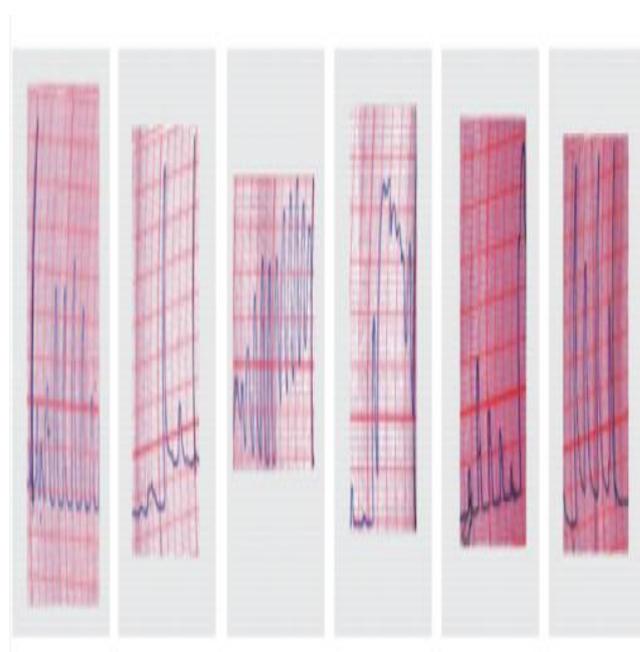
Notes: ACH – Acetylcholine, OXY – Oxytocin, MISO – Misoprostol, ERGOT – Ergometrine, KCl – Potassium

Figure 2 – Rat uterus response to drugs (Non treated)
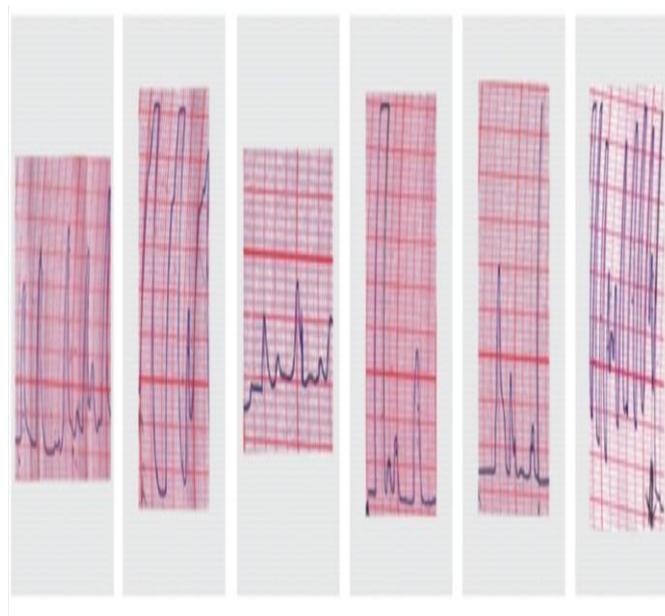
Notes: ACH – Acetylcholine, OXY – Oxytocin, MISO – Misoprostol, ERGOT – Ergometrine, KCl – Potassium

Figure 3 – Rat uterus response to drugs after ten days of pretreatment with RICOM 1013-J
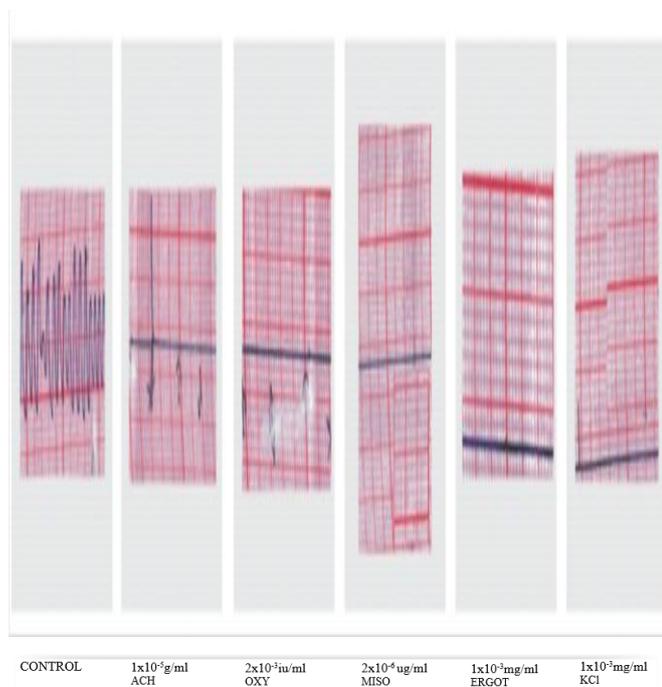
Notes: ACH – Acetylcholine, OXY – Oxytocin, MISO – Misoprostol, ERGOT – Ergometrine, KCl – Potassium

Figure 4 – Rat uterus response to drugs after 30 days of pretreatment with RICOM 1013-J
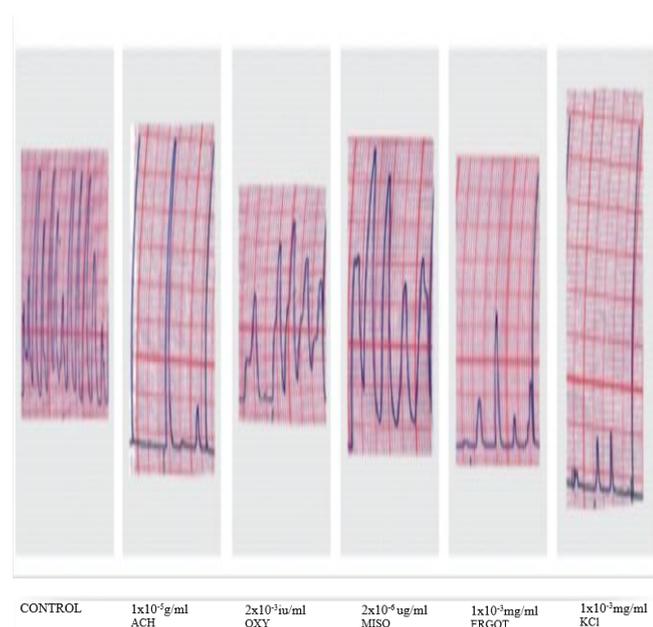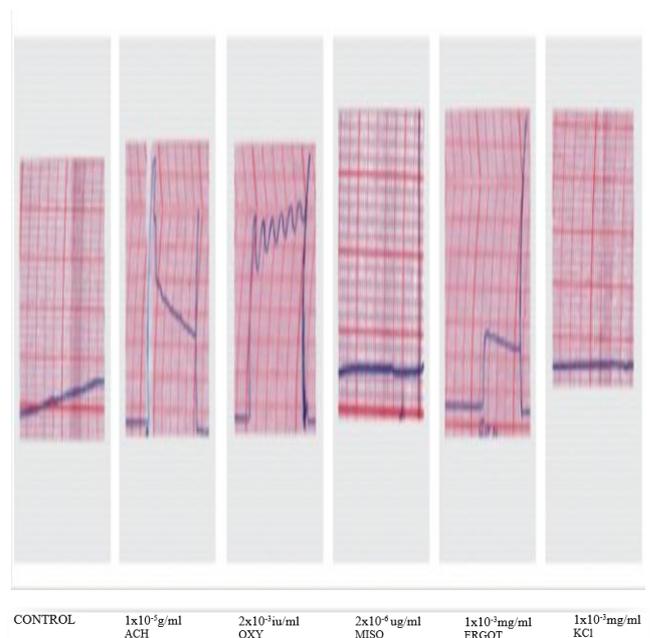

Notes: ACH – Acetylcholine, OXY – Oxytocin, MISO – Misoprostol, ERGOT – Ergometrine, KCl – Potassium

Figure 5 – Rat uterus response to drugs after 60 days of pretreatment with RICOM 1013-J

Notes: ACH – Acetylcholine, OXY – Oxytocin, MISO – Misoprostol, ERGOT – Ergometrine, KCl – Potassium chloride

Figure 6 – Rat uterus response to drugs after 90 days of pretreatment with RICOM 1013-J

Authors [30] demonstrated the possible contraceptive efficacy of Ricinus communis by exerting its regulatory role over luteinizing hormone (LH), primary ovarian cell function and secretion activity. All those processes could disrupt the estrogen/progesterone balance, leading to an unfavourable environment in the endometrium that prevents implantation of the fertilized ovum.

Pretreatment of rats and rabbits with RICOM 1013-J alters the activity profile of the uterus as well as their responsiveness to uterotonic agents in a characteristic pattern. The uterine inertia after days 30 and 90 pretreatment mimics the effect of progesterone [31, 32]. The disordered uterine quiescence and inertia seen in this study may contribute to the antifertility property of RICOM 1013-J [33]. When all the effects of RICOM 1013-J on the uterus are considered together, it is not unreasonable that changes in estrogen/progesterone balance may partly be responsible for the antifertility efficacy of RICOM 1013-J.

CONCLUSIONS

This study has demonstrated the dose-dependent efficacy of RICOM 1013-J in protecting

against pregnancy for over five gestation periods in rats. This protective effect may be due to the alterations in the activity profile exhibited in smooth muscle quiescence and uterine inertia. In addition, the changes in the responsiveness of the uterus to the uterotonic drugs further confirm the anti-conceptive effects of RICOM 1013-J.

Ethical Considerations

Ethical clearance was obtained from the Research and Ethical and Animal Research Committee of the Faculty of Pharmaceutical Sciences, University of Jos, Nigeria.

REFERENCES

1. National Population Commission. (2018). *Nigeria Demographic and Health Survey*. Retrieved from https://ngfrepository.org.ng:8443/jspui/bitstream/123456789/3145/1/NDHS%202018.pdf

2. UN. (2022). *UN Population Prospects 2022*. Retrieved from https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

3. UN. (2018). *World Urbanization Prospects. The 2018 Revision*. Retrieved from https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

4. Okwuasaba, F. K., Das, S. C., Isichei, C. O., Ekwenchi, M. M., Onoruvwe, O., Olayinka, A. O., Uguru, V. E., Dafur, S. J., Ekwere, E. O., Parry, O. (1997). Pharmacological studies on the antifertility effects of RICOM-1013-J from Ricinus communis var minor and preliminary clinical studies on women volunteers. *Phytotherapy Research, 11*, 547–551.

5. Salhab, A. S., Issa, A. A., & Alhougog, I. (1997). On the Contraceptive Effect of Castor Beans. *International Journal of Pharmacognosy, 35*(1), 63–65. doi: 10.1076/phbi.35.1.63.13268

6. Hou, Y.-L., Ding, X., Duan, S.-Q., Yang, Z.-R., & Gao, P. (2010). Microencapsulation and pharmacological evaluations for the antifertility effect of castor bean extract in female mice. *International Journal of Pharmacy and Pharmacology, 5*(10), 001-008.

7. Salami, S. A., & Raji, Y. (2014). Oral *Ricinus communis* oil exposure at different stages of pregnancy impaired hormonal, lipid profile and histopathology of reproductive organs in Wistar rats. *Journal of Medicinal Plant Research, 8*(44), 1289–1298.

8. Elkousy, R. H., Said, Z. N. A., Ali, M. A., Kutkat, O., & Abu El Wafa, S. A. (2023). Anti-SARS-CoV-2 in vitro potential of castor oil plant (Ricinus communis) leaf extract: in-silico virtual evidence. *Zeitschrift Für Naturforschung C, 78*(9–10), 365–376. doi: 10.1515/znc-2023-0075

9. Abdul, W., Hajrah, N., Sabir, JamalS. M., Al-Garni, S., Sabir, M., Kabli, S., Saini, K., & Bora, R. (2018). Therapeutic role of Ricinus communis L. and its bioactive compounds in disease prevention and treatment. *Asian Pacific Journal of Tropical Medicine, 11*(3), 177. doi: 10.4103/1995-7645.228431

10. Okwuasaba, F. K., Osunkwo, U. A., Ekwenchi, M. M., Ekpenyong, K. I., Onwukeme, K. E., Olayinka, A. O., Uguru, M. O., & Das, S. C. (1991). Anticonceptive and estrogenic effects of a seed extract of Ricinus communis var. minor. *Journal of Ethnopharmacology, 34*(2–3), 141–145. doi: 10.1016/0378-8741(91)90031-8

11. Akpan, G. J., Udongwo, A. M., & Obodom, M. I. (2022). Extraction, Characterization And Applications Of Castor Seed Oil From Wild Ricinus communis. *Journal of Chemical Society of Nigeria, 47*(4). doi: 10.46602/jcsn.v47i4.795

12. Sandford, E. C., Muntz, A., & Craig, J. P. (2021). Therapeutic potential of castor oil in managing blepharitis, meibomian gland dysfunction and dry eye. *Clinical and Experimental Optometry, 104*(3), 315–322. doi: 10.1111/cxo.13148

13. Sharma, R., Goyal, A., Bhat, R. (2013). *Antifertility Activity Of Plants Extracts On Female Reproduction: A Review*. Retrieved from https://www.researchgate.net/publication/262938502_Antifertility_Activity_of_Plants_Extracts_on_Female_Reproduction_A_Review

14. Salihu, B. Z., Gana, A. K., & Apuyor, B. O. (2014). Castor oil plant (Ricinus communis L.): Botany, Ecology and Uses. *International Journal of Science and Research, 3*(5), 1333–1334.

15. Patel, V. R., Dumancas, G. G., Viswanath, L. C. K., Maples, R., & Subong, B. J. J. (2016). Castor Oil: Properties, Uses, and Optimization of Processing Parameters in Commercial Production. *Lipid Insights, 9*, LPI.S40233. doi: 10.4137/lpi.s40233

16. JU, I., Nnamdi, N. C., PC, N., PO, A., & FK, O. (2023). Studies on Acute and Sub-Chronic Toxicities of N-Hexane Seed Extract of Ricom-1013-J in Wistar Rats. *Saudi Journal of Biomedical Research, 8*(05), 63–68. doi: 10.36348/sjbr.2023.v08i05.003

17. Basiri, N., & Ibraheem O. (2014). Assessing Ricinus communis L.(castor) whole plant parts for Phenolics and Saponins constituents for Medicinal and Pharmaceutical applications. Retrieved from https://www.semanticscholar.org/paper/Assessing-Ricinus-communis-L-.-(-castor-)-whole-for-Inayor-Ibraheem/c6e611fd7d3e0d1bba266d355cd3f05c068e2394

18. Vandita, P., Nirali, A., Kyati, P., & Monisha, K. (2013). Effect of phytochemical constituents of Ricinus communis, Pterocarpus santalinus, Terminalia belericaon antibacterial, antifungal and cytotoxic activity. *International Journal of Toxicological and Pharmacological Research, 5*(2), 47–54.

19. Chouhan, H. S., Swarnkar, G., & Jogpal, B. (2021). Medicinal properties of Ricinus communis: A review. *International Journal of Pharmaceutical Sciences and Research, 12*(7), 3632–3642.

20. Abbas, M., Ali, A., Arshad, M., Atta, A., Mehmood, Z., Tahir, I. M., & Iqbal, M. (2018). Mutagenicity, cytotoxic and antioxidant activities of Ricinus communis different parts. *Chemistry Central Journal, 12*(1). doi: 10.1186/s13065-018-0370-0

21. Raji, Y., Oloyo, A. K., & Morakinyo, A. O. (2006). Effect of methanol extract of Ricinus communis seed on reproduction of male rats. *Asian Journal of Andrology, 8*(1), 115–121. doi: 10.1111/j.1745-7262.2006.00055.x

22. Desouky, M. M. A., Abd El-Atti, M. S., Elsheakh, A. A., & Elgohary, W. S. (2022). Effect of *Eucalyptus globulus* oil and *Ricinus communis* methanolic extract as potential natural molluscicides on the reproductive biology and some antioxidant enzymes of the land snail. *Theba pisana*. *Heliyon*, *8*(12), e12405. doi: 10.1016/j.heliyon.2022.e12405

23. Britannica. (2024). *Castor-oil plant*. Retrieved February 28, 2024, from https://www.britannica.com/plant/castor-oil-plant

24. Sbihi, H. M., Nehdi, I. A., Mokbli, S., Romdhani-Younes, M., & Al-Resayes, S. I. (2018). Hexane and ethanol extracted seed oils and leaf essential compositions from two castor plant (Ricinus communis L.) varieties. *Industrial Crops and Products, 122*, 174–181. doi: 10.1016/j.indcrop.2018.05.072

25. Erhirhie, E. O., Ihekwereme, C. P., & Ilodigwe, E. E. (2018). Advances in acute toxicity testing: strengths, weaknesses and regulatory acceptance. *Interdisciplinary Toxicology, 11*(1), 5–12. doi: 10.2478/intox-2018-0001

26. Odebiyi, O. O., & Sofowora, E. A. (1978). *Phytochemical screening of Nigerian medicinal plants II*. Retrieved from https://pubmed.ncbi.nlm.nih.gov/672462/

27. Kaur, S., & Prabha, V. (2012). Infertility as a Consequence of Spermagglutinating Staphylococcus aureus Colonization in Genital Tract of Female Mice. *PLoS ONE, 7*(12), e52325. doi: 10.1371/journal.pone.0052325

28. Sari, G. P., Hilario, P. L. L., Yuri, S., Honda, A., & Isotani, A. (2022). Scheduled simple production method of pseudopregnant female mice for embryo transfer using the luteinizing hormone-releasing hormone agonist. *Scientific Reports, 12*(1). doi: 10.1038/s41598-022-26425-2

29. Green, N., Stout, G., & Taylor, D. (1995). *Biological Sciences* (2nd ed.) Cambridge: Cambridge University Press.

30. Nath, S., Kadasi, A., Grossmann, R., Sirotkin, A. V., Kolesarova, A., Talukdar, A. D., & Choudhury, M. D. (2015). Ricinus communis L. stem bark extracts regulate ovarian cell functions and secretory activity and their response to Luteinising hormone. *International Journal of Impotence Research, 27*(6), 215–220. doi: 10.1038/ijir.2015.19

31. Conneely, O. M. (2002). Reproductive Functions of Progesterone Receptors. *Recent Progress in Hormone Research, 57*(1), 339–355. doi: 10.1210/rp.57.1.339

32. Graham, J. D., & Clarke, C. L. (1997). Physiological Action of Progesterone in Target Tissues. *Endocrine Reviews, 18*(4), 502–519. doi: 10.1210/edrv.18.4.0308

33. Kaluwa Kaingu, C., Oduma, J. A., & Kanui, T. (2012). Preliminary investigation of contractile activity of Ricinus communis and Euclea divinorum extracts on isolated rabbit uterine strips. *Journal of Ethnopharmacology, 142*(2), 496–502. doi: 10.1016/j.jep.2012.05.026

Application of Different Rates of N:P:K Fertilizer on the Growth and Yield Components of Upland Rice in Rice-Soybean Intercropping System

Effam Marian Ozioma [1]**, Ogbodo Emmanuel Nwabunwanne** [1]**, Mba Emmanuel Ukaoba** [1]**, Onyeaghala Innocent Daniel** [1]

[1] *Michael Okpara University of Agriculture*
P. M. B. 7267 Umuahia Umudike, Abia State, Nigeria

Abstract. Nigeria is one of the fastest developing countries in sub-Saharan Africa, and hence, there is an urgent need to invest in agriculture to boost food production to meet the citizen's nutritional needs and for export. Due to the increasing population, urbanisation and industrialisation in Nigeria, especially in the South East, with a small land mass, intercropping is highly recommended. A two-year field experiment was carried out in the 2018 and 2019 cropping seasons to assess the effect of the application of different rates of N:P:K fertiliser on the growth and yield components of upland rice in a rice-soybean intercropping system. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The treatment includes rice and soybeans with five levels of N:P:K 15 :15 :15 (0, 100, 200, 300 and 400 kg) fertiliser rates, as well as rice sole and soybean sole. The result showed that the interaction of upland rice and soybean with N:P:K fertiliser significantly affected the plant height, number of leaves, leaf area index, number of panicles per plant and number of seeds per rice plant. Based on the result of this investigation, it was observed that the cropping system and increased fertiliser rates positively affected upland rice's growth and yield component. It was noted that the N:P:K fertiliser rate (400 kg) gave the highest growth and yield component of upland rice in the rice/soybean intercropping system.

Keywords: Intercropping; Fertilizer; Rice; Soybean; System.

INTRODUCTION

Nigeria is one of the fastest developing countries in sub-Saharan Africa. Hence, there is an urgent need to invest in agriculture to boost food production to meet the citizen's nutritional needs and for export. Due to the increasing population, urbanisation and industrialisation in Nigeria, especially in the South East, with a small land mass, intercropping is highly recommended. Agricultural research initially focused on sole cropping and ignored the potential of intercropping [1], but there has been a gradual recognition of the value of the intercropping system [2]. Intercropping is growing two or more crops on the same land within the same year to promote their interaction and maximise productivity by avoiding dependence on only one crop [3]. The author [4] stated that mixed cropping or intercropping expresses African farmer's desire to minimise risk.

Authors [5, 6] observed that the yield advantage of intercropping has yet to be marked in several situations, possibly due to the use of either super-optimal or sub-optimal plant population proportion for component crops.

Rice is the primary food for nearly half the people on earth. It has become a highly strategic and priority commodity for food security in Africa. Consumption is growing faster than any other major staple on the continent because of high population growth, rapid urbanisation, and changes in eating habits [7].

Rice is an annual crop and the most important staple food crop in tropical countries; commercially, it is the most important cereal after wheat. It is the most critical source of dietary energy in West Africa and the third most important for Africa. Nigeria is the largest producer of rice in the West Africa sub-region. In Nigeria, rice is one of

the few food items whose consumption has no cultural, religious, ethnic or geographical boundary. It is highly priced and widely accepted for festivity. In some rural areas, it is so adored that it is eaten only on Sundays and sometimes on market days [8].

Upland rice (Oryza sativa) is a staple food crop for millions in Asia and Africa [9]. It is typically grown in rainfed and upland areas, where the soil is often poor in nutrients and prone to erosion. Intercropping upland rice with legumes can increase rice yields and improve soil fertility through the nitrogen-fixing capabilities of mungbean [9]. Upland rice has been found to have allelopathic effects on other crops, which can be both positive and negative [10]. Some studies have reported that intercropping upland rice with legumes like cowpea and soybean can improve soil fertility and increase the yield of both crops. However, other studies have shown that intercropping with upland rice can also negatively affect the growth and yield of crops such as maise and groundnut [11].

Soybean (Glycine max) is another crucial legume crop known for its high protein content and oil production. It is widely grown in the Americas, Asia, and Africa [12]. Soybeans face low soil fertility and pest and disease pressure like mung beans. Intercropping soybeans with upland rice can improve soybean yields and reduce pest and disease pressure through the allelopathic effect of rice [12].

Soybean is an important leguminous crop widely grown in many parts of the world, including Asia, North America, and South America. It is a rich source of protein and oil, making it a valuable crop for human and animal consumption. To increase productivity, soybeans are often intercropped with maise, rice, and other crops. Intercropping soybeans with maise has been found to improve the nitrogen economy of the cropping system, as soybeans fix atmospheric nitrogen, which is then used by Maise [9]. Moreover, intercropping soybeans with other crops has improved soil health, reduced pest and disease incidence, and increased yield.

Therefore, the current study assessed upland rice and soybean growth, yield, and productivity in an intercropping system. It specifically determined the effect of different N:P:K fertiliser rates on the growth and yield of upland rice in a rice-soybean intercropping system.

MATERIALS AND METHODS

Study Area and Location. Three field experiments were conducted at the research farm of Michael Okpara University of Agriculture Umudike in the 2017/2018 and 2018/2019 cropping seasons. Umudike is located around longitude 07° 33'E and latitude 05° 29' N at an elevation of 122 m above sea level in the humid tropical lowland of southeastern Nigeria. Umudike is a typical rainforest vegetation with a relative humidity of 50-95% and a bimodal rainfall pattern with an average temperature of about 20 °C [13]. The soil of the site is classified as an ultisol [14].

Planting Materials. The seeds of Rice (FARO 58) and TGX 47 soybean varieties were used in Experiment 1. Rice (FARO 58) and Soybean (TGX 47) varieties were used in Experiment 2, while Rice (FARO 58), cowpea (SAMPEA 16) groundnut, mungbean and Soybean (IT87K-318-33) were used in Experiment 3. Rice seeds were sourced from the National Cereals Research Institute (NCRI) Amakama Olokoro, Abia State. In contrast, soybean, cowpea, and groundnut seeds were sourced from the Institute of Agricultural Research (IAR), Zaria, except mungbean seeds, which were sourced from the College of Crop and Soil Science, Umudike, Abia State.

Meteorological Information. Weather records such as rainfall, temperature, relative humidity, wind speed, and sunshine were obtained from the National Root Crop Research Institute, Umudike, an Agrometeorological unit located about 350 m from the experimental site.

Experiment: Effect of Application of Different Rates of N:P:K Fertilizer on the Growth and Yield of Upland Rice in Rice/ Soybean Intercropping System

Field preparation and soil sampling. The experimental site was slashed manually on 12th March, and the disc was ploughed and harrowed on 16th March 2018. In 2019, the site was slashed on 5th June, ploughed and harrowed on 7th June. After the ploughing and harrowing, weeds were removed manually to achieve a clean and weed-free experimental site for planting. The field was marked out into plot sites of uniform measurement.

Soil samples were collected randomly at a depth of 0-20 cm from different representation locations of the experimental site with a soil auger and taken to the National Root Crop Research Institute Soil Laboratory, Umudike, to determine

the chemical and physical properties of the soil. Bouyoucos method was used to determine the % of sand, silt, and clay. Soil pH in 1:2.5 soil/water ratio was determined using a pH meter. Organic matter content was obtained by multiplying total carbon by 1.724. Organic carbon content was determined by the Walkey-Black method. Total nitrogen was used to determine by the microkjeldahl method. The bray-1 method was used to determine available phosphorus. Exchangeable cations (Ca, Mg, K and Na) were extracted with one standard neutral ammonium acetate solution and exchangeable K and Na were read using a flame photometer. In contrast, Ca and Mg were read using an atomic absorption spectrophotometer (AAS).

NPK 15:15:15 fertiliser was sourced from the opened market.

Treatments and experimental design. The treatment used were rice (FARO 58)-T_1 and TGX 47 soybean- T_2 with five rates of N.P.K 15:15:15(0, 100, 200, 300 and 400 kg)

Treatments include Sole Rice + 0 kg/ha of N:P:K , Sole Rice + 100 kg/ha of N:P:K , Sole Rice + 200 kg /ha of N:P:K, Sole Rice + 300 kg/ha of N:P:K, Sole Rice + 400 kg/ha of N:P:K, Sole Soybean + 0 kg/ha of N:P:K, Sole Soybean + 100 kg/ha of N:P:K, Sole Soybean + 200 kg/ha of N:P:K, Sole Soybean + 300 kg/ha of N:P:K, Sole Soybean + 400 kg/ha of N:P:K, Rice + soybean + 0 kg /ha of N:P:K, Rice + Soybean + 100 kg/ha of N:P:K, Rice + Soybean + 200 kg/ha of N:P:K , Rice + Soybean + 300 kg of N:P:K, Rice + soybean + 400 kg of N:P:K. Each treatment was replicated three times. Each plot measured 2 x 2 m (4 m^2). Each replication had 15 plots with an intra-block spacing of 0.5 m and inter-block spacing of 1 m. Rice seeds were sown at the recommended spacing of 20 x 20 cm, giving a population of 500,000 plants/ha. Sowing was done on (14th March 2018 for the first cropping season and 10th June 2019 for the second cropping season). Rice seeds were sown by direct seeding. Pest was controlled at 2 and 4 weeks after planting using Lambdacyhalothrin 2.5 EC at the rate of 300 ml/ha.

Growth and Yield parameters. Growth parameters were measured 2, 4, 6, 8, and 10 weeks after planting. Four plants were tagged for the collection of growth parameters, while yield parameters were measured ten weeks after planting from 4 plants when the rice plant's panicles and soybean pods started drying up. The plants for observation and data collection were taken from the inner rows of the treatment plot.

The following data were collected for rice and soybean:

1. Plant height (cm) was measured with a linear tape from the ground level to the tip of the plant.

2. The number of leaves per plant was determined by counting.

3. The leaf area index (LAI) was calculated from the leaf area.

4. The length of the panicle (cm) was measured with a linear tape

5. The number of panicles per plant was determined by counting.

6. The number of seeds per panicle was determined by counting.

7. The number of seeds per pod was obtained by counting.

8. Weight of pods per plant.

Statistical analysis. The morphological and yield data collected were subjected to Analysis of Variance (ANOVA) for a single-factor experiment in Randomized Complete Block Design (RCBD) using Genstat. Treatment means obtained were appropriately compared for statistical significance using Fisher's least significant difference (F-LSD) at the 0.05 probability level.

RESULTS AND DISCUSSION

Soils and Meteorological Data. The soils of the experimental sites were texturally sandy loam in 2018 and 2019 (Table 1). The table below indicates the soil pH was low, with a value of 4.5 in 2018 but high in 2019, with a value of 5.13. Soil organic matter and nitrogen were high in both years, but values in 2018 were higher than in 2019

Available P was high in both years but higher in 20118 than in 2019. Soil calcium and magnesium were above the critical levels. The soil's base saturation was also high in both years.

Table 2 shows the total annual rainfall for 2018 and 2019 as 2028.6 mm and 3075.0 mm, respectively. The rainfall was bimodal and peaked in April and September of 2018 and July and September of 2019, but it was higher in September of 2019 than in other months. April to October experienced high and stable rainy days in 2018

but were higher in 2019. The temperature was relatively high throughout the year 2018 and 2019. The mean monthly max temp was 32.9 °C and 31.7 °C, respectively, in 2018 and 2019. Relatively, humidity was lowest in Feb while it was highest in July.

Table 1 − Physico-chemical properties of the experimental sites in 2018 and 2019 cropping seasons

	2018	2019
Physical properties		
Sand (%)	64,7	81,20
Silt (%)	11,40	9,70
Clay (%)	12,90	11,10
Textural class	Sandy	Sandy

	2018	2019
	loam	loam
Chemical properties		
pH (H_2O)	4,50	5,13
Organic matter (%)	2,42	1,71
Organic carbon (%)	1,13	1,07
Total N (%)	0,23	0,17
Available P (mg Kg^{-1})	19,80	13,78
Exchangeable K (cmol Kg^{-1})	0,17	0,24
Exchangeable Na (cmol Kg^{-1})	0,23	0,12
Exchangeable Ca (cmol Kg^{-1})	7,40	3,20
Exchangeable Ea (cmol Kg^{-1})	0,48	1,49
Exchangeable Mg (cmol Kg^{-1})	1,00	1,08
Effective CEC (cmol Kg^{-1})	9,14	4,76
Base saturation (%)	94,68	81,53

Table 2 − Agrometeorological data of the experimental sites for 2018 and 2019

Month	Rainfall Amount, mm	Maximum air temperature, °C 2018	Relative humidity, % (0900Hrs)	Rainfall Amount, mm	Maximum air temperature, °C 2019	Relative Humidity (%) (0900Hrs)
January	0.0	34.1	78	38.9	35	65
February	80.1	34.5	81	80.9	34	69
March	9.6	34.4	87	65.7	34	84
April	337.5	32.5	88	137.1	36	79
May	246.6	32.6	87	355.7	32	77
June	326.6	30.9	87	523.4	29	76
July	237	29.6	84	554.1	28	90
August	173.3	30.4	80	206.6	30	89
September	334.7	30.1	85	635.0	27	88
October	238.9	40.8	78	367.3	31	78
November	44.3	30.7	81	107.2	32	70
December	0.0	34.5	87	0.0	32	47
Total	2028.6	395.1	79	3075.0	32	76

Table 3 shows the effect of the cropping system and fertiliser rate on the plant height of rice. The cropping system had no significant difference (P>0.05) in the plant height of rice in both cropping seasons except at 8 WAP in 2018. This could be due to the low nutrient uptake and resource competition between the legume crops and rice plants. However, intercrop rice produced significantly the lowest plant height at 2 WAP in both years among the cropping systems. This is consistent with [15], who reported that intercropping significantly reduced the plant height of rice, which could be attributed to competition for resources.

The fertiliser rate showed no significant difference in plant height of rice except at 6 and 10

WAP in 2018, while significant differences were observed at 4, 6 and 8 WAP. 0kg NPK (Control) gave significantly the lowest plant height of rice across all the sample ages in 2019. By implication, nitrogen increases and improves considerably the vegetative growth of rice.

Interaction of rice and fertiliser in both sole and intercrop showed consistent significant differences in plant height of rice at 6WAP in the 2018 and 2019 cropping seasons. This is consistent with [16], who reported that fertiliser application in intercropping significantly impacted upland rice's growth and development. Among the intercrop crop interactions, the intercrop 0 kg NPK (control) consistently produced the lowest number of plant heights of rice at 4, 8, and 10 WAP in both years. This is consistent with the findings of

[17], who reported that no fertiliser application can affect the height of upland rice. Intercrop interaction in sole had 400 kg NPK fertiliser as the highest plant height of rice at 4 and 6 WAP in 2018, while in 2019, the trend changed as 400 kg fertiliser gave the highest plant height at 4, 8 and 10 WAP, respectively. This is also consistent with [16], who reported that the combination of fertiliser and intercropping significantly impacted rice's plant height.

Table 3 – Effect of cropping system and fertiliser rate on plant height of rice at different stages of growth in 2018 and 2019 cropping seasons

	2018						2019			
	Plant height (cm)									
Treatment	Weeks after planting (WAP)									
Cropping system (C)	2	4	6	8	10	2	4	6	8	10
Sole rice	4.39	9.84	15.27	16.73	22.25	5.15	10.28	15.41	23.54	39.5
Intercrop rice	4.35	9.20	16.09	18.63	22.74	5.29	10.73	16.58	22.14	39.1
LSD(0.05)	ns	ns	ns	1.407	ns	ns	ns	ns	ns	ns
NPK-15:15:15 Fertilizer rate (F) (kg ha-1)										
0 (Control)	4.61	9.09	14.16	16.20	19.83	5.02	9.70	14.03	19.45	35.4
100	4.44	9.54	13.77	18.25	20.88	5.07	9.88	15.20	21.00	37.7
200	4.43	9.03	16.14	18.03	22.60	5.05	10.45	14.87	21.08	37.6
300	4.58	10.15	16.29	18.22	25.94	5.30	10.80	18.81	23.34	38.3
400	3.80	9.79	18.03	17.70	23.63	5.68	11.68	17.07	26.82	47.5
LSD(0.05)	ns	ns	2.371	ns	3.077	ns	1.587	2.225	5.500	ns
Interaction (C × F)										
Sole rice × 0 kg ha-1	4.39	9.96	14.17	16.30	19.83	4.53	9.58	13.50	19.60	35.8
Sole rice × 100 kg ha-1	4.62	10.22	13.77	18.17	22.57	4.93	9.47	13.50	21.73	38.6
Sole rice × 200 kg ha-1	4.27	9.22	16.14	15.38	23.67	5.07	10.93	15.20	22.50	34.1
Sole rice × 300 kg ha-1	4.82	9.48	16.29	15.77	23.74	5.27	10.23	18.57	25.20	40.1
Sole rice x 400 kg ha-1	3.87	10.32	18.03	18.03	21.47	5.93	11.17	16.30	28.65	49.1
Intercrop rice × 0 kg ha-1	4.83	8.23	14.13	16.10	19.03	5.50	9.83	14.57	19.29	35.0
Intercrop rice × 100 kg ha-1	4.27	8.87	13.52	18.33	19.20	5.20	10.30	16.90	20.27	36.8
Intercrop rice× 200 kg ha-1	4.60	8.83	16.75	20.67	21.53	4.97	9.97	14.54	19.66	41.0
Intercrop rice × 300 kg ha-1	4.33	10.82	18.02	20.67	28.13	5.33	11.37	19.05	21.47	36.6
Intercrop rice × 400 kg ha-1	3.73	9.27	18.02	17.37	25.80	5.43	12.20	17.83	25.00	45.9
LSD(0.05)	ns	ns	3.353	3.147	4.351	1.169	2.244	3.147	ns	Ns

Table 4 shows the effect of the cropping system and fertiliser on several leaves/plants of rice at different stages of growth in 2018 and 2019. The cropping system had no significant effect (P>0.05) on the number of leaves/plants of rice in both cropping seasons across the sampled dates except at 8 WAP in 2019 (Table 4). This is consistent with [18], who reported no significant difference in the number of leaves per plant between sole cropping and intercropping systems. However, intercrop rice consistently gave the lowest number of leaves/plant of rice at 2 WAP in both cropping seasons.

Among the fertiliser rates, 4, 6, and 10, WAP produced significant differences in the number of rice leaves in 2018, while significant differences were observed across the sample ages expected at 2 WAP in 2019, respectively. Among the fertiliser rates, 0 kg (control) gave the lowest number of leaves of rice significantly across the sample dates in 2018, except at 4 WAP, while consistency was observed in the trend in 2019, except at 2 WAP. This is consistent with previous studies by [19], who reported that 0 kg N:P:K (control) significantly produced the lowest number of leaves of rice/plant in sole crop and intercrop.

The interaction of rice and fertiliser in sole and intercrop showed a significant difference across all the sampled ages, except for 2 WAP in both cropping seasons. This is consistent with [20], who reported a positive effect of intercropping on the crops. Among the interactions of rice and fertiliser in sole 0 kg N:P:K (control), fertiliser consistently gave the lowest number of rice

leaves at 4, 6, and 10 WAP in 2018 and 2019, respectively. Among the intercrop crop interactions of rice and fertiliser, 100 kg fertiliser gave the lowest number of rice leaves at 6 WAP in both

years. In comparison, 400 kg fertiliser gave the highest number of rice leaves at 6 WAP in 2018 and 2019, respectively. This could be attributed to the availability of nutrients to the rice plant.

Table 4 − Effect of cropping system and fertiliser rates on the number of leaves/plants of rice at different stages of growth in the 2018 and 2019 cropping seasons

	2018						2019			
	Number of leaves/plant									
Treatment	Weeks after planting (WAP)									
Cropping system (C)	2	4	6	8	10		2	4	6	8	10
Sole rice	3.820	10.51	26.4	35.6	37.19		4.27	10.71	23.46	40.6	40.4
Intercrop rice	3.747	8.90	25.1	36.9	37.75		4.13	10.55	23.09	30.8	41.2
LSD$_{(0.05)}$	ns	ns	ns	ns	ns		ns	ns	ns	6.53	ns
NPK-15:15:15 Fertilizer rate (F) (kg ha^{-1})										
0 (Control)	3.717	8.52	20.2	31.0	29.98		4.33	8.50	18.71	29.3	32.6
100	3.719	8.47	23.3	33.0	30.65		4.17	9.97	20.32	32.7	46.6
200	3.817	10.00	26.2	39.5	44.84		4.00	11.23	23.05	33.7	40.2
300	3.767	11.40	28.9	38.7	40.40		4.17	11.42	25.59	39.7	39.8
400	3.900	10.13	30.0	39.1	41.48		4.33	12.02	28.70	43.0	44.8
LSD$_{(0.05)}$	ns	2.734	6.68	ns	6.041		ns	2.780	4.775	10.32	11.34
Interaction (C × F)										
Sole rice × 0 kg ha^{-1}	3.833	8.53	20.8	35.0	29.82		4.00	8.33	16.77	27.6	23.6
Sole rice × 100 kg ha^{-1}	3.500	9.33	28.2	33.1	32.90		4.67	9.33	23.38	35.5	45.5
Sole rice × 200 kg ha^{-1}	3.933	11.67	27.3	34.9	44.63		4.00	11.80	24.50	43.1	47.0
Sole rice × 300 kg ha^{-1}	3.933	12.00	27.7	34.6	36.71		4.33	12.40	25.62	44.9	34.1
Sole rice x 400 kg ha^{-1}	3.900	11.00	28.0	40.7	41.88		4.33	11.67	27.04	51.7	51.9
Intercrop rice × 0 kg ha^{-1}	3.600	8.50	19.7	27.0	30.13		4.67	8.67	20.65	31.0	41.6
Intercrop rice × 100 kg ha^{-1}	3.933	7.60	18.5	32.9	28.39		3.67	10.60	17.27	29.9	47.7
Intercrop rice× 200 kg ha^{-1}	3.700	8.33	25.2	44.2	45.05		4.00	10.67	21.60	24.2	33.5
Intercrop rice × 300 kg ha^{-1}	3.600	10.80	30.2	42.9	44.10		4.00	10.43	25.57	34.6	45.5
Intercrop rice × 400 kg ha^{-1}	3.900	9.27	32.1	37.6	41.07		4.33	12.37	30.37	34.2	37.6
LSD$_{(0.05)}$	ns	3.866	9.45	12.56	8.544		ns	3.932	6.753	14.60	16.04

As shown in Table 5, the cropping system significantly affected the leaf area index of rice across all the sampled ages in both years, except at 2 and 4 WAP in 2018. However, the intercrop rice gave the highest leaf area index at 8 and 10 WAP in the 2018 and 2019 cropping seasons. This is due to the availability of N from the legumes to the upland rice.

The fertiliser rates showed significant differences (p<0.05) in the leaf area index of rice across all the sampled dates in 2018 and 2019 except at 4 WAP in 2018, respectively. This is consistent with previous studies by [21], who reported that the application difference in fertiliser rate thus significantly influenced the leaf area index of rice. Among the fertiliser rates, 0 kg (control) of N:P:K gave the lowest leaf area index across the sampled ages in both years except at 4

and 6 WAP in 2018, respectively. This is consistent with the studies by [22], who reported that inadequate fertilisation resulted in nutrient deficiency, leading to stunted growth and a decreased leaf area index, while 400 kg N:P:K gave the highest leaf area index at 2, 4, and 6 WAP in 2018 as well produced the highest leaf area index consistently across all the sample age in 2019. This implies that a higher fertiliser application would significantly increase the leaf area index of upland rice compared to a lower fertiliser application rate.

Interaction of rice and fertiliser in both sole and intercrop showed a consistent trend and significant difference in both cropping seasons across the sample dates except at 4 WAP in 2018. Among the interaction of rice and fertiliser in sole rice, 100 kg fertiliser consistently gave the

lowest leaf index of rice at 4 and 6 WAP in both years, whereas 400 kg consistently showed the highest leaf area index of rice at 2, 4, 6, and 8 WAP in both cropping season. Intercrop crop in-

teraction of rice and fertiliser 0 kg N:P:K (control) significantly gave rice's lowest leaf area index across all the sampled ages in both years except at 10 WAP in 2018, respectively.

Table 5 − Effect of cropping system and fertiliser rate on leaf area index of rice at different stages of growth in 2018 and 2019 cropping seasons

	2018					2019				
	Leaf area index									
Treatment	Weeks after planting (WAP)									
Cropping system (C)	2	4	6	8	10	2	4	6	8	10
Sole rice	0.030	0.137	0.829	1.771	2.065	2.553	0.029	0.139	0.806	1.916
Intercrop rice	0.031	0.131	2.051	2.238	2.505	0.027	0.139	0.871	1.680	2.687
LSD$_{(0.05)}$	ns	ns	0.203	0.333	0.364	0.002	0.037	0.187	0.271	0.356
NPK-15:15:15 Fertilizer rate (F) (kg ha^{-1})										
0 (Control)	0.026	0.079	0.637	1.248	1.561	0.023	0.106	0.502	1.206	1.552
100	0.029	0.073	0.617	1.337	1.767	0.028	0.109	0.628	1.382	2.365
200	0.031	0.095	0.968	2.270	2.944	0.029	0.126	0.877	1.729	2.795
300	0.034	0.167	1.188	2.703	2.342	0.031	0.168	1.046	2.258	2.976
400	0.034	0.268	1.290	2.463	2.811	0.031	0.187	1.142	2.415	3.412
LSD$_{(0.05)}$	0.005	ns	0.321	0.527	0.575	0.003	0.059	0.296	0.428	0.562
Interaction (C × F)										
Sole rice × 0 kg ha^{-1}	0.025	0.079	0.698	1.368	1.287	0.0230	0.1051	0.458	1.112	1.099
Sole rice × 100 kg ha^{-1}	0.028	0.073	0.503	1.217	1.749	0.0286	0.0868	0.549	1.371	2.365
Sole rice × 200 kg ha^{-1}	0.031	0.095	0.833	1.674	2.769	0.0325	0.1287	0.944	2.000	3.517
Sole rice × 300 kg ha^{-1}	0.032	0.167	0.949	2.039	2.136	0.0308	0.1717	0.986	2.416	2.650
Sole rice x 400 kg ha^{-1}	0.033	0.268	1.165	2.557	2.385	0.0325	0.2027	1.095	2.682	3.153
Intercrop rice × 0 kg ha^{-1}	0.027	0.089	0.576	1.129	1.835	0.0228	0.1064	0.547	1.300	2.004
Intercrop rice × 100 kg ha^{-1}	0.032	0.131	0.731	1.457	1.784	0.0275	0.1309	0.707	1.393	2.385
Intercrop rice× 200 kg ha^{-1}	0.031	0.123	1.103	2.865	3.119	0.0258	0.1232	0.810	1.459	2.073
Intercrop rice × 300 kg ha^{-1}	0.036	0.183	1.427	3.368	2.548	0.0303	0.1649	1.105	2.100	3.302
Intercrop rice × 400 kg ha^{-1}	0.036	0.128	1.415	2.370	3.236	0.0294	0.1715	1.188	2.148	3.670
LSD$_{(0.05)}$	0.007	ns	0.453	0.745	0.813	0.005	0.0838	0.4178	0.605	0.796

Table 6 shows the effect of the cropping system and fertiliser rate on soybean plant height at different stages of growth. The cropping system showed no significant difference across all the sampled ages in 2018 and 2019, respectively. However, sole soybean consistently gave the highest plant height across all the sample ages in both cropping seasons, except at 10 WAP in 2019.

The fertiliser rates showed significant differences in soybean plant height across all the sampled ages in cropping seasons except at 2 and 4 WAP in 2018, respectively. This is consistent with previous studies that reported a positive correlation between fertiliser rate and plant height of soybeans [23, 24]. This implies that the higher the fertiliser rate, the taller the plant, which can be attributed to the increase in nutrient availability.

The result showed that fertiliser rates' effect on soybean plant height varied in different cropping seasons. This can be due to the variation in environmental conditions such as temperature, rainfall and sunlight, which can affect the uptake and utilisation of nutrients.

Among the fertiliser rates of 0 kg (control), N:P:K consistently gave the lowest soybean plant height at 2 and 6 WAP in 2018 and 2019. Statistically, 400 kg of N:P:K produced the highest soybean plant height across all the sampled ages in both cropping seasons except at 10 WAP in 2019.

The interaction of soybean and fertiliser showed significant differences across all the sampled ages in both cropping seasons except at 2WAP in 2018. However, soybean and fertiliser interaction in sole soybean indicated that 0 kg N:P:K produced the lowest soybean plant height across

all the sample ages in 2018, except at 4 WAP. Although the trend was not consistent in 2019, in the intercrop crop interaction, 400 kg consistently gave the highest plant height of soybeans across the sampled ages in both cropping seasons, except for 4 and 6 WAP in 2018.

Table 6 − Effect of the cropping system and fertiliser rate on yield and yield components of rice in the 2018 and 2019 cropping seasons

Treatment	Length of panicles, cm	Number of panicles / plant	Number of seeds / plant	Length of panicle (cm)	Number of panicles / plant	Number of seeds / plant
Cropping system (C)						
Sole rice	33.79	5.99	597.	27.87	8.4	1061.
Intercrop rice	34.11	6.02	656.	27.05	19.3	956.
LSD$_{(0.05)}$	ns	ns	ns	ns	ns	ns
NPK-15:15:15 Fertilizer rate (F) (kg ha^{-1})						
0 (Control)	32.99	4.22	395.	26.93	6.6	645.
100	30.89	5.85	596.	26.95	31.9	884.
200	35.61	6.21	629.	28.09	10.7	987.
300	34.07	6.84	778.	27.06	10.1	1088.
400	36.20	6.92	815.	28.27	9.9	1439.
LSD$_{(0.05)}$	3.107	0.747	ns	ns	ns	411.3
Interaction (C × F)						
Sole rice × 0 kg ha^{-1}	33.05	3.97	376.	27.49	5.4	619.
Sole rice × 100 kg ha^{-1}	28.95	6.24	516.	25.74	6.5	665.
Sole rice × 200 kg ha^{-1}	36.05	5.69	527.	28.40	9.2	1172.
Sole rice × 300 kg ha^{-1}	34.35	7.01	767.	28.65	10.4	1221.
Sole rice x 400 kg ha^{-1}	36.57	7.06	798.	29.05	10.3	1629.
Intercrop rice × 0 kg ha^{-1}	32.94	4.47	414	26.36	7.8	671.
Intercrop rice × 100 kg ha^{-1}	32.80	5.47	516.	28.16	57.4	1102.
Intercrop rice× 200 kg ha^{-1}	35.18	6.73	732	27.79	12.2	803.
Intercrop rice × 300 kg ha^{-1}	33.79	6.67	789.	25.47	9.8	954.
Intercrop rice × 400 kg ha^{-1}	35.84	6.79	832	27.49	9.5	1249.
LSD$_{(0.05)}$	4.393	1.056	127.9	ns	46.50	581.7

Table 7 shows that the cropping system showed no significant difference in the length of panicles, number of panicles per plant, and number of seeds per rice in both years. Intercrop rice produced the most extended length of panicles and the highest number of seeds per plant in 2018. The NPK fertiliser rates showed significant differences in the size of panicles per plant and the number of panicles per plant of rice in 2018, but the trend was not consistent in 2019 (Table 7). However, among the N:P:K fertiliser rates, 400 kg NPK produced the highest panicle length per plant, the highest number of panicles per plant, and the highest number of seeds per plant in 2018, consistent in 2019 except for several panicles per plant.

Among the interaction of rice and fertiliser in sole rice, 400 kg NPK produced the highest length of panicle, number of panicles and number of seeds/plants in 2018, while in 2019, 100 kilograms NPK produced the highest length of panicles and highest number of panicles, and highest number of seeds/plant.

Table 8 indicates the effect of the cropping system and fertiliser rates on the number of leaves/plants of soybeans at different stages of growth in 2018 and 2019. The cropping system showed no significant difference across all the sampled ages in 2018 and 2019, respectively. The number of leaves under the cropping system produced significantly the highest number of soybean leaves in 2018.

Table 7 – Effect of cropping system and fertiliser rate on plant height of soybean at different stages of growth in 2018 and 2019 cropping seasons

Treatment	2018					2019				
	Plant height (cm)									
	Weeks after planting (WAP)									
Cropping system (C)	2	4	6	8	10	2	4	6	8	10
Sole soybean	9.32	13.78	30.64	37.6	37.6	12.11	21.72	36.39	44.28	46.9
Intercrop soybean	8.71	12.96	28.29	34.8	34.8	11.53	20.13	36.11	44.22	48.2
LSD$_{(0.05)}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
NPK-15:15:15 Fertilizer rate (F) (kg ha^{-1})										
0 (Control)	8.23	13.59	26.47	32.2	32.2	10.90	19.98	32.63	39.93	43.9
100	8.94	13.13	30.44	36.6	36.6	11.40	19.75	34.50	42.69	44.2
200	9.19	12.46	29.64	35.1	35.7	11.18	19.32	34.42	39.67	42.7
300	9.12	13.37	28.34	32.5	34.5	12.38	22.08	38.27	47.75	53.7
400	9.58	13.79	32.43	42.1	42.1	13.22	24.08	41.42	51.20	53.3
LSD$_{(0.05)}$	ns	ns	5.526	6.97	6.97	1.352	3.797	4.585	6.547	7.41
Interaction (C × F)										
Sole soybean× 0 kg ha^{-1}	8.70	13.53	25.62	30.7	30.7	12.01	21.27	33.70	42.30	44.6
Sole soybean× 100 kg ha^{-1}	9.75	13.22	35.27	40.4	40.4	10.97	18.83	32.40	41.73	43.8
Sole soybean× 200 kg ha^{-1}	9.05	11.39	27.15	36.2	36.2	11.87	19.70	35.03	38.50	42.5
Sole soybean × 300 kg ha^{-1}	9.47	15.33	30.53	36.4	36.4	11.77	22.90	40.30	45.70	48.7
Sole soybean x 400 kg ha^{-1}	9.62	15.33	34.65	44.5	44.5	13.93	25.90	40.50	53.17	55.1
Intercrop soybean× 0 kg ha^{-1}	7.76	13.55	27.32	33.6	33.6	9.80	17.50	31.57	37.57	43.3
Intercrop soybean× 100 kg ha^{-1}	8.13	13.05	25.62	32.9	32.9	11.83	20.67	36.60	43.65	44.5
Intercrop soybean × 200 kg ha^{-1}	9.33	13.53	32.13	35.1	35.1	10.50	18.93	33.80	40.83	43.0
Intercrop soybean× 300 kg ha^{-1}	8.77	12.42	26.15	32.7	32.7	13.00	21.27	36.23	49.80	58.6
Intercrop soybean× 400 kg ha^{-1}	9.55	12.25	30.22	39.7	39.7	12.50	22.27	42.33	49.23	51.51
LSD$_{(0.05)}$	ns	3.432	5.525	2.10	9.54	1.912	5.370	6.484	9.259	10.47

The fertiliser rates produced a significance (p<0.05) on the number of soybean leaves across all the sample dates in both cropping seasons, expected at 4 WAP in 2018 and 2019, respectively, among the N:P:K fertiliser rates, 400 kg produced the highest number of soybean leaves at 2, 8 and 10 WAP in both cropping seasons. This implies that an increasing fertiliser rate on soybeans would significantly increase the number of leaves per soybean plant.

The interaction of soybean and fertiliser indicated a significant difference in the number of soybean leaves across all the sampled ages in cropping seasons except at 2 and 4 WAP in 2018 (Table 8). To this effect, 400 kg NPK produced consistently the highest number of leaves at 4 and 10 WAP in both cropping seasons in sole soybeans. Intercrop interaction of 400 kg consistently produced the highest soybean leaves at 2, 8, and 10 WAP in both cropping seasons. The intercrop interaction result aligns with [25] findings, which reported that increasing fertiliser rates significantly increased the number of leaves per plant of soybean intercropped with sorghum, pearl millet, and maise. This finding implies that in-creasing fertiliser rates positively affected the number of leaves per plant of soybean in the intercropping system.

Table 9 shows that the cropping system showed no significant difference in the soybean leaf area index across all the sampled ages in 2018 and 2019 except at 10 WAP in both years. This is consistent with previous studies by [26, 27], who reported no significant difference in the soybean leaf area index in different planting patterns within a cropping system.

The fertiliser rate showed a significant difference in the leaf area index of soybeans across all the sample ages in both cropping seasons except at 2 WAP in 2018. However, 400 kg N:P:K gave consistently the highest leaf area index of soybean at 6 and 8 WAP in both cropping seasons. This is consistent with studies by [28, 29, 30, 31, 32], who reportedly established that increasing the fertiliser rate statistically increased the leaf area index of soybean while it is in disagreement with the finding [33] who noted a decrease in leaf area index of soybean as a result of an increase in Nitrogen fertiliser application.

Table 8 − Effect of cropping system and fertiliser rate on the number of leaves/plant of soybean at different stages of growth in the 2018 and 2019 cropping seasons

	2018					2019				
	Number of leaves/plant									
Treatment	Weeks after planting (WAP)									
Cropping system (C)	2	4	6	8	10	2	4	6	8	10
Sole soybean	9.32	13.78	23.45	37.57	42.8	5.335	10.14	19.00	29.7	41.26
Intercrop soybean	8.71	12.96	23.17	35.14	42.1	5.473	9.85	19.60	32.1	42.25
LSD$_{(0.05)}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
NPK-15:15:15 Fertilizer rate (F) (kg ha^{-1})										
0 (Control)	8.22	13.59	20.21	32.15	38.4	5.370	9.54	14.70	28.3	36.47
100	8.94	13.13	22.77	36.65	42.1	5.500	8.99	15.65	25.7	43.52
200	9.19	12.46	25.29	35.50	40.9	5.367	10.73	21.75	28.8	38.52
300	9.58	13.87	23.46	34.55	42.3	5.067	10.24	21.36	35.7	42.70
400	10.2	13.79	24.82	42.90	48.8	5.717	10.47	23.02	36.1	47.57
LSD$_{(0.05)}$	1.646	ns	4.143	6.348	7.87	0.595	ns	4.436	8.23	6.018
Interaction (C × F)										
Sole soybean× 0 kg ha^{-1}	8.70	13.63	18.78	30.70	34.4	5.307	10.57	17.43	28.8	34.23
Sole soybean× 100 kg ha^{-1}	9.75	13.22	26.53	40.40	45.1	5.400	8.07	13.67	25.0	44.40
Sole soybean× 200 kg ha^{-1}	9.05	11.39	23.55	35.87	41.4	4.967	10.77	20.20	27.9	37.21
Sole soybean × 300 kg ha^{-1}	9.47	15.33	23.50	36.37	42.3	5.433	9.60	21.13	33.8	44.07
Sole soybean x 400 kg ha^{-1}	9.62	15.33	24.88	44.50	50.8	5.567	11.68	22.55	33.0	46.41
Intercrop soybean× 0 kg ha^{-1}	7.75	13.55	21.63	33.61	42.4	5.433	8.51	11.97	27.7	38.70
Intercrop soybean× 100 kg ha^{-1}	8.13	13.05	19.00	32.90	39.2	5.600	9.91	17.64	26.3	42.63
Intercrop soybean × 200 kg ha^{-1}	9.33	13.53	27.03	35.13	40.5	5.767	10.70	23.30	29.7	39.83
Intercrop soybean× 300 kg ha^{-1}	8.77	12.42	23.42	32.73	41.7	4.700	10.87	21.58	37.7	41.33
Intercrop soybean× 400 kg ha^{-1}	9.55	12.25	24.75	41.31	46.9	5.867	9.27	23.50	39.2	48.73
LSD$_{(0.05)}$	ns	ns	5.859	8.977	11.13	0.841	2.565	6.274	11.63	8.511

The interaction of soybean and fertiliser consistently showed significant differences in the leaf area index of sole soybean in both years (Table 9). This is consistent with the findings [15], which reported that the leaf area index increased with the fertiliser application rate. To these effects, 400 kg N:P:K produced consistently the lowest leaf area index of soybean at 6 and 8 WAP in both cropping seasons in intercrop soybean. In Intercrop interaction, 400 kg consistently gave the highest leaf area index at 2 and 10 WA in both cropping seasons, respectively.

Table 9 − Effect of cropping system and fertiliser rate on Leaf area index of soybean at different stages of growth in 2018 and 2019 cropping seasons

	2018					2019				
	Leaf area index									
Treatment	Weeks after planting (WAP)									
Cropping system (C)	2	4	6	8	10	2	4	6	8	10
Sole soybean	0.155	0.443	1.157	3.99	5.48	0.355	1.202	3.070	5.27	6.43
Intercrop soybean	0.134	0.402	1.200	3.46	6.48	0.321	1.215	3.206	5.03	7.51
LSD$_{(0.05)}$	ns	ns	ns	ns	0.666	ns	ns	ns	ns	0.525
NPK-15:15:15 Fertilizer rate (F) (kg ha^{-1})										
0 (Control)	0.137	0.543	0.761	3.14	5.57	0.308	0.883	2.082	4.14	6.14
100	0.137	0.420	0.833	3.88	5.66	0.306	0.998	2.607	4.86	6.46
200	0.133	0.447	1.250	2.93	5.22	0.300	1.214	3.224	4.90	6.02
300	0.169	0.340	1.284	3.74	5.95	0.324	1.279	3.411	5.87	7.32
400	0.143	0.363	1.764	4.95	7.50	0.401	1.670	4.367	6.00	8.91
LSD$_{(0.05)}$	ns	0.201	0.434	1.047	1.052	0.083	0.564	0.422	1.087	0.830
Interaction (C × F)										
Sole soybean× 0 kg ha^{-1}	0.146	0.694	0.675	3.50	4.89	0.320	0.997	2.230	4.32	5.25

	2018					2019				
	Leaf area index									
Sole soybean× 100 kg ha-1	0.154	0.375	0.751	4.22	5.22	0.307	0.805	2.220	4.86	6.23
Sole soybean× 200 kg ha-1	0.145	0.391	0.989	2.85	4.50	0.298	1.267	3.177	4.92	5.73
Sole soybean × 300 kg ha-1	0.192	0.321	1.306	4.37	6.09	0.358	1.218	3.385	5.91	6.88
Sole soybean x 400 kg ha-1	0.136	0.434	2.063	5.03	6.70	0.390	1.725	4.338	6.36	8.07
Intercrop soybean× 0 kg ha-1	0.128	0.393	0.847	2.79	6.25	0.297	0.769	1.935	3.96	7.04
Intercrop soybean× 100 kg ha-1	0.122	0.466	0.914	3.54	6.10	0.304	1.191	2.993	4.86	6.69
Intercrop soybean × 200 kg ha-1	0.121	0.502	1.511	3.02	5.94	0.302	1.160	3.271	4.88	6.32
Intercrop soybean× 300 kg ha-1	0.146	0.359	1.263	3.10	5.81	0.289	1.340	3.436	5.82	7.76
Intercrop soybean× 400 kg ha-1	0.150	0.291	1.465	4.87	8.31	0.412	1.616	4.396	5.64	9.75
LSD(0.05)	0.060	0.285	0.613	1.481	1.488	0.117	0.798	0.597	1.537	1.174

The cropping system indicated a significant difference in the number of seeds/plants in 2018, while in 2019, the number of seeds per plant and the number of seeds/pods gave significant differences (Table 10). This is consistent with the findings of [16], who reported that the number of seeds per plant in intercropping gave statically a higher number of seeds per plant of soybean. These could be attributed to efficient resource utilisation, leading to better plant growth and a higher seed production/pod.

Table 10 – Effect of cropping system and fertiliser rate on yield components of Soybeans in 2018 and 2019 cropping seasons

Treatment	Number of seeds per plant	2018 Number of seeds per pod	Number of seeds per plant	2019 Number of seeds per pod
Cropping system (C)				
Sole rice	134.1	1.942	1.834	130.5
Intercrop rice	159.8	2.122	2.086	139.0
LSD(0.05)	8.09	ns	0.205	8.31
NPK-15:15:15 Fertilizer rate (F) (kg ha-1)				
0 (Control)	120.0	1.690	1.739	95.9
100	136.7	1.989	1.919	126.5
200	152.0	2.141	2.039	145.4
300	157.9	2.207	1.901	135.4
400	168.2	2.133	2.202	170.5
LSD(0.05)	12.79	0.337	0.325	13.13
Interaction (C × F)				
Sole rice × 0 kg ha-1	110.4	1.466	1.554	91.1
Sole rice × 100 kg ha-1	120.5	1.862	1.599	115.8
Sole rice × 200 kg ha-1	139.1	2.036	1.923	135.9
Sole rice × 300 kg ha-1	145.5	2.255	1.888	143.4
Sole rice x 400 kg ha-1	155.3	2.092	2.206	166.2
Intercrop rice × 0 kg ha-1	129.7	1.914	1.924	100.7
Intercrop rice × 100 kg ha-1	152.8	2.116	2.239	137.2
Intercrop rice× 200 kg ha-1	165.0	2.247	2.155	154.8
Intercrop rice × 300 kg ha-1	170.4	2.159	1.913	127.3
Intercrop rice × 400 kg ha-1	181.0	2.175	2.198	170.5
LSD(0.05)	18.09	0.477	0.459	18.57

The fertiliser showed significant differences across all the yield components of soybeans in 2018 and 2019, while 0 kg NPK consistently produced the lowest yield component in 2018 and 2019. This implies that the higher the fertiliser rate, the higher the yield component. On the other hand, 400 kg NPK fertiliser produced a static yield component of soybeans in both cropping

seasons, with the expected number of seeds/pods of soybeans in 2018. The interaction of soybean and fertiliser rates produced significant differences in all yield components of soybeans (Table 10) in both cropping seasons. Interaction of soybean and fertiliser rates in sole and intercrop indicated 0 kg in sole and intercrop produced consistently, the lowest yield component in both the 2018 and 2019 cropping seasons except on the number of seeds/plant in 0 kg (control) and soybean intercrop.

CONCLUSIONS

Based on the result of this investigation, it was observed that the cropping system and increased fertiliser rates positively affected upland rice's growth and yield component. It was noted that the N:P:K fertiliser rate (400 kg) gave the highest growth and yield component of upland rice in the rice/soybean intercropping system.

REFERENCES

1. Willey, R. W., & Osiru, D. S. O. (1972). Studies on mixtures of maise and beans (Phaseolus vulgaris) with particular reference to plant population. *The Journal of Agricultural Science, 79*(3), 517–529. doi: 10.1017/s0021859600025909

2. Stanford, B. (1991). *Evaluation of Cowpea lines in Nigerian Cropping Systems* (Doctoral thesis). Retrieved from https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://escholarship.mcgill.ca/downloads/k0698829f.pdf&ved=2ahUKEwido-OSmbWGAxX9RfEDHfQ_ANoQFnoECBIQAQ&usg=AOvVaw03srIa3wXpRxtrU5Z0iehG

3. Sullivan, P. (1998). *Intercrop Principles and practices. Agronomy Systems Guide.* Retrieved from https://www.iatp.org/sites/default/files/Intercropping_Principles_and_Production_Practi.htm

4. Ruthenberg, H. (1971). *Farming systems in the tropics.* Retrieved from https://pdf.usaid.gov/pdf_docs/PNAAP608.pdf

5. Fisher, N. (1977). Studies in Mixed Cropping. II. Population Pressures in Maize–Bean Mixtures. *Experimental Agriculture, 13*, 185–191.

6. Adetiloye, P. O. (1985). A mathematical model for formulating intercrop proportions for intercropping systems' design. *Ecological Modelling, 27*(1–2), 81–93. doi: 10.1016/0304-3800(85)90026-2

7. Diagne, A., Alia, D. Y., Wopereis, M. C. S., Saito, K., Nakelse, T., & Seck, P. A. (2013). Impact of rice research on income, poverty and food security in Africa: an ex-ante analysis. *Realising Africa's Rice Promise*, 390–423. doi: 10.1079/9781845938123.0390

8. Omofonmwan, S. I., & Kadiri, M. A. (2007). Problems and Prospects of Rice Production in Central District of Edo State, Nigeria. *Journal of Human Ecology, 22*(2), 123–128. doi: 10.1080/09709274.2007.11906010

9. Chandrakar, C. K., Prabha, N., Verma, O. N., & Pandey, K. K. (2019). Standardisation of Planting Geometry of Sugarcane with Suitable Intercropping under Drip Irrigation in Chhattisgarh Plains. *International Journal of Current Microbiology and Applied Sciences, 8*(07), 2878–2884. doi: 10.20546/ijcmas.2019.807.358

10. Kumar, S., Shrivastava, G., Navaz, M., Navrang, S., Pali, G., & Pandey, N. (2017). Impact of various organic sources of nitrogen on growth, yield attribbutes and yield of scented rice (Oryza sativa L.) under irrigated conditions of Chhattisgarh plains. *Journal of Pharmacognosy and Phytochemistry, 6*(6), 1388–1391.

11. Wang, Z., Zhao, X., Wu, P., He, J., Chen, X., Gao, Y., & Cao, X. (2015). Radiation interception and utilisation by wheat/maise strip intercropping systems. *Agricultural and Forest Meteorology, 204*, 58–66. doi: 10.1016/j.agrformet.2015.02.004

12. Kumari, R., Ravi, R. K., Tushar, R., & Anil, K. (2017). Global Approaches For Identification Of Markers Of Seed Quality. *International Journal of Advances in Agricultural Science and Technology, 4*(4), 29–43.

13. NRCRI. (2007). *Sweet Potato Programme.* Retrieved from https://nrcri.gov.ng/sweetpotato-research/

14. Eke-Okoro, O. N., Ikeorgu, J. E. G., & Okorocha, E. O. A. (1999). Comparative evaluation of five legume species for soil fertility improvement, weed suppression and component crop yield in cassava/legume intercrops/legume intercrops. *African Journal of Root and Tuber Crops, 3*(2), 54–57.

15. Huang, C., Liu, Q., Li, H., Li, X., Zhang, C., & Zhang, F. (2018). Optimised sowing date enhances crop resilience towards size-asymmetric competition and reduces the yield difference between intercropped and sole maise. *Field Crops Research, 217*, 125–133. doi: 10.1016/j.fcr.2017.12.010

16. Undie, U. L., Uwah, D. F., & Attoe, E. E. (2012). Effect of Intercropping and Crop Arrangement on Yield and Productivity of Late Season Maize/soybean Mixtures in the Humid Environment of South Southern Nigeria. *Journal of Agricultural Science, 4*(4). doi: 10.5539/jas.v4n4p37

17. Hauggaard-Nielsen, H., Ambus, P., & Jensen, E. S. (2001). Interspecific competition, N use and interference with weeds in pea–barley intercropping. *Field Crops Research, 70*(2), 101–109. doi: 10.1016/s0378-4290(01)00126-5

18. Bilal, H., Aman, F., Ullah, I. (2019). Response of Chilli Varieties to Various Sources Of Organic Fertilizers. *Journal of Agricultural and Biological Science, 14*(2), 15–24.

19. Fageria, N. K., Baligar, V. C., & Clark, R. B. (2002). Micronutrients in Crop Production. *Advances in Agronomy*, 185–268. doi: 10.1016/s0065-2113(02)77015-6

20. Lithourgidis, A. S., Dordas, C. A., Damalas, C. A., & Vlachostergios, D. N. (2011). Annual intercrops: an alternative pathway for sustainable agriculture. *Australian Journal of Crop Science, 5*(4), 396–410.

21. Mohammed, I. B., Olufajo, O. O., Singh, B. B., Miko, S., & Mohammed, S. G. (2008). Evaluation of yield of components of sorghum/cowpea intercrops in the Sudan Savanna ecological zone. *ARPN Journal of Agricultural and Biological Science, 3*(3), 30–37.

22. Varma, D., Adhikary, R., Reddy, M., & Maitra, S. (2022). Influence of nitrogen and phosphorus on growth and yield of summer maize (Zea mays L.). *Crop Research, 57*(3). doi: 10.31830/2454-1761.2022.020

23. Khalili, A., Dhar, S., Mohammadi, M., Rasooli, M. (2021). Effect of nitrogen on yield and yield attributes of soybeanin Kunar, Afghanistan. *E-planet, 19*(1), 46–49.

24. Khan, B., Elahi, A., Adnan, M., Amin, M., Toor, M., Aziz, A., Sohail, M., Wahab, A., & Ahmad, R. (2020). *Effect of phosphorus on growth, yield and quality ofsoybean (Glycine max L.): A review.* Retrieved from https://www.researchgate.net/publication/343485073_Effect_of_phosphorus_on_growth_yield_and_quality_of_soybean_Glycine_max_L_A_review

25. Akanbi, O. N., Adepoju, A. A., Olawuyi, S. O., & Olarinde, L. O. (2024). Cost and returns analysis of upland and lowland rice production among farmers in North Central Nigeria. *International Journal of Research in Business and Social Science, 13*(1), 288–302. doi: 10.20525/ijrbs.v13i1.2989

26. Ragin, B., Akond, M., Kantartzi, S., Meksem, K., Herrera, H., Akbay, C., Lightfoot, D. A., & Kassem, M. A. (2014). Effect of Row Spacing on Seed Isoflavone Contents in Soybean [Glycine max (L.) Merr.]. *American Journal of Plant Sciences, 05*(26), 4003–4010. doi: 10.4236/ajps.2014.526418

27. Zhou, X., Yang, L., & Chen, Y. (2011). Row Spacing Effect On Soil And Leaf Water Status Of Summer Soybean. *The Journal of Animal & Plant Sciences, 21*(4), 680–685

28. Chaudhary, D., Surve, V., Bambhaneeya, S., Raj, A., & Deshmukh, S. (2023). Effect of Organics on Yield, Quality, Nutrient Content and Uptake of Soybean [glycine Max (L.)] Under Rainfed Condition. *International Journal of Agricultural Science, 8*, 286–298.

29. Herencia, J. F., & Maqueda, C. (2016). Effects of time and dose of organic fertilisers on soil fertility, nutrient content and yield of vegetables. *The Journal of Agricultural Science, 154*(8), 1343–1361. doi: 10.1017/s0021859615001136

30. Rodger, J. B. A. (1982). The effect of fertiliser nitrogen, phosphorus and potassium on the calcium, magnesium and phosphorus status of pasture cut for silage. *The Journal of Agricultural Science, 99*(1), 199–205. doi: 10.1017/s0021859600055209

31. Shinoto, Y., Matsunami, T., Otani, R., & Maruyama, S. (2018). Growth and yield of maise using two tillage systems in crop rotation of paddy fields. *Plant Production Science, 22*(1), 58–67. doi: 10.1080/1343943x.2018.1545456

32. Cafaro La Menza, N., Monzon, J. P., Specht, J. E., & Grassini, P. (2017). Is soybean yield limited by nitrogen supply? *Field Crops Research, 213*, 204–212. doi: 10.1016/j.fcr.2017.08.009

33. Abera, Y., Masso, C., & Assefa, F. (2019). Inoculation with indigenous rhizobial isolates enhanced nodulation, growth, yield and protein content of soybean (Glycine max L.) at different agro-climatic regions in Ethiopia. *Journal of Plant Nutrition, 42*(16), 1900–1912. doi: 10.1080/01904167.2019.1648684

Dependence of Sheet Resistivity on Urbach Energy of Nano TiO$_2$ - Graphene-based Electrode for DSSC Application

Geoffrey Gitonga Riungu [1], **Simon Waweru Mugo** [1], **James Mbiyu Ngaruyia** [1], **Leonard Gitu** [1]

[1] *Jomo Kenyatta University of Agriculture and Technology*
P.O. Box 62000 – 00200 Nairobi, Kenya

Abstract. The importance of renewable energy cannot be over-emphasized. Titanium IV oxide (TiO$_2$) is the most suitable semiconductor for dye-sensitized solar cells (DSSC) due to its chemical stability, non-toxicity and excellent optoelectronic properties. In this research, TiO$_2$ is coated on Graphene to enhance its charge transport, aiming to reduce recombination, a main setback in DSSCs. Understanding Graphene- TiO$_2$ contact is, therefore, essential for DSSC application. Using doctor blading, TiO2 thin films were deposited on single-layer graphene (SLG) and fluorine tin oxide (FTO). The films were annealed at 2 °C /min and 1 °C/min up to a temperature of 450 °C, then sintering at this temperature for 30 minutes. Four four-point probes SRM -232 were used to measure the samples' sheet resistance. The film thickness was obtained from transmittance using pointwise unconstrained minimization approximation (PUMA). UV−VIS spectrophotometer was employed to measure transmittance. The resistivity of TiO$_2$ on both FTO and Graphene was of order 10^{-4} Ω cm. However, TiO$_2$ annealed on graphene matrix exhibited a slightly lower resistivity, 5.6 x10^{-4} Ω cm, compared to 6.0 x10^{-4} Ω cm on FTO. Optical transmittance on the visible region was lower for TiO$_2$ on FTO than on SLG, 71.48% and 80.11%, respectively. The annealing rate decreased the weak absorption region's Urbach energy (Eu). Urbach energies for 1°C/min TiO$_2$ on FTO and SLG were 361 meV and 261 meV, respectively. This accounted for the decrease in film disorders due to annealing. A striking relation between sheet resistivity and Urbach was reported, suggesting SLG as a suitable candidate for the photoanode of a DSSC.

Keywords: Graphene; Urbach energy; Resistivity; Annealing; Titanium IV oxide.

INTRODUCTION

Dye-sensitized cells researchers have revolution is mainly based on titanium dioxide (TiO$_2$) films due to their excellent optoelectronic properties, such as high refractive index, large band gap and high transmittance in the visible region [1]. The optical and structural properties of TiO$_2$ films can be tailored to promote their applications via deposition methods such as sputtering, doctor blading, chemical vapour deposition, and sol-gel processes [2]. Doctor Blade is a popular approach because it is simple, easy to scale up, cost-effective and suitable for large-area processing [3]. Several studies have been initiated to modify the electrical transport properties of TiO$_2$ using binary-system electrodes [4].

Graphene-based devices are promising candidates for future high-speed field-effect transistors (FETs) because they have a high carrier mobility of more than $10^4 cm^2 V^{-1} s^{-1}$ [5]. The mono-layer Graphene is a zero-gap semiconductor with a linear dispersion. In contrast, the multilayer graphene is a semimetal with a small band overlap between the conduction and valence bands. Electrons through single-layer graphene hop with minimal scattering and at a very high Fermi velocity of $\sim 10^6 m/s$ [6].

The SRM-232 offers a low-cost hand-held sheet resistance meter with a four-point probe for measuring the sheet resistance of applied coatings such as conductive paints, EMI coatings, ITO on glass, and many other types of thin films.

Generally, near band edges in optical absorption, an electron from the top of the valence band gets excited into the bottom of the conduction band across the energy band gap [7]. The Urbach energy, indicating the width of the exponentially decaying sub-bandgap absorption tail, is commonly used to indicate the electronic quality of thin-film materials for application in solar cells [8].

This work analyses the electrical conductivity of TiO2 grown on single-layer Graphene (SLG), and the relationship to Urbach energies is thus reported. This study aims to advance the optoelectronic applications of SLG to dye-sensitized solar cells.

Experimental procedure

Graphene. Single-layer Graphene was sourced from Charmgraphene Co. Ltd, Gwonseon-gu, Suwon, Republic of Korea. Graphene films were synthesized with thermal chemical vapour deposition (CVD) technology based on the roll-to-roll method. SLG was coated on a SiO2 substrate.

TiO2. Nanocrystalline TiO2 (T/SP, 18% wt, sourced from Solaronix, Switzerland.

Fluorine-doped tin IV oxide (FTO). FTO (SnO2: F) 7 Ω/sq, was sourced from Xinyan Technology Co. Limited, China.

Thin film deposition and annealing. Thin films were coated on FTO and SLG using the doctor blading technique. The prepared films were annealed using a muffle furnace at controlled rates of 1 °C/min and 2 °C/min from room temperature up to 450 °C. The films were then sintered for 30 minutes and cooled gradually back to room temperature.

Measurements and analysis

The optical transmittance was measured using a beam UV-visible spectrophotometer (Shimadzu UV probe 1800, Japan) in the 200-1100 nm wavelength range. Absorption coefficient Values for all corresponding wavelengths were obtained using SCOUT thin film analysis software [9]. The sheet resistance of the films was measured using a four-point probe, model SRM-232, as shown in Figure 1.
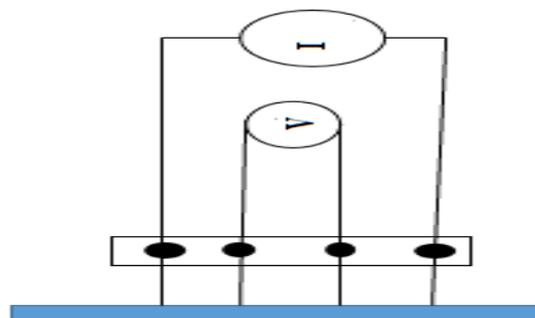
Figure 1 − Functional block diagram of SRM-232 Four-point probe

The voltage was measured across the inner probes, while the current was measured across the outer probes. The probes were operated manually by pressing the film. Sheet resistance (R_S) values are calculated and displayed on the digital panel. Resistivity (ρ) is defined in terms of voltage (V), current (I) and thickness (t) as in Equations 1 and 2.

$$\rho = 4.532 \frac{V}{I} t \tag{1}$$

$$\rho = 4.532 R_s \, t \; (\Omega\text{cm}) \tag{2}$$

The Urbach energy was calculated by plotting $\ln(\alpha)$ vs $h\nu$ and fitting the linear part of the curve with a straight line. The gradient of the line was used to calculate the search energies [10] as in Equation 3.

$$\alpha(h\nu) = \alpha_0 exp\left(\frac{h\nu}{E_u}\right) \tag{3}$$

A pointwise unconstrained optimization approach (PUMA) was used to estimate the thickness of the films from transmittance data [11]. Fora thin film deposited on a thick transparent substrate. The formulae giving thickness of film from the transmittance as a function of the wavelength λ is derived as shown [12] from Equations 4-9:

$$\text{Transmittance (T)} = \frac{Ax}{B - Cx + Dx^2} \tag{4}$$

$$\text{where } A = 16s(n^2 + \kappa^2) \tag{5}$$

$$B = [(n + 1)^2 + \kappa^2]$$
$$[(n + 1)(n + s^2) + \kappa^2] \tag{6}$$

$$C = [(n^2 - 1 + \kappa^2)(n^2 - s^2 + \kappa^2) - 2\kappa^2(s^2 + 1)]2\cos\phi - \kappa[2(n^2 - s^2 + \kappa^2) + (s^2 + 1)(n^2 - 1 + \kappa^2)]2\sin\phi \tag{7}$$

$$D = [(n - 1)^2 + \kappa^2]$$
$$(n - 1)(n - s^2) + \kappa^2] \tag{8}$$

$$\phi = 4\pi nd/\lambda, \; x = \exp(-\alpha d), \; \alpha = 4\pi\kappa/\lambda. \tag{9}$$

where d is the thickness of the film, s and n are the substrate and film's refraction index, α is the absorption coefficient, and κ is the (dimensionless) extinction coefficient.

RESULTS AND DISCUSSION

Sheet resistance. Figure 2 shows sheet resistance for annealed TiO_2 on fluorine-doped tin IV oxide (FTO) and single-layer *G*raphene (SLG).
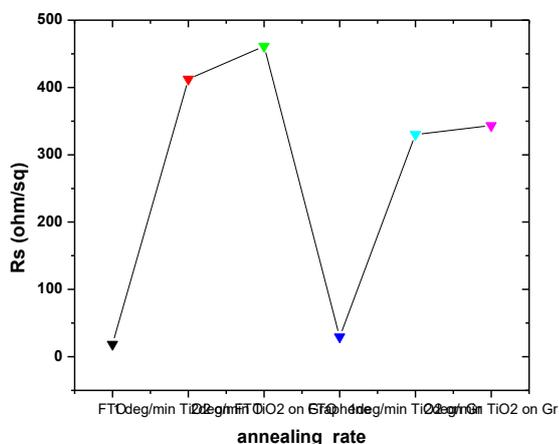
Figure 2 − Sheet resistance for annealed TiO2 on FTO and Graphene films

The *s*heet resistance of FTO is lower than SLG, 14.94798 and 31.62315 Ω/sq, respectively. However, TiO_2 annealed on graphene substrate exhibited lower resistance than on FTO substrate, 3.28 $\times 10^2$ and 4.12 $\times 10^2$ Ω/sq, respectively. Mono-layer *G*raphene, through its planar hexagonal lattice structure, increases the layer conductivity for annealed TiO2, resulting in better electron transport for the composite film.

Sheet resistivity. Figure 3 shows the sheet resistivity of TiO_2 as a function of annealing and *the* effects of *G*raphene on the resistivity.
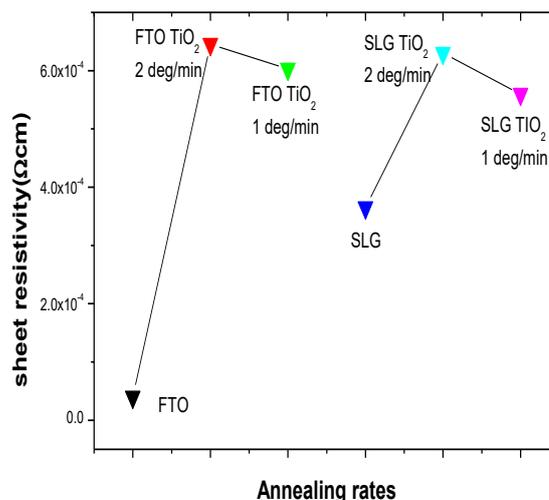
Figure 3 − Sheet resistivity against annealing for TiO2 on FTO and Graphene

The sheet resistivity of TiO_2 on both FTO and Graphene was of order 10^{-4} Ωcm. However, upon annealing TiO_2 at 1 °C per minute on the SLG sheet, resistivity is lower than on FTO. 5.6 $\times 10^{-4}$ Ωcm is thus reported for SLG as compared to 6.0×10^{-4} Ωcm on FTO. FTO has uneven morphology, which results in high porosity of the TiO_2 layer, consequently producing subsurface defects in the FTO/TiO_2 interface. On the other hand, Graphene is highly crystalline. Therefore, this reduction in resistivity for TiO_2 annealed on Graphene could be attributed to better charge transport due to decreased lattice defects for TiO_2 annealed on Graphene.

Transmittance. Figure 4 shows transmittance spectra for tio2 annealed on FTO and SLG. Graphene on glass had a transmittance peak at a wavelength of 502.89 nm and 81.62%. Conversely, FTO peaked at 746.43 nm and 80.28% transmittance, as shown in Table 1.

For the annealed TiO_2, the peaks were at 686.71 nm and 754.22 nm for SLG and FTO, respectively. Transmittance for annealed films decreased more for FTO than Graphene at 66.25% and 71.95%, respectively.
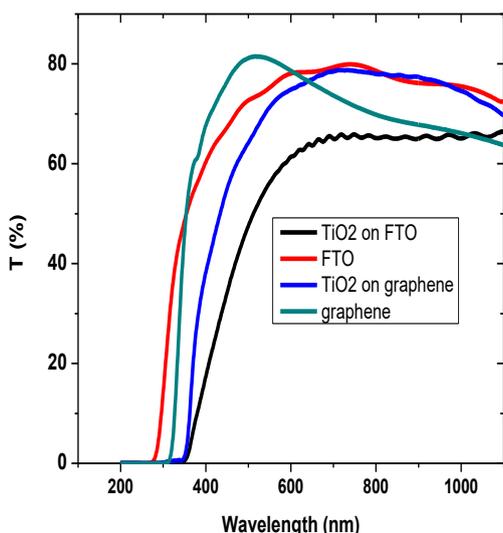
Figure 4 – Transmittance for annealed TiO2 on Graphene and FTO versus wavelength

Figure 5 – Absorption coefficient for deposited and annealed TiO2 films on Graphene

High transmittance means that very few bonds of TiO_2 absorb a particular wavelength. Low transmittance implies a high number of TiO_2 bonds corresponding to vibrational energies of the incident wavelength. Thus, there is more absorption for TiO_2 on FTO than on Graphene. The peaks shift deeper in the visible region due to annealing, as shown in Table 1.

Table 1 – Transmittance peaks for TiO2 annealed on FTO and Graphene

Sample	Peak wavelength (λ) (nm)	Peak Transmittance (%)
Graphene	502.89	81.62
TiO_2 on Graphene	686.71	71.95
FTO	746.43	80.28
TiO_2 on FTO	754.22	66.25

Absorption coefficient. A graph of absorption coefficients against wavelength is shown in Figure 5. The absorption is of order 10^4 for all samples.

The coefficients decrease exponentially for all samples within the visible region. This indicates the presence of localized states in the band gap. The absorption edge can be used to measure the energy bandgap. The absorption coefficient's dependence was used to evaluate Urbach energies using the Urbach rule as in Equation 3.

Urbach energy for TiO_2 on Graphene and FTO. Figure 6 shows the dependence of absorption coefficient edges tailing in weak absorption region (W) and Urbach region (U) optical transitions from the extended state (T). Tailing of $\rho(h\nu)$ extending into the energy band gap in region W is observed for TiO_2 on Graphene and FTO. The tailing is more pronounced for TiO_2 on FTO than on Graphene.
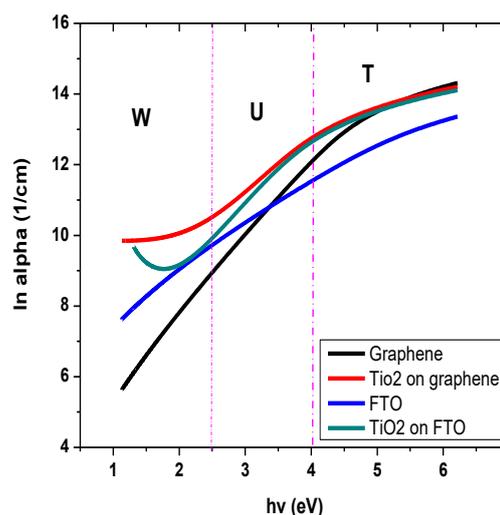
Figure 6 – ln (α) vs ($h\nu$) for annealed TiO2 on Graphene and FTO

Exponential tails are associated with low crystalline films and disordered amorphous materials

because of localized states [13, 14]. Further, band tailing is associated with lattice vibration due to the creation of sub-surface defects such as vacancy-interstitial pairs and antisites [15]. Therefore, this tailing implies the presence of more localized states in the band gap for TiO₂ coated on FTO than on Graphene. The absence of tailing for Graphene and FTO signifies minimal or no localized states. To quantify the broadness of the density of states, Ubarch energies were evaluated using Equation 3. The Urbach Energy enumerates the steepness of the absorption onset near the band edge.

The evaluated Urbach energies of TiO2 films on FTO were higher than those of SLG, as shown in Table 2. High Urbach energy confirms enhanced photocatalytic efficiency due to the disorder and defects that introduced localized states at or near the conduction band level [16]. Therefore, lower Urbach energies of 260 meV signify fewer lattice defects for TiO₂ on the SLG substrate.

Table 2 – Urbach energies of TiO2 on FTO and Graphene

Urbach energy	2°/ min	1°/min
Tio$_2$ on FTO Eu (meV)	414	365
TiO$_2$ on Graphene(meV)	329	260

Relationship of Urbach energy and resistivity of TiO₂ on Graphene and FTO. In Figure 7, we observe a direct variation between Urbach energy and sheet resistivity of TiO2 on FTO and SLG. The optical band gap, Urbach energy, and electrical resistivity were found to depend systematically on the crystallite size [17]. In low crystalline, weakly crystalline, disordered, and amorphous materials, an exponential tail, known as the Urbach tail, exists at the band edge of the absorption/absorption coefficient curve. This exponential tail plays a crucial role in understanding the electronic transport properties of composite materials [18].

Therefore, as observed in Figure 7, TiO₂ annealed films on Graphene have a lower Urbach energy and sheet resistivity of 260 meV and 5.6 x10^{-4} Ωcm. Annealing gradually increases crystallite

sizes, decreases lattice imperfections, and enhances nucleation and coalescence.
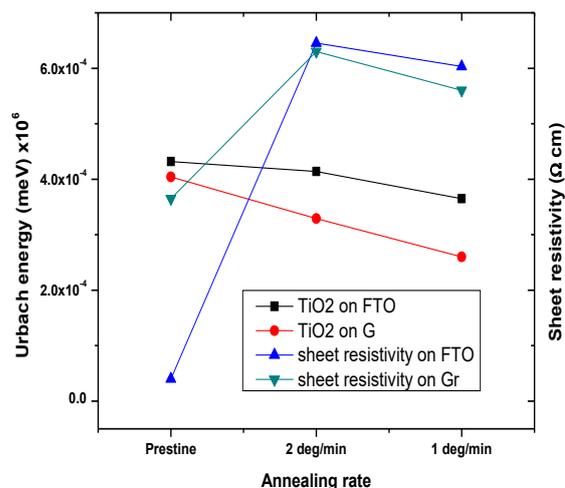
Figure 7 – A relation between Urbach energies and resistivity for TiO2 on FTO and Graphene

However, studies by [19] have reported that localized tail states in amorphous semiconductors arise from defects-generated disorder. The decrease in resistivity of TiO₂ on SLG can be attributed to the excellent conductivity of Graphene.

CONCLUSIONS

Uniform TiO₂ nanocomposite thin films were deposited on FTO and graphene interface glass substrates using the doctor-blading deposition technique. The four-point probe, model SRM-232, was used to measure the sheet resistance of the films. Sub-surface defects of the TiO₂ films on FTO and SLG, as manifested by the Urbach energy tails in the bandgap, were used to measure the disorder of the movie. A direct relation between Urbach energy and sheet resistivity as a result of annealing is thus reported for both TiO₂ on FTO and on Graphene. These observations indicate that fine control over sheet resistivity and microstructure of the films can be achieved via annealing TiO₂ on Graphene to harness it for various optoelectronic applications.

REFERENCES

1. Fuyuki, T., & Matsunami, H. (1986). Electronic Properties of the Interface between Si and TiO2 Deposited at Very Low Temperatures. *Japanese Journal of Applied Physics, 25*(9R), 1288. doi: 10.1143/jjap.25.1288

2. Miao, L., Jin, P., Kaneko, K., Terai, A., Nabatova-Gabain, N., & Tanemura, S. (2003). Preparation and characterization of polycrystalline anatase and rutile TiO2 thin films by rf magnetron sputtering. *Applied Surface Science*, 212–213, 255–263. doi: 10.1016/s0169-4332(03)00106-5

3. Benjamin, M., Simon, W., & James, M. (2018). Effect of Annealing Rates on Surface Roughness of TiO2 Thin films. *Journal of Materials Physics and Chemistry, 6*(2), 43–46.

4. Jose, R., Thavasi, V., & Ramakrishna, S. (2009). Metal Oxides for Dye-Sensitized Solar Cells. *Journal of the American Ceramic Society, 92*(2), 289–301. doi: 10.1111/j.1551-2916.2008.02870.x

5. Geim, A. K., & Novoselov, K. S. (2007). The rise of Graphene. *Nature Materials, 6*(3), 183–191. doi: 10.1038/nmat1849

6. Novoselov, K. S., Geim, A. K., Morozov, S. V., Jiang, D., Zhang, Y., Dubonos, S. V., Grigorieva, I. V., & Firsov, A. A. (2004). Electric Field Effect in Atomically Thin Carbon Films. *Science, 306*(5696), 666–669. doi: 10.1126/science.1102896

7. Boubaker, K. (2011). A physical explanation to the controversial Urbach tailing universality. *The European Physical Journal Plus, 126*(1). doi: 10.1140/epjp/i2011-11010-4

8. Subedi, B., Li, C., Chen, C., Liu, D., Junda, M. M., Song, Z., Yan, Y., & Podraza, N. J. (2022). Urbach Energy and Open-Circuit Voltage Deficit for Mixed Anion–Cation Perovskite Solar Cells. *ACS Applied Materials & Interfaces, 14*(6), 7796–7804. doi: 10.1021/acsami.1c19122

9. Theiss, W. (2008). *Scout.* Retrieved from https://www.wtheiss.com/download/scout3.pdf

10. Boubaker, K. (2011). A physical explanation to the controversial Urbach tailing universality. *The European Physical Journal Plus, 126*(1). doi: 10.1140/epjp/i2011-11010-4

11. Birgin, E. G., Chambouleyron, I. E., Martínez, J. M., & Ventura, S. D. (2003). Estimation of optical parameters of very thin films. *Applied Numerical Mathematics, 47*(2), 109–119. doi: 10.1016/s0168-9274(03)00055-2

12. Birgin, E. G., Chambouleyron, I., & Martínez, J. M. (1999). Estimation of the Optical Constants and the Thickness of Thin Films Using Unconstrained Optimization. *Journal of Computational Physics, 151*(2), 862–880. doi: 10.1006/jcph.1999.6224

13. El-Nahass, M. M., Soliman, H. S., & El-Denglawey, A. (2016). Absorption edge shift, optical conductivity, and energy loss function of nano thermal-evaporated N-type anatase TiO2 films. *Applied Physics A, 122*(8). doi: 10.1007/s00339-016-0302-6

14. Mathews, N. R., Morales, E. R., Cortés-Jacome, M. A., & Toledo Antonio, J. A. (2009). TiO2 thin films – Influence of annealing temperature on structural, optical and photocatalytic properties. *Solar Energy, 83*(9), 1499–1508. doi: 10.1016/j.solener.2009.04.008

15. Wibowo, K. M., Sahdan, M. Z., Asmah, M. T., Saim, H., Adriyanto, F., Suyitno, & Hadi, S. (2017). Influence of Annealing Temperature on Surface Morphological and Electrical Properties of Aluminum Thin Film on Glass Substrate by Vacuum Thermal Evaporator. *IOP Conference Series: Materials Science and Engineering, 226*, 012180. doi: 10.1088/1757-899x/226/1/012180

16. Jayasinghe, L., Jayaweera, V., de Silva, N., & Mubarak, A. M. (2022). Role of ZrO2 in TiO2 composites with rGO as an electron mediator to enhance the photocatalytic activity for the photodegradation of methylene blue. *Materials Advances, 3*(21), 7904–7917. doi: 10.1039/d2ma00754a

17. Ali, D., Butt, M. Z., Muneer, I., Bashir, F., & Saleem, M. (2017). Correlation between structural and optoelectronic properties of tin doped indium oxide thin films. *Optik, 128*, 235–246. doi: 10.1016/j.ijleo.2016.10.028

18. Rahman, Md. (2023). Synthesis of CdS and CdTe Through A Novel Solution Process for Application in Thin Film Solar Cells. Retrieved from https://www.researchgate.net/publication/373603736

19. Al-Shomara, S. M., & Alahmad, W.R. (2019). Annealing temperature effect on structural, optical and photocatalytic activity of nanocrystalline tio2films prepared by sol-gel method used for solar cell application. *Digest Journal of Nanomaterials and Biostructures, 14*(3), 617–625.

Effect of Endophytic *Serratia marcescens* Isolated from *Bryophyllum pinnatum* against Clinical Bacterial Isolates

Habib Aishatu Idris [1], **Charles Oluwaseun Adetunji** [2]

[1] *Abubakar Tafawa Balewa University*
Dass road, P. M. B. 0248, Bauchi, 740272, Nigeria

[2] *Edo State University, Uzairue*
Km 7, Auchi-Abuja Road, Iyamho-Uzairue Edo State, Nigeria

Abstract. The world's health is being threatened by antimicrobial resistance (AMR). According to the World Health Organization, it is one of humanity's top ten worldwide public health problems. *Serratia marcescens* is an opportunistic pathogen that can be isolated from soil, plants, water, and air. Additionally, *Serratia* species offer a valuable supply of secondary metabolites that are comparatively underutilised and may have anti-MDR pathogenic properties. The present research aimed to determine the antibacterial potential of *Serratia marcescens* isolated from the leaves of *Bryophyllum pinnatum* against clinical bacterial isolates. The leaves of *Bryophyllum pinnatum* were collected, surface sterilised, cultured at 37 °C for 24 hours and identified utilising viteks 2 automated techniques and molecular methods. The crude metabolites extract of *Serratia marcescens* were extracted and utilised for antibacterial susceptibility testing using agar healthy diffusion methods. The data were measured in the diameter zone of inhibition. This study revealed six endophytic bacteria were isolated from *Bryophyllum pinnatum* following standard microbiological culture methods. The endophytic bacteria isolate tag L03 was found to be Gram-Negative Rod. The isolate was tentatively identified as *Serratia ficaria* and molecularly identified as *Serratia marcescens*. The metabolites of *Serratia marcescens* endophytes revealed a significant antibacterial activity on *Klebsiella pneumoniae* with a diameter zone of inhibition of 17.7 mm at 100% concentration, followed by *Staphylococcus sciuri* with a 12.7 mm diameter zone of inhibition. These results suggested that endophytic bacteria *Serratia marcescens* were isolated from the leaves of *Bryophyllum pinnatum* and had shown potent antibacterial activity that could be employed to create new antibacterial agents.

Keywords: Endophytic bacteria; Serratia marcescens; Bryophyllum pinnatum; Antibacterial activity.

INTRODUCTION

Increased antibiotic resistance has recently become a significant obstacle in healthcare, presenting a considerable danger to public health worldwide. Excessive and incorrect usage of antibiotics has expedited the emergence of resistance in disease-causing bacteria, making numerous traditional medicines ineffective [11]. This worrisome pattern highlights the immediate necessity for new tactics to address bacterial infections. Investigating medicinal and endophytic bacteria as possible reservoirs of new antimicrobial substances has gained significant interest.

Bryophyllum pinnatum Lam. a member of the Crassulaceae family, is native to Madagascar and is also found in parts of Asia, America, New Zealand, Australia, and Africa. The leaves of this plant, commonly known as "folha-da-fortuna" in Brazil, are used to treat asthma and bronchitis. Additionally, it is applied externally to treat burns, eye infections, blisters, kidney stones, wounds, ulcers, and insect bites [4].

Endophytes are symbiotic organisms that reside within plant tissues for at least a portion of their life cycles without causing harm or disease [8]. Endophytic bacteria present a hopeful opportunity for identifying novel antibiotics and medicinal substances. Unlike traditional antibiotics from soil bacteria or fungi, endophytes reside in a specific ecological environment within plants. This environment exposes them to various selection pressures and promotes the creation of bioactive chemicals with unique chemical structures and modes of action [15].

Serratia marcescens is an endophyte bacterium that has been shown to affect plants positively. *Serratia marcescens* is beneficial in several scientific journals. This bacterium is classified as a Gram-negative member of a genus with two subspecies and fourteen recognised species. As per [1], *Serratia marcescens* is a rod-shaped, gram-negative *Enterobacteriaceae* bacterium. Its ability to produce prodigiosin, a red pigment, even at room temperature is one of its unique qualities [14].

Serratia are prevalent in the environment and can be found in plants, animals, food, soil, and water. *Serratia* species are a great source of secondary metabolites that have not yet been fully utilised and may be active against Multi-Drug Resistant pathogens.

MATERIALS AND METHODS

Collection of leaves of *Bryophylum pinnatum.* Fresh and healthy leaves of *Bryophyllum pinnatum* were picked and collected from the garden in a sealed zipper bag. They were identified and validated at the Department of Biological Sciences, Edo State University, Uzairue, Nigeria.

Isolation of Endophytic *Serratia marcescens.* The leaves were chopped into little bits of 5.5 mm (length and width) with sterile blades. These parts were cleaned three times using tap and sterile water. The leaflets were washed twice with sterile water, with the parts remaining in each wash for 3 minutes. The leaf pieces were surface sterilised for one minute in 70 % ethanol and then soaked in 2% sodium hypochlorite solution for 5 minutes. The samples were then washed three times in sterile distilled water and placed on Nutrient Agar, and a sterility test was also done by inoculating an aliquot of the last rinse water on NA.

Morphological and Biochemical Characterisation of Endophytic Serratia marcescens. The primary characterisation of *Serratia marcescens* was performed through Gram Staining and biochemical tests using vitek 2 compact systems. The endophytic bacterial isolates were stained using Gram staining techniques [12] and biochemical tests using vitek 2 compact systems as described [16].

Molecular Characterization of Endophytic Serratia marcescens. The isolate underwent another identification round using molecular techniques to verify the primary identification. The DNA of the endophytic bacterial isolate was isolated and purified utilising a zymo bacterial mini prep extraction kit in line with the manufacturer's instructions. Primers 27F (5'-AGAGTTTGATCMTGGCTCAG-3') and 1492R (5'-CGGTTACCTTGTTACGA CTT-3') were used to amplify the 16S rRNA gene at the following temperatures: 95^0C for two minutes; 30 cycles of 95°C for thirty seconds; 55°C for forty-five seconds; 72°C for ninety seconds; and 72°C for the final elongation of seven minutes. 50 ng of DNA, 30 µl of each primer, and 12.5 µl of Thermo Scientific's 2x Dream Taq PCR Master Mix were all included in the 25 µl PCR mixture. PCR was carried out using an amplifier Master cycler (Thermo Scientific). PCR products were separated in a 1% agarose gel containing 0.01% ethidium bromide. UV light was used to visualise the data. The resultant amplicon, about 1500 bp in size, was extracted from the gel and purified using the BigDye Terminator v3.1 cycling sequencing Kit, manufactured by applied Biosystem and sequenced utilising ABI 3500 sequencer [9].

Extraction of Endophytic Bacteria Secondary Metabolite. The endophytic *Serratia marcescens* were subjected to submerged fermentation in a sterile Nutrient broth medium as described by [2]. An inoculum development was formed by inoculating a few colonies of *Serratia marcescens* from a 24-hour pure culture growth into a 100 ml Erlenmeyer flask containing 15 ml of nutrient broth. It was incubated for 24 hours at 37 °C. Afterwards, the inoculums were transferred onto separate 100 ml Erlenmeyer flasks containing 100 ml of nutrient broth. This was then allowed to stay incubated at 200 rpm for 72 hours, utilising a rotary shaker. Following fermentation, the culture broth was strained, and ethyl acetate was used three times to extract the filtrate; after being run through sodium sulphate, the organic phase evaporated until it was scorched.

Antibacterial Activity of Endophytic Serratia marcescens. Antibacterial evaluation of the *Serratia marcescens* crude metabolites on laboratory strains of *Escherichia coli, Staphylococcus aureus, Staphylococcus sciuri,* and *Klebsiella pneumoniae* was carried out using the agar well diffusion method as described by [3]. Meropenem (5 µg/ml) was used as a positive control, and DMSO (100% v/v) was used as a negative control. A volume of 0.1 ml of different concentrations (100, 50, 25%, and 12.5%) of the metabolite's supernatant was transferred into an agar well of plates streaked with *Escherichia coli, Staphylococcus aureus, Staphylococcus sciuri,* and *Klebsiella pneumoniae.* The plates were incubated for 24 hours at 37 °C. The experiment was conducted in triplicate, and the resulting diameter zone of inhibition was measured in millimetres (mm).

Figure 1

RESULTS AND DISCUSSION

Following standard procedures of surface sterilisation and culturing of the fresh leaves of *Bryophyllum pinnatum* for 24 hours at 37 °C, the endophytic bacteria *Serratia marcescens* (L03) was isolated and revealed to be circular, raised, smooth, small, and bright red on nutrient agar plate after 24 hours of incubation. The isolate was determined to be a Gram-Negative rod, as represented in Table 1. A similar result was obtained from the research of [16].

The endophytic bacteria isolate (L03) was identified as *Serratia ficaria* using the substrates card of Vitek 2 bacteriological identification system (BioMeriex) based on the biochemical and substrates

characteristics with a probability percentage of 94% identification as displayed in Table 2.

Table 1 – Cultural and Morphological Characteristics of *Serratia marcescens*

Parameters	Endophytic *Serratia marcescens*
Shape	Circular
Elevation	Raised
Colour	Bright red
Size	Small
Transparency	Opaque
Surface	Smooth
Gram stain	Gram-Negative Rod

Table 2 – Vitek 2 Biochemical Identification of *Serratia marcescens*

Tests Substrates	Amount (mg)	LF3
Glutamylarylamidasepna	0.0324	-
Adonitol	0.1875	+
D-Mannose	0.3	+
L-Pyrrolydonyl-Arylamidase	0.018	-
Beta-Galactosidase	0.036	-
L-Arabitol	0.3	+
D-Maltose	0.3	+
D-Cellobiose	0.3	+
L-prolinearylamidase	0.0234	-
Beta-N-Acetyl-Glucosaminidase	0.0408	-
D-Glucose	0.3	+
Fermentation/Glucose	0.45	-
H_2O Production	0.0024	-
Beta-Glucosidase	0.036	+
D-Mannitol	0.1875	+
Urease	0.15	-
Beta-Xylosidase	0.0324	-
Saccharose/Sucrose	0.3	+
Beta-Alanine arylamidasepna	0.0174	-
Lipase	0.0192	-
Palatinose	0.3	+
Tyrosine Arylamidase	0.0276	-
Gamma-Glutamyl-Transferase	0.0228	-
D-Sorbitol	0.1875	+
D-Tagalose	0.3	-
5-Keto-D-Gluconate	0.3	-
D-Trehalose	0.3	+
Ala-phe-pro-Arylamidase	0.0384	-
Malonate	0.15	-
Citrate (Sodium)	0.054	-
L-Lactate Alkalinisation	0.15	-

Tests Substrates	Amount (mg)	LF3
Alpha-Glucosidase	0.036	-
Succinate Alkalinisation	0.15	-
Beta-N-Acetyl Galactosamini-dase	0.0306	-
Alpha-Galactosidase	0.036	-
Phosphatase	0.0504	-
L-Histide Assimilation	0.087	-
Ornithine Decarboxylase	0.3	-
L-Lactase Assimilation	0.186	-
Lysine Decarboxylase	0.15	-
Beta-Glucoronidase	0.0378	-
Glucine Arylamidase	0.012	-
Glu-Glu-Arg-Arylamidase	0.0576	-
Coumarate	0.126	+
L-Malate Assimilation	0.042	-
O/129 Resistance (comp. Vibrio)	0.0105	-
Ellman	0.03	-
Characterised as	*Serratia ficaria*	

The isolate (L03) was further subjected to molecular characterisation utilising 16 SrRNA genes, which was confirmed to be identified as *Serratia marcescens* with a similarity percentage of 83.2% with *Serratia marcescens* strain Tc-8 when compared using BLAST at the National Center for Biotechnology Information (NCBI) as shown in Table 3.

As the rule implies, the accession number was not obtained due to the low similarity percentage of 83.2%, below 90%. This finding is similar to the report of several researchers. According to reports, *Serratia marcescens* has previously been identified from a variety of plants, including rice [6], leaves of *Vaccinium uliginosum* [17], and tomatoes [13]. Nonetheless, this is the first time an endophytic *Serratia marcescens* has been identified from the plant *Bryophyllum pinnatum.*

Following fermentation and secondary metabolite extraction from *Serratia marcescens*, the crude metabolites extract was tested for antibacterial activity against four bacterial isolate strains: *Staphylococcus aureus, Klebsiella pneumoniae, Escherichia coli,* and *Staphylococcus scuiri.* The antibacterial analysis shows that the crude metabolites extract of *Serratia marcescens* displayed a broad spectrum antibacterial activity, with *Klebsiella pneumoniae* having the highest diameters zone of inhibition of 17.7 mm, followed by *Staphylococcus scuiri* 12.7 mm compared to *Staphylococcus aureus* and *Escherichia coli* 2.7 mm and 2.0 mm respectively as showed in Table 4.

Table 3 − Molecular Characterisation of Endophytic Bacteria *Serratia marcescens*

Endophytic bacteria isolate	Molecularly characterised isolate	Pairwise Percentages (%)	Similarity Percentages (%)	Accession Number
Isolates L03	*Serratia marcescens* strain Tc-8	84.9	83.2	NIL

Table 4 − Antibacterial Effect of *Serratia marcescens* Metabolites Crude Extract on Clinical Isolates

Concentrations Diameter zone of inhibition (mm)				
	Klebsiella pneumoniae	*Staphylococcus aureus*	*Staphylococcus sciuri*	*Escherichia coli*
100	17.7	2.0	12.7	2.7
50	11.3	1.3	6.3	1.7
25	6.7	00	3.7	00
12.5	00	00	00	00
Positive Control (MEROPENEM)	32	11	21	15
Negative Control (DMSO)	00	00	00	00

Authors [10] reported the antibacterial activity of *Serratia marcescens* metabolites on *Staphylococcus aureus* and *Klebsiella pneumoniae*. This could result from the biosynthesis of prodigiosin, an antimicrobial compound Serratia produces.

CONCLUSIONS

In conclusion, *Serratia marcescens* endophytic bacteria was isolated and identified from the leaves of *Bryopphyluum pinnatum*. The crude

metabolites of *Serratia marcescens* displayed moderate antibacterial potential on gram-negative and Gram-positive bacteria.

Conflict of Interests

There was no conflict of interest in preparing this writing piece.

REFERENCES

1. Abreo, E., & Altier, N. (2019). Pangenome of Serratia marcescens strains from nosocomial and environmental origins reveals different populations and the links between them. *Scientific Reports, 9*(1). doi: 10.1038/s41598-018-37118-0

2. Adetunji, C. O., Oloke, J. K., Prasad, G., Bello, O. M., Osemwegie, O. O., Pradeep, M., & Jolly, R. S. (2017). Isolation, identification, characterisation, and screening of rhizospheric bacteria for herbicidal activity. *Organic Agriculture, 8*(3), 195–205. doi: 10.1007/s13165-017-0184-8

3. Akpotu, M. O., Eze, P. M., Abba, C. C., Umeokoli, B. O., Nwachukwu, C. U., Okoye, F. B. C., & Esimone, C. O. (2017). Antimicrobial activities of secondary metabolites of endophytic fungi isolated from Catharanthus roseus. *Journal of Health Sciences, 7*(1), 15–22. doi: 10.17532/jhsci.2017.421

4. Chibli, L. A., Rodrigues, K. C. M., Gasparetto, C. M., Pinto, N. C. C., Fabri, R. L., Scio, E., Alves, M. S., Del-Vechio-Vieira, G., & Sousa, O. V. (2014). Anti-inflammatory effects of Bryophyllum pinnatum (Lam.) Oken ethanol extract in acute and chronic cutaneous inflammation. *Journal of Ethnopharmacology, 154*(2), 330–338. doi: 10.1016/j.jep.2014.03.035

5. Eid, A. M., Fouda, A., Abdel-Rahman, M. A., Salem, S. S., Elsaied, A., Oelmüller, R., Hijri, M., Bhowmik, A., Elkelish, A., & Hassan, S. E.-D. (2021). Harnessing Bacterial Endophytes for Promotion of Plant Growth and Biotechnological Applications: An Overview. *Plants, 10*(5), 935. doi: 10.3390/plants10050935

6. Gyaneshwar, P., James, E. K., Mathan, N., Reddy, P. M., Reinhold-Hurek, B., & Ladha, J. K. (2001). Endophytic Colonization of Rice by a Diazotrophic Strain of Serratia marcescens. *Journal of Bacteriology, 183*(8), 2634–2645. doi: 10.1128/jb.183.8.2634-2645.2001

7. The Green Institute. (2019, February 18). *Bryophyllum pinnatum*. Retrieved from https://greeninstitute.ng/plants/2019/2/18/bryophyllum-pinnatum

8. Kandasamy, G. D., & Kathirvel, P. (2023). Insights into bacterial endophytic diversity and isolation with a focus on their potential applications –A review. *Microbiological Research, 266*, 127256. doi: 10.1016/j.micres.2022.127256

9. Kiroiants, M., Patyka, T., & Patyka, M. (2020). Phylogenetic analysis of dominant microorganisms of the genera Bacillus and Phyllobacterium, isolated from the rhizosphere of spring barley. *Visnyk Agrarnoi Nauky, 98*(5), 48–53. doi: 10.31073/agrovisnyk202005-06

10. Mai, A.-G. (2018). Serratia A Novel Source of Secondary Metabolites. *Advances in Biotechnology & Microbiology, 11*(3). doi: 10.19080/aibm.2018.11.555814

11. Manage, P. M., & Liyanage, G. Y. (2019). Antibiotics induced antibacterial resistance. *Pharmaceuticals and Personal Care Products: Waste Management and Treatment Technology*, 429–448. doi: 10.1016/b978-0-12-816189-0.00018-4

12. Sebola, T. E., Uche-Okereafor, N. C., Mekuto, L., Makatini, M. M., Green, E., & Mavumengwana, V. (2020). Antibacterial and Anticancer Activity and Untargeted Secondary Metabolite Profiling of Crude Bacterial Endophyte Extracts from Crinum macowanii Baker Leaves. *International Journal of Microbiology, 2020*, 1–15. doi: 10.1155/2020/8839490

13. Someya, N., Nakajima, M., Hirayae, K., Hibi, T., & Akutsu, K. (2001). Synergistic Antifungal Activity of Chitinolytic Enzymes and Prodigiosin Produced by Biocontrol Bacterium, Serratia marcescens Strain B2 against Gray Mold Pathogen, Botrytis cinerea. *Journal of General Plant Pathology, 67*(4), 312–317. doi: 10.1007/pl00013038

14. Sutio, G., Iskandar, I., Indriyati, L. T., & Djajakirana, G. (2023). Endophytic Testing Of Serratia marcescens strain NPKC3_2_21 Against INPARA 3 Rice Variety. *Biovalentia: Biological Research Journal, 9*(1), 48–55. doi: 10.24233/biov.9.1.2023.372

15. Tidke, S. A., Kiran, S., Giridhar, P., & Gokare, R. A. (2018). Current Understanding and Future Perspectives of Endophytic Microbes vis-a-vis Production of Secondary Metabolites. *Reference Series in Phytochemistry*, 1–16. doi: 10.1007/978-3-319-76900-4_12-1

16. Vijayalakshmi, R., Kairunnisa, K., Narender Sivvaswamy, S., Dharan, S. S., & Natarajan, S. (2016). Enzyme Production and Antimicrobial Activity of Endophytic Bacteria Isolated from Medicinal Plants. *Indian Journal of Science and Technology, 9*(14). doi: 10.17485/ijst/2016/v9i14/83143

17. Xu, D., Xia, X., Xu, N., & An, L. (2007). Isolation and identification of a novel endophytic bacterial strain with antifungal activity from wild blueberryVaccinium uliginosum. *Annals of Microbiology, 57*(4), 673–676. doi: 10.1007/bf03175372

Handling Strategies for Areas and Slums Settlements with the Implementation of Sustainable Development Goals in Mojokerto Regency, Indonesia

Donny Setyaelvanda Julkarnain [1] **, Mohammad Bisri** [1] **, Moh. Khusaini** [1] **, Andy Fefta Wijaya** [1]

[1] *Brawijaya University*
169 Jl. MT. Haryono, Ketawanggede, Lowokwaru Sub-District, Malang, East Java, 65145, Indonesia

Abstract. The new direction in the current development process is the implementation of the Sustainable Development Goals (SDGs). The concept of sustainable development is organised into four dimensions: economic, social, environmental and institutional. The Sustainable Development Goals have 17 goals and several indicators for their measurement. The United Nations (UN) 2015 formulated these 17 points of Sustainable Development Goals (SDGs) to overcome the problems that exist in the world. One of the goals contained in the SDG's is goal No 11, namely Sustainable Cities and Communities. One of the world problems discussed in this goal is slums found in Target 11.1 points, namely: "Ensure access to decent, safe and affordable housing and basic services for all and improve the quality of slums". This research method uses mixed methods and then solves with qualitative because it can produce a study of existing phenomena. In this case, case studies greatly help handle settlements and slums in other places and different handling methods as a comparative study. Mojokerto's success in addressing slums in Kedungmaling Village was achieved through strategic integration of various aspects: involving the community as active actors and working group formers, intensive on-the-ground mentoring with facilitators, land management without eviction while consolidating public spaces, strong commitment from local institutions, and program integration through DAK Integration and funding collaboration. This approach, which is aligned with the Sustainable Development Goals (SDG's), not only targets local solutions but also steers Mojokerto towards international standards of slum upgrading, making a significant impact at both local and national levels.

Keywords: Sustainable Development Goals; Slum Areas; Settlements.

INTRODUCTION

The new direction in the current development process is the implementation of the Sustainable Development Goals (SDGs). The concept of sustainable development is organised into four dimensions: economic, social, environmental and institutional. The Sustainable Development Goals have 17 goals and several indicators for their measurement. The United Nations 2015 formulated these 17 Sustainable Development Goals (SDGs) to tackle the world's problems, such as poverty and global warming, and address social, economic and environmental issues in cities. One of the goals contained in the SDGs is goal no. 11,

Sustainable Cities and Communities. One of the world's problems discussed in this goal is slums, which are found in Target 11.1 points, namely: "Ensure access to decent, safe and affordable housing and basic services for all and improve the quality of slums", where this problem is still widely found in the world, one of which is in Mojokerto District. In analysing the population settlements, indicators are often used to calculate the area of slums divided by the city's total population and expressed as a percentage. UN-HABITAT describes the characteristics of slums as residential areas that do not have basic settlement facilities and infrastructure, settlements located in illegal areas and do not have the legal status of land and

buildings, inadequate building conditions, high density, located in unhealthy regions and have the potential for disasters, inhabited by the poor, and minimal residential areas. UN-Habitat has developed a definition of slum housing that allows for household-level surveys to identify slum dwellers among the urban population. Slum households are groups of individuals living under the same roof in metropolitan areas that do not have any of the following indicators [1]:

1. A sturdy house that can protect its inhabitants from extreme weather conditions

2. Adequate living space, which means no more than three people inhabit the same space

3. Easy access to clean (safe) water in sufficient quantities and at affordable prices

4. Access to adequate sanitation in the form of private or shared toilets

5. Certainty and security of tenure can protect residents from forced evictions.

What has been formulated by the United Nations by the government of the Republic of Indonesia has been harmonised with the policies implemented to realise a Strategy for Handling Sustainable Settlements and Slums, which, of course, is also adapted to the characteristics and conditions of each Province and Regency within the territory of the unitary state of the Republic of Indonesia.

The definition of Settlements, according to Law No 4 of 1992, concerning Housing and Settlements, is part of the living environment outside protected areas, both in urban and rural areas, that function as a living environment or residential environment and a place of activities that support livelihoods and livelihoods. In addition, the urbanisation rate in Indonesia reaches ± 1.7% per year, and ± 23% are city dwellers who still live in slum areas. The definition of slums is "Settlements that are uninhabitable due to building irregularities, high building density, and inadequate quality of buildings and facilities and infrastructure".

The government has enacted Law No 1/2011 on Housing and Settlement Areas, revising Law No 4/1992 on housing. Generally, this law is a form of government attention to handling housing and slums. In Article 1 point 1 of law No 1 Year 2011, it is stated that housing and settlement areas are a unified system consisting of guidance, housing administration, settlement area administration, maintenance and repair, prevention and quality improvement of slum housing and slums, land

provision, funding and financing systems, and the role of the community. The law explicitly states that one scope of implementing Housing and Settlement Areas is preventing and improving the quality of slums and slums. This is then translated into policies, strategies, and programs by various government institutions responsible for controlling and enhancing slum housing and settlements.

To implement the provisions of Law No 1 Year 2011 on Housing and Settlement Areas, Government Regulation of the Republic of Indonesia No 88 Year 2014 on the Development of Housing and Settlement Areas has been stipulated. Guidance on implementing Housing and Settlement Areas is an effort to realise the objectives of implementing housing and settlement areas. Guidance is carried out within planning, regulation, control, and supervision. The government's responsibility is carried out through coordination; socialisation of laws and regulations; guidance, supervision and consultation; education and training; research and development; assistance and empowerment; and information and communication systems development.

Looking at the Regional Medium-Term Development Plan (RPJMD) of East Java Province in 2019-2024, handling slum areas in East Java Province is also a significant concern. Chapter II on Regional Overview in East Java mentions that the condition needs handling of slum areas covering 1,792.59 ha. In the period 2016-2018, the handling of urban slums covering 1,382.42 Ha, so there is still a need to handle slum areas covering 410.17 Ha spread across East Java.

Chapter IV on Strategic Issues also highlights the problem of Slum Area Handling. At Point 5 on Environmentally Sound and Sustainable Infrastructure Development, it is stated that the challenge of regional development in East Java is accessibility and connectivity between regions to develop and optimise potential in the Wilis Ring Area, Bromo Ring, Ijen Ring, Gerbangkertosusila, Java Madura Maritime Corridor, and Java South Maritime Corridor. In the Mataraman region, the potential for tourism and agro-based and maritime industries on the south coast is not yet supported by access to freight ports and airports. The fulfilment of basic housing and settlement service coverage includes providing regional drinking water, urban wastewater management systems, and regional landfills. On the other hand, the fulfilment of the housing backlog is still limited, and the handling of slum areas is still not optimal because the

handling of slum areas has not been implemented in an integrated manner. Fulfilment of infrastructure service coverage to reduce poverty and regional inequality is constrained by limited government funding sources. For this reason, alternative efforts are needed to provide non-APBD funding sources.

Furthermore, in the Mojokerto District Medium-Term Development Plan (RPJMD) 2021-2026, Slum Area Management is a critical issue listed in Chapter IV, Problems and Strategic Issues. It is stated that the Mojokerto District Government, in its development, has faced various social dynamics that have grown in the community. Through in-depth analysis, the preparation of medium-term plans needs to consider issues and problems that often occur in the region as a reference in preparing the RPJMD planning framework. By knowing the issues that usually arise, it is hoped that all programs and activities will be able to overcome these problems or at least minimise the impact of all existing issues. Regional development planning is carried out within the integrated national and regional development planning framework. Therefore, the initial stage of regional development planning begins with analysing development results and problems. The aim is for regional development planning to synergise and contribute to solving development problems at the regional, regional, and national levels.

Furthermore, identifying development problems according to local government affairs is detailed as the basis for formulating general policies and development programs. In the discussion of strategic issues, it is conveyed that the analysis of strategic issues is an essential and decisive part of the process of preparing regional development plans to complement the stages that have been carried out previously. Identifying appropriate and strategic issues increases the acceptability of development priorities so that they can be accounted for morally and bureaucratically. Strategic issues are conditions or things that must be considered or prioritised in development planning because of their significant impact on the entity (region/community) in the future. A strategic issue is also defined as an essential condition/event or situation that, if not anticipated, will cause more significant harm. The characteristics of a strategic issue are conditions or things that are essential, fundamental, long-term, urgent, institutional/organisational and determine future goals. Therefore, it is necessary to analyse various vital facts and information identified as strategic issues to formulate strategic issues. Another essential factor that must be considered in formulating strategic issues is the review of the elected Regional Head's Vision, Mission and Program. It is intended that the formulation of the resulting issues is in line with the ideals and expectations of the community towards the elected regional head and deputy regional head.

Furthermore, development disparities between regions are often a serious problem and, if not eliminated gradually, can lead to more complex issues (such as population, social, economic, political and environmental problems). Therefore, it is necessary to understand the factors that cause development disparities between regions. These include biophysical factors/regional characteristics (natural resources), artificial resources (availability of socio-economic facilities and infrastructure), human resources, social resources, regional economic structure characteristics, and local government policies. By knowing the factors that cause disparities, it is hoped that policies and strategies can be developed to reduce them. The following matters need to be improved. First, the improvement of district roads is still not 100%, the condition of bridges does not match the width of the existing road, and there is still a lack of street lighting.

For this reason, a policy direction is needed to strengthen the connectivity of growth area facilities or potential areas. Second, physical infrastructure and social institutions should be improved to create a livable, safe and comfortable environment for residents. Third, encouraging the value of investment from the set target is necessary to increase the value of investment by the set target.

To synergise regional and sectoral development, the preparation and stipulation of the Mojokerto Regency RPJMD 2021-2026 also takes into account the existence of other documents outside the planning component, such as the Strategic Environmental Assessment (KLHS) RPJMD of the Mojokerto Regency Government, where the KLHS document is one of the considerations in the RPJMD preparation process, so it is necessary to have a KLHS document that can be used as a consideration in the preparation process. The function of the KLHS RPJMD is to ensure that the issues of strategic problems and strategic targets of sustainable development goals in Mojokerto district are included in the RPJMD. In addition, the preparation of KLHS is mandated by Permendagri No 86 of 2017 concerning Procedures for

planning, controlling and evaluating regional development, procedures for assessing draft regional regulations on Regional Long-Term Development Plans and Regional Medium-Term Development Plans, as well as methods for amending Regional Long-Term Development Plans, Regional Medium-Term Development Plans, and Regional Apparatus Work Plans. This is necessary to prepare the Strategic Environmental Assessment of the Mojokerto Regency RPJMD 2021-2026. In other parts, sectoral and micro-planning documents also need to refer to the RPJMD.

Strategic Environmental Assessment (SEA) is closely related to the regional development Policy and Program Plan. Strategy is an action or activity carried out from the beginning of the decision-making process that significantly impacts the final results to be achieved. Thus, in the context of SEA, the activity is a study that, from the beginning, considers environmental aspects in the decision-making process in the direction of policies, plans, or programs. For the decision-making process, it is necessary first to formulate the strategic issues occurring in Mojokerto Regency that are included in the environmental aspects. The analysis of strategic issues is an essential and decisive part of the process of preparing regional development plans to complement the stages that have been carried out previously. Identifying appropriate and strategic issues increases the acceptability of development priorities so that they can be morally and ethically accountable to the bureaucracy. Strategic issues are conditions or things that must be considered or prioritised in development planning because of their significant impact on the entity (region/society) in the future. A strategic issue is also defined as an essential condition/event or situation that, if not anticipated, will cause more significant harm. The characteristics of a strategic issue are conditions or things that are essential, fundamental, long-term, urgent, institutional/organisational and determine future goals. The following are the strategic issues of the environmental assessment resulting from the strategic issue scoping discussion process.

By photographing the SEA document above along with the strategic issues discussed, it is concluded that the Mojokerto District Government is still paying serious attention to the handling of settlements and slums, especially in improving the availability of drinking water, proper sanitation and solving urban waste problems, which are outlined in the 3 points of strategic issues of the SEA document.

The existence of slums with building irregularities and low housing quality is still a classic problem, especially for urban areas in developing countries, including Indonesia. The attractiveness of the metropolitan regions that are not matched by the financial affordability of urbanites to access formal housing is one of the causes of the emergence of slums. Not only do they affect spatial planning and encourage environmental degradation, but slums are also an illustration of inequality, poverty, and low levels of community welfare. Therefore, the global forum aims to provide decent and affordable housing for every resident through the 2030 Sustainable Development Goals (SDGs) in goal eleven, namely "sustainable cities and communities".

The government has implemented various slum upgrading efforts, as the party is constitutionally responsible for providing housing and settlements. The slum upgrading program has also evolved from the concept of the Kampung Improvement Program (KIP) in 1969 to the preparation of the 100-0-100 baseline (100% access to drinking water, reduction of slum areas to 0%, and 100% access to proper sanitation) in 2015 and the national-scale KOTAKU (Kota Tanpa Kumuh) program in 2016 which continues to this day. In addition to improving the quality of slums and preventing the emergence of new slum areas, the KOTAKU program also makes efforts to improve access to basic infrastructure and services, the formation of District / City PKP Working Groups, and integrating community development through participation.

Although various efforts have been made, problems related to the existence of slums are still homework that cannot be resolved. It is not uncommon for the handling program that has been carried out to be considered partial because it only focuses on physical development and seems to only "beautify" the area, so it has not regarded as various possibilities that can occur in the future, including the sustainability of the arrangement. This is reinforced by the lack of control and follow-up programs after the improvement of settlement quality is carried out, which becomes an opportunity for the return of slums due to the inability of residents to maintain and develop the environment.

The central government has rolled out various programs and strategies for handling slum areas and settlements throughout Indonesia by involving local governments, both provincial and

district/city. The focus is on locations listed in the Slum Decree issued by the regional district, starting with the calculation of the Slum Value (Scoring) and then continuing with the construction of Infrastructure, Facilities and Utilities (PSU) to reduce the slum value of an area. However, what happens is that this Slum Area Handling is less successful, indicated by the slow reduction in the area of slum areas. Even in some areas, the area of slums has increased, marked by the issuance of new Slum Decrees containing new locations that require handling. There are many influencing factors, one of which is the development of PSU infrastructure that is less targeted, so it cannot significantly reduce the slum area.

In Mojokerto District itself, from the data we obtained, the Slum Decree has been issued by the Mojokerto District Government several times since 2015, 2016, 2019 and, most recently, 2020. Each time the Slum Decree was issued, it was revised from the previously issued decree. The handling of Slum Areas and Settlements in Mojokerto District from year to year has not made significant progress or can be said to be incomplete. It can be seen that from 2015 to 2016, with the same area and the exact location, it continued by changing the composition of the area in these locations. What is worse is that from 2019 to 2020, there was a drastic jump in the slum area, from 81.22 Ha to 314 Ha, with the emergence of many new locations that require Slum Area handling. Based on the description above, this research aims to determine a strategy to improve the existing handling of slum areas and settlements in Mojokerto using the SDG's framework.

In research on sustainable development and slum upgrading, the international journal literature provides deep insights. For the SDG agenda, studies [2, 3] highlight local responses to this global agenda [4] and present an essential framework for sustainable urban development. Regarding slum upgrading through relocation and stimulus, studies [5, 6, 7, 8] provide diverse perspectives on the successes and failures of various approaches.

Studies on slums and their social problems are presented [9, 10, 11], which discuss social dynamics, beliefs, and health issues in the neighbourhood. Meanwhile, the identification of slum characteristics and factors is described [12, 13].

In the context of typologies and patterns of slum upgrading, the works [14, 15] provide insights into various approaches to addressing the issue. Regarding urban slum management planning and strategies, research [16, 17, 18] highlights the importance of management and development strategies.

Regarding infrastructure provision as a solution [19, 20], discuss the importance of infrastructure in slum upgrading. Finally, community participation is crucial to improving the quality of slum environments. This literature provides a comprehensive overview of the various aspects and approaches to addressing slum issues in different geographical and social contexts.

METHODS

This research method uses mixed methods and then solves with qualitative methods because it can produce a study of existing phenomena. In this case, case studies greatly help it handle settlements and slums in other places and different handling methods as a comparative study.

Table 1 – Conceptual Framework Summary Matrix

No	Research Stages	Variable
1.	Research Objective 1: Analysis of Existing Slum Areas in Mojokerto	X: SDG'S Goal 11, as the basic concept of the research Y: Existing condition of Mojokerto slum Z: 7 SDG'S Goals as analysis parameters in the survey questionnaire
2.	Research Objective 2: Determine the Dominant Factors of Slum Areas in Mojokerto	X: Conducting Mix Methods Research Y: Study of Slum Areas & Settlements of SDG's Framework Z: Analyse Statistical Data to find Dominant Factors
3.	Research Objective 3: Slum Area Management Strategy by the SDG Framework	X: Strategy Management Concept Y: Slum Aspects & Criteria for Slum Value Calculation Z: Slum Area and Settlement Handling Strategy according to SDG's

The general scope of this research is Mojokerto district. The research was focused on taking a case study of one of the areas determined in the Mojokerto Regent Decree related to Slum Area Management, namely Kedungmaling Village, Sooko Sub-

district, Mojokerto District. The identification of slum conditions in slum areas in the villages that are the object of research is carried out by scoring the variables, indicators and items that have been previously determined, namely on infrastructure, which includes 1) building condition, 2) environmental road condition, 3) drinking water supply condition, 4) environmental drainage condition, 5) wastewater management condition, 6) waste management condition, 7) fire protection condition.

While the Land Status variable and the Population Density variable are assessed from the results of field data collection and secondary data, the assessment of each infrastructure item uses a range of values/scores with significant differences, namely values of 5, 3, and 1. This is done so that in the slum value obtained, there is a clear difference between the conditions of slums with the categories of severe slums, moderate slums and light slums. While the meaning of each value is:

1. A score of 5 represents a deplorable condition on the assessed item, with the percentage of condition/level of service parameters in the 76-100% range.

2. Score 3 represents a relatively poor condition on the assessed item, with the percentage of condition/level of service parameters in the range of 51-75%.

3. Score 1 represents a poor condition on the assessed item, with the percentage of condition/level of service parameters in the 25-50% range.

The respondents' ratings on each item were summed up, resulting in a total score on each indicator, and the scores on each indicator were also summed up, resulting in a score on each variable. The value of each variable is summed up again so that a total value is obtained, which shows the condition of the slum in the slum settlement area.

RESULTS AND DISCUSSION

Housing and Settlement Development Policy by RPJMN 2020-2024. Following Law No 1 of 2011 concerning Housing and Settlement Areas, settlement areas are part of the living environment outside protected areas, both in urban and rural areas, which function as living environments or residential environments and places of activity that support livelihoods and livelihoods. In the Housing and Settlement Area Sector, the indicator is

measured based on the percentage of households occupying dwellings with the following criteria:

1. Building Durability: Roof, wall and floor building materials of houses meet the requirements; National Achievement in 2021: 82,47 %.

2. Adequacy of Living Area: Floor area per capita ≥7.2 m2. National Outcome in 2021: 93,56 %.

3. Access to decent drinking water: Access to decent drinking water. National achievement in 2021: 90,78 %.

4. Access to proper sanitation: Access to appropriate sanitation. National achievement in 2021: 80,29 %

RPJMN 2020-2024 Policy Directions and Strategies have been determined by the Government of the Republic of Indonesia so that the development carried out has clear guidelines. Policy directions related to Housing and Settlement Areas are: Gradually increasing community access to decent, safe and affordable housing and settlements to realise an inclusive and livable city. Meanwhile, strategies related to housing and settlements can be described as follows:

1. Demand Strategy:

1.1. Strengthening the primary and secondary housing financing system, including optimising the utilisation of long-term financing sources (Taspen, BPJS).

1.2. Reforming housing subsidies that are more efficient and well-targeted.

1.3. Expanding housing financing facilities, especially for irregular-income people and building their houses independently.

1.4. Developing the services of the Public Housing Savings Agency (BP Tapera) to expand access to housing finance.

2. Supply Strategy:

2.1. Increased provision of housing that is by spatial planning and integrated with essential settlement infrastructure services, including public transportation systems.

2.2. Development of a public housing system based on flats in urban areas.

2.3. Inclusive urban rejuvenation and land consolidation to realise cities without slums.

2.4. Utilisation of land owned by the state / state-owned enterprises to support housing provision for the lower middle-income community.

2.5. The development of the role of the business world includes BUMN / BUMD in housing provision (Perumnas, SMF, BTN).

3. Enabling Environment Strategy:

3.1. Strengthening the implementation of reliability standards and building order, ease of licensing and land administration.

3.2. Increasing the capacity of the government / local governments, communities and businesses to provide housing.

3.3. Collaboration between the government, local governments, communities, and businesses should be increased.

3.4. Developing a system of incentives and disincentives in housing provision.

3.5. Developing national and regional housing public service agencies.

Integrated Slum Management Program with DAK Integration*.* The concept of integrated Settlement and Slum Area Management is to focus on dealing with existing slums while also preventing the formation of new slums. Therefore, a comprehensive Housing and Settlement handling program is needed to Improve the quality of slums, urban renewal, Structurally ill slums, and the provision of housing and new settlements (public housing). Aspects towards Cities Without Slums are determined so that slum area management is more focused on things that have an essential influence in reducing the slum value of a housing and slum area. These aspects are:

1. Essential Infrastructure Aspects: Neighbourhood roads, drainage, drinking water, sanitation. Waste and fire Protection (currently still a priority)

2. Aspects of Housing Provision: With efforts to increase MBR access to livable housing.

3. Aspects of Housing Finance: Increasing MBR access to housing finance to access livable homes.

4. Aspects of Land Status Certainty: Provide security of tenure for the community.

5. Spatial Plan Aspects: Spatial enforcement and space provision for MBR housing in spatial plans.

6. Socio-economic Aspects: Linking slum upgrading with improving the economic capacity and social life of slum dwellers.

Currently, the government, through the Ministry of PUPR, budgets funding for handling Housing and Settlement Areas in an integrated manner through DAK Integration, which is expected to be one of the sources of funding to complete the

program that the local government has in handling an area as a whole from various aspects which are expected to resolve the slum significantly. The position of DAK Integration funding against other programs, both from the Central and Regional Governments, can be described in the following chart:
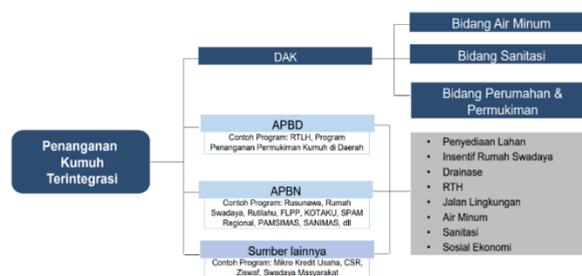
Figure 1 – Funding Integration Chart for Slum Settlement Management

From the chart above, it can be illustrated that DAK Integration is one of the funding alternatives in handling settlements and slums that complements other sources of funds, which will be discussed further because the Mojokerto District Government is planning it at the research location in Kedungmaling village, Sooko sub-district.

1. Implementation Objectives of DAK Integration Activities

1.1. Integrate city-scale slum upgrading programs both across sectors and across institutions in a comprehensive manner

1.2. Improve the quality of life of the community through the provision of decent housing and settlements in slum areas for households living in slums

1.3. Improve the implementation of essential aspects of slum upgrading, especially those related to community empowerment and livelihood.

1.4. Helping to increase the capacity of local governments to build program integration and conduct comprehensive slum upgrading planning and implementation.

1.5. Create opportunities for collaboration with other stakeholders in developing livable settlements.

2. Expectations from Slum Settlement Management through DAK Integration:

2.1. Apply the Holistic, Integrative, Thematic and Spatial (HITS) approach to slum upgrading.

2.2. Making the local government an integrator of multi-sector and multi-actor programs.

2.3. Develop and modify central government programs and activities to be compatible with various needs in the field.

2.4. Ensure that the fundamental components of slum upgrading are addressed comprehensively to have a tangible impact.

2.5. As a form of support for regional programs that are national priorities.

2.6. Completing the most challenging and neglected for years is risky but impactful.

Programs in Achieving Cities Without Slums that DAK Integration can fund.

1. New Housing Development: Development of new decent and affordable housing through government facilitation and community roles.

2. Local improvement: Improving the physical, social, and economic environment into livable settlements.

3. Regeneration: Comprehensive improvement and arrangement to ensure the fulfilment of livable settlements.

4. Relocation/Resettlement: Relocation of communities from locations that cannot be rebuilt/are not by spatial plans and/or are prone to disasters)

Best Practice of DAK Integration Program Implementation. DAK Integration Activities are in Tangerang, Kotabaru, and Pemalang District.

Critical Points of DAK Integration Implementation Stages. Several things need to be considered in each stage of the DAK Integration implementation that can be learned from best practices and other locations that have implemented this program so that it is hoped that the District Government can emulate it for the success of Settlement and Slum Area Management activities. These stages are:

1. Preparation Stage

1.1. The site plan must be agreed upon before the settlement infrastructure activity plan is prepared.

1.2. The work plan must be by the conditions in the field so that no changes occur during implementation.

1.3. Coordination between stakeholders is needed to prepare DED & RAB for all DAK Integration infrastructure activities adjusted to technical standards.

1.4. The arrangement implemented must be able to resolve the slum in that location (referring to the Numerical Slum Baseline)

1.5. There is a need for 1 Coordinator to coordinate all DAK Integration fields (Drinking Water, Sanitation, Housing, and Environmental Drainage Roads).

2. Planning Stage

2.1. Local governments are expected to study policies and regulations related to DAK Integration.

2.2. Data and problems submitted during the beauty contest are expected to match the reality.

2.3. Districts/cities are expected to coordinate with BPN and have started the process of the Location Determination Decree and Slum Regulations.

2.4. The land must be clean and clear.

2.5. It is necessary to conduct socialisation and community meetings for affected communities to prevent social conflicts.

2.6. Predetermined criteria must determine the list of beneficiaries / PAPs.

3. Implementation Stage

3.1. There is a need for communication and coordination between stakeholders in the field's implementation.

3.2. Ensure the availability of resource allocations in infrastructure development.

3.3. Ensure that implementation in the field is to the plan

3.4. Special attention is needed to the administrative process of DAK Integration activities

3.5. Special attention is required from each stakeholder regarding the implementation of construction so that it does not exceed the budget time limit

4. Monitoring Stage

4.1. It is necessary to carry out joint monitoring of all sectors regularly

4.2. Special attention must be paid to the stakeholders regarding the implementation deadline that has been mutually agreed upon (including the funding disbursement).

Settlement and Slum Area Management of Kedungmaling Village with DAK Integration. In handling settlements and slums in Kedungmaling Village, the Mojokerto Regency government is based on several laws and regulations, namely: Mojokerto District Regional Regulation No 9 of 2021 concerning the Mojokerto District RPJMD, concerning the Direction of the Regional Medium-

Term Development Plan (RPJMD) of Mojokerto District in 2021-2026, which contains the development vision of the Mojokerto District government for the 2021-2026 period is: "The realisation of an Advanced, Fair and Prosperous Mojokerto Regency through Strengthening Infrastructure and Improving the Quality of Human Resources". In addition, the Direction of the Regional Long-Term Development Plan (RPJPD) of Mojokerto District 2005-2025 also states to sustainably implement the management and preservation of Natural Resources (SDA) and the Environment and increase economic activities and community income. In addition, the Regional Spatial Planning Policy based on the Mojokerto District RTRW 2012-2032 states:

1. Policies and Strategies for developing a balanced system of activity centres between the North and South.

2. Policies and Strategies for developing interconnections of local infrastructure and facilities to national, regional and local infrastructure and facilities to support the region's potential.

3. Policies and strategies for improving the quality and range of telecommunications, energy and water resources infrastructure network services that can support the improvement and equitable distribution of community services and environmental preservation.

Concept and Strategy for Handling Kedungmaling Area. The handling of the Kedungmaling area carries the theme: "Slum Area Management Through Infrastructure Development Integrated with Wine Village Arrangement and Supporting Community Livelihood".

1. Issues of the Areas :

1.1. The Kedungmaling area is a moderate slum area based on 7 indicators of slum

1.2. Many street vendors use the sidewalks as a place to sell, causing chaos

1.3. Lack of facilities that the community can use for activities that can attract people to visit

1.4. There is no particular area that can accommodate street vendors and UMKM centres/storefronts

2. The potential of the Areas:

2.1. It is an area close to the city centre and is traversed by the National road, so it is very strategic for the economic development activities of the community

2.2. There are public facilities that support economic and social activities, such as markets, banks, mosques and educational facilities

2.3. There has been development of the Vineyard tourism village area

2.4. Kedungmaling is a home industry centre for bag making that is already known regionally

2.5. There is a bamboo forest location (barongan) that can be developed into a recreation and culinary centre

3. Area Improvement Concept: Restoration

3.1. Area Improvement Strategy: 1) Rehabilitation / Repair of channels and drainage along the corridor jl.Kemas Setyoadi; 2) Quality Improvement of roads leading to Kampung Anggur Tourism Area and Tas home industry; 3) Quality Improvement / Construction of Drainage in RT. 9, RT. 10, RT.11, and RT.12; 4) Pedestrian Development along the corridor of jl. Kemas Setyoadi; 5) Construction of Public Open Space (RTP) on Kemas Setyoadi road (former Brangkal Market land) equipped with Retail area, Gazebo, Main Plaza, Playground, Mushola and Parking Area; 6) Development of Kampung Anggur Tourism Area; 7) Construction / Provision of Fire Protection facilities (Dry Hydrant); 8) Provision of trash bins (3R) along the corridor jl. Kemas Setyoadi; 9) Construction of Waste Management Sites (TPS 3R); 10) Neighbourhood scale slum handling related to 7 slum indicators connected to area scale slum handling.

3.2. Area Physical Development Strategy: 1) Improving the quality of pedestrian paths/pedestrians with the addition of ornaments such as street lights, disability-friendly signs, and seating that characterises the distinctiveness of the area, which is undoubtedly free from street vendors; 2) Arrangement of Public Open Space (RTP) as a social and economic centre for the community; 3) Arrangement of bamboo forest tourism areas as a centre for recreation and culinary tourism; 4) Creation of sales centres/storefronts for MSME products.

3.3. Non-physical development strategy: 1) Development of joint systems and rules for waste management and maintenance of other infrastructure; 2) Socialisation of Clean and Healthy Living Behavior (PHBS); 3) Establishment of branding of Kedungmaling Area as a Wine Tourism Village and Bag Industry Center; 4) Improvement of the quality of MSMEs and product marketing.

3.4. Map of Kedungmaling Area Potential: Future potential with Public Open Space (RTP) will

support all existing potentials and become unity-linked tourism, which can ultimately improve the community's economy.

Masterplan and Proposed Management of Kedungmaling Area. The Mojokerto district government, with the assistance of related parties, has developed a master plan for handling the Kedungmaling area along with funding proposals that are planned to be built with the collaboration of funds from the central and local governments.
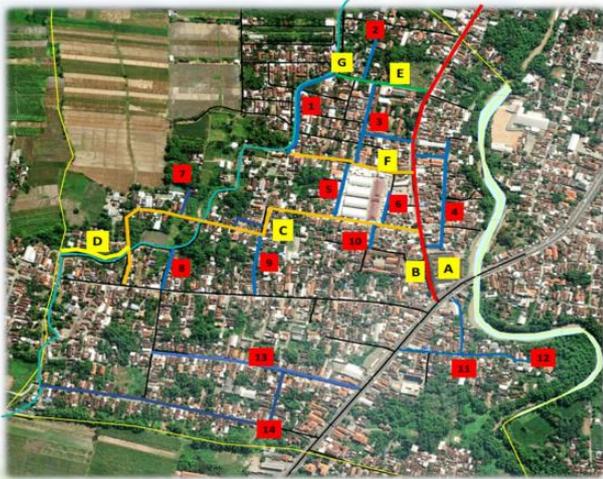

Figure 1 – Masterplan for Kedungmaling Area Management

Figure 2 – Proposed activities for handling the Kedungmaling area

Figure 3 – The volume of Proposed Area Management Activities

Outcome Analysis of Area Slum Reduction. The Planning and Roadmap for Slum Management for 4 Years from 2022-2025 Can Reduce Slum Area Around 42.97 Ha with Collaborative Funding of APBN, APBD, Village Funds, CSR and Community Self-Help.

Table 2 – Area Slum Reduction Outcome Calculation

Figure 4 – Roadmap and Investment for Kedungmaling Area Management

Table 3 – Investment in Kedungmaling Area Management

a)

NO	KODE PETA	KEGIATAN	LOKASI	VOL	SATUAN	TAHUN PENANGANAN 2022 2023 2024 2025	Pendanaan APBN	OPD Penanggungjawab
		PENDANAAN APBN SKALA KAWASAN						
1	A	Pembangunan RTP (Eks Pasar Kedungmaling	Jl. Kemas Setyoadi	1	Unit		6,500,000,000	DLH
2	B	Rehabilitasu Saluran Drainase (2 Lajur)	Jl. Kemas Setyoadi	770	Meter		6,769,229,705	DPUPR
3	B	Pembangunan Pedestrian (2 Lajur)	Jl. Kemas Setyoadi	770	Meter		1,776,425,477	DPUPR
4	B	Pembangunan Jalan (Aspal Hotmix)	Jl. Kemas Setyoadi	770	M		445,966,202	DPUPR
5	B	Beutifikasi (PJU , Kursi Taman)	Jl. Kemas Setyoadi	188	Unit		2,746,489,686	DPUPR; DPRKP2
6	B	Hidran Kering	Jl. Kemas Setyoadi	10	Unit		1,959,617,400	BPBD
7	C	Pembangunan Jalan Paving (Koridor Jalan Kedungmaling 2)	RT09, RT10, RT11, RT12	911	Meter		1,020,700,115	DPRKP2
8	C	Pembangunan Saluran Drainase (Koridor Jalan Kedungmaling 2)	RT09, RT10, RT11, RT12	1822	Meter		1,151,650,109	DPRKP2
9	D	Penataan dan Beutifikasi Kampung Anggur	RT10 dan RT11	2.233	M2		626,335,732	DPRKP2
10	E	Pembangunan Saluran Drainase (Koridor Jalan Kemakmuran)	RT03-RW02	194	Meter		826,205,781	DPRKP2
11	E	Pembangunan Jalan (Koridor Jalan Kemakmuran) (Aspal Hotmix)	RT03-RW02	194	Meter		91,756,156	DPRKP2
12	F	Pembangunan Jalan Paving	Koridor Jalan Kedungmaling 3	258	Meter		289,345,960	DPRKP2
13	F	Pembangunan Drainase	Koridor Jalan Kedungmaling 3	258	Meter		318,828,239	DPRKP2
14	G	Pembangunan Taman Toga	RT03-RW02	289	M2		350,548,912	Pemerintah Desa
15		RTLH	Semua RT	50	Unit		1,000,000,000	DPRKP2

b)

NO	KODE PETA	KEGIATAN	LOKASI	VOL	SAT	TAHUN PENANGANAN 2022 2023 2024 2025	SUMBER PENDANAAN APBD	DD	CSR	SWADAYA	Lainnya	OPD Penanggung jawab
		PENDANAAN APBD, DANA DESA, CSR, SWADAYA DAN LAINNYA										
38		Pemasangan SR & Perpipaan Perumdam	SEMUA RT	500	Unit		500,000,000					Perumdam
39		Jalan Rabat	RT09-RW04	400	Meter		130,000,000					DPRKP2
40		Jalan Rabat	RT10-RW04	400	Meter		130,000,000					DPRKP2
41		TPS 3R	DESA	1	Unit		312,614,000					DPUPR
42		Motor Sampah	DESA	2	Unit				63,000,000			Swasta
43		Bak Sampah	SEMUA RT	200	Unit			10,000,000	20,000,000	10,000,000		Pemerintah Desa dan Swasta
44		Bak Sampah Pilah 3 Warna	SEMUA RT	30	Unit		45,000,000					DLH
45		Gerobak Sampah	SEMUA RT	17	Unit		63,000,000					DLH
46		Pembangunan Jamban Pribadi	SEMUA RT	109	Unit		763,000,000					DPRKP2
47		APAR	SEMUA RT	30	Unit		30,000,000					BPBD
48		RTLH	SEMUA RT	276	Unit		2,000,000,000		3,000,000,000	520,000,000		DPRKP2

c)

NO	KODE PETA	KEGIATAN	LOKASI	VOLUME	SATUAN	TAHUN PENANGANAN 2022 2023 2024 2025	SUMBER PENDANAAN APBD	DD	CSR	SWADAYA	OPD Penanggungjawab
		PENDANAAN APBD, DANA DESA, CSR, SWADAYA dan Sumber Lain									
15	1	Pembangunan Jalan Paving	RT06-RW03	250	Meter		312,500,000				DPRKP2
16	2	Pembangunan Jalan Paving	RT03-RW02	110	Meter		137,500,000				DPRKP2
17	2	Pembangunan Drainase	RT03-RW02	110	Meter		132,000,000				DPRKP2
18	3	Pembangunan Drainase	RT08-RW03	300	Meter		360,000,000				DPRKP2
19	4	Pembangunan Jalan Paving	RT14-RW06	361	Meter		451,250,000				DPRKP2
20	4	Pembangunan Drainase	RT14-RW06	361	Meter		433,200,000				DPRKP2
21	5	Pembangunan Jalan Paving	RT07-RW03	138	Meter		172,500,000				DPRKP2
22	5	Pembangunan Drainase	RT07-RW03	138	Meter		165,600,000				DPRKP2
23	6	Pembangunan Jalan Paving	RT08-RW03	80	Meter				100,000,000		Pemerintah Desa
24	6	Pembangunan Drainase	RT08-RW03	80	Meter				96,000,000		Pemerintah Desa
25	7	Pembangunan Jalan Paving	RT10-RW04	45	Meter		56,250,000				DPRKP2
26	7	Pembangunan Drainase	RT10-RW04	45	Meter		54,000,000				DPRKP2
27	8	Pembangunan Jalan Paving	RT09-RW04	98	Meter				122,500,000		Pemerintah Desa
28	8	Pembangunan Drainase	RT09-RW04	98	Meter				117,600,000		Pemerintah Desa
29	9	Pembangunan Drainase	RT13-RW05	146	Meter				175,200,000		Pemerintah Desa
30	10	Pembangunan Jalan Paving	RT11-RW05	210	Meter		262,500,000				DPRKP2
31	10	Pembangunan Drainase	RT11-RW05	210	Meter		252,000,000				DPRKP2
32	11	Pembangunan Jalan Paving	RT11 dan 24-RW09	456	Meter		570,000,000				DPRKP2
33	12	Penataan Wisata Bidara/ Barongan	RT24-RW09	1	Unit			50.000.000	50.000.000		Pemerintah Desa dan Swasta
34	13	Pembangunan Jalan Aspal	RT20-RW08	428	Meter		149,000,000				DPRKP2
35	13	Pembangunan Drainase	RT20-RW08	428	Meter		556,000,000				DPRKP2
36	14	Pembangunan Jalan Aspal	RT21-RW08	630	Meter		220,500,000				DPRKP2
37	14	Pembangunan Drainase	RT21-RW08	630	Meter		819,000,000				DPRKP2

CONCLUSIONS

The critical successes and regional innovations in the implementation of DAK Integration as one of the strategies in handling settlements and slums that the Mojokerto district government can use in its efforts to deal with slums in Kedungmaling village, Sooko sub-district, Mojokerto district are:

1. From the aspect of community participation in the location.

1.1. Communities as actors, not just beneficiaries, so that they support government programs.

1.2. Communities participate as volunteer labour and monitor the progress

1.3. Establish a community working group (Pokja)/community for management.

2. From the aspect of program assistance in the field

2.1. Involvement of facilitators to assist the community intensively in the structuring process, mediate between the community and the government and monitor progress

2.2. Assistance and facilitation are carried out continuously by the District/City Government.

3. From the aspect of land availability

3.1. Build without displacing

3.2. Local government commits and fights for asset release until certification

3.3. Consolidating land and providing public space are multiple objectives.

4. From an Institutional Aspect in the Region

4.1. There is a commitment from the Regional Head.

4.2. There is a coordinator for the planning and implementing slum upgrading programs.

4.3. Facilitators and communities are actively involved.

4.4. There is good collaboration and coordination between parties.

5. From the aspect of program integration

5.1. DAK Integration is implemented as a form of support for the vision and programs of the Regional Integrated Slum Management.

5.2. Collaboration of funding (APBD, CSR) in the exact location so that the program results have a significant impact and are visible spatially.

The Slum Area and Settlement Management Program in Mojokerto will be more successful and have a national impact if the program is carried out by applying the handling of the dominant factors discussed in Chapter IV earlier because these factors are guided by the goals listed in the Sustainable Development Goals (SDG's). So, applying these dominant factors, it is hoped that Mojokerto can have international standards in handling Slum Areas and Settlements.

REFERENCES

1. Badan Pusat Statistik. (2014). *Kajian Indikator* [Sustainable Development Goals]. Retrieved from https://media.neliti.com/media/publications/48852-ID-kajian-indikator-sustainable-development-goals.pdf (in Indonesian).

2. Patel, Z., Greyling, S., Simon, D., Arfvidsson, H., Moodley, N., Primo, N., & Wright, C. (2017). Local responses to global sustainability agendas: learning from experimenting with the urban sustainable development goal in Cape Town. *Sustainability Science, 12*(5), 785–797. doi: 10.1007/s11625-017-0500-y

3. Hitesh, V., & Tathagarta, C. (2020). Actioning the Global Goals for Local Impact. In I. B. Franco, T. Chatterji, E. Derbyshire, & J. Tracey (Eds.), *Science for Sustainable Societies*. Springer Singapore. doi: 10.1007/978-981-32-9927-6

4. Participatory Slum Upgrading Programme. (2020). *Sustainable Urban Development And Agenda 2030: UN-Habitat's Programme Framework*. Retrieved from https://unhabitat.org/sites/default/files/download-manager-files/1527072751wpdm_SDGsandPSUP.pdf

5. Arandel, C., & Wetterberg, A. (2013). Between "Authoritarian" and "Empowered" slum relocation: Social mediation in the case of Ennakhil, Morocco. *Cities, 30*, 140–148. doi: 10.1016/j.cities.2012.02.005

6. Viratkapan, V., & Perera, R. (2006). Slum relocation projects in Bangkok: what has contributed to their success or failure? *Habitat International, 30*(1), 157–174. doi: 10.1016/j.habitatint.2004.09.002

7. Nakamura, S. (2016). Does slum formalisation without title provision stimulate housing improvement? A case of slum declaration in Pune, India. *Urban Studies, 54*(7), 1715–1735. doi: 10.1177/0042098016632433

8. Kim, H.-S., Yoon, Y., & Mutinda, M. (2019). Secure land tenure for urban slum-dwellers: A conjoint experiment in Kenya. *Habitat International, 93*, 102048. doi: 10.1016/j.habitatint.2019.102048

9. Bogaert, K. (2011). The Problem of Slums: Shifting Methods of Neoliberal Urban Government in Morocco. *Development and Change, 42*(3), 709–731. doi: 10.1111/j.1467-7660.2011.01706.x

10. Carpenter, J. P., Daniere, A. G., & Takahashi, L. M. (2004). Cooperation, trust, and social capital in Southeast Asian urban slums. *Journal of Economic Behavior & Organization, 55*(4), 533–551. doi: 10.1016/j.jebo.2003.11.007

11. Semba, R. D., de Pee, S., Kraemer, K., Sun, K., Thorne-Lyman, A., Moench-Pfanner, R., Sari, M., Akhter, N., & Bloem, M. W. (2009). Purchase of drinking water is associated with increased child morbidity and mortality among urban slum-dwelling families in Indonesia. *International Journal of Hygiene and Environmental Health, 212*(4), 387–397. doi: 10.1016/j.ijheh.2008.09.001

12. Fitria, N., & Setiawan, R. P. (2014). Identifikasi karakteristik lingkungan permukiman kumuh di Kelurahan Kapuk, Jakarta Barat [Identifying environmental characteristics of slums in Kapuk Urban Village, West Jakarta]. *Jurnal Teknik Pomits, 3*(2) (in Indonesian).

13. Zulkarnaini, W. R., Elfindri, E., & Sari, D. T. (2019). Faktor-Faktor Yang Mempengaruhi Permukiman Kumuh di Kota Bukittinggi [Factors Affecting Slums in Bukittinggi City]. *Jurnal Planologi, 16*(2), 169. doi: 10.30659/jpsa.v16i2.5047 (in Indonesian).

14. Setiadi, A. (2014). Tipologi Dan Pola Penanganan Permukiman Kumuh Di Kota Bontang [The Typology and Patterns of Slum Improvement Management in Bontang City]. *Jurnal Tataloka, 16*(4), 220. doi: 10.14710/tataloka.16.4.220-233 (in Indonesian).

15. Barbara, B. P., & Umilia, E. (2014). Clustering Permukiman Kumuh di Kawasan Pusat Kota Surabaya [Clustering Slum Settlements in Surabaya City Centre Area]. *Jurnal Teknik Pomits, 3*(2) (in Indonesian).

16. Wijaya, D. W. (2016). Perencanaan Penanganan Kawasan Permukiman Kumuh (Studi Penentuan Kawasan Prioritas untuk Peningkatan Kualitas Infrastruktur pada Kawasan Pemukiman Kumuh di Kota Malang) [Planning for Slum Settlement Area Handling (Study on Determining Priority Areas for Infrastructure Quality Improvement in Slum Settlement Areas in Malang City)]. *Jurnal Ilmiah Administrasi Publik, 2*(1), 1–10. doi: 10.21776/ub.jiap.2016.002.01.1 (in Indonesian).

17. Ervianto, W. I., & Felasari, S. (2019). Pengelolaan Permukiman Kumuh Berkelanjutan di Perkotaan [Sustainable Urban Slum Management]. *Jurnal Spektran, 7*(2), 178–186 (in Indonesian).

18. Arisa, S., Sukendi, S., & Syahril, S. (2021). Strategi Pengembangan Ekowisata Bahari Selat Baru Kabupaten Bengkalis [Development Strategy for Marine Ecotourism in Selat Baru, Bengkalis Regency]. *Jurnal Ilmu Lingkungan, 15*(1), 45. doi: 10.31258/jil.15.1.p.45-53 (in Indonesian).

19. Kusumawardhani, V., Sutjahjo, S. H., Dewi, I. K., & Panjaitan, N. F. (2016). Penyediaan Infrastruktur Pengelolaan Persampahan di Lingkungan Permukiman Kumuh Kota Bandung [Provision of Waste Management Infrastructure in Bandung City Slum Neighbourhoods]. *Jurnal Permukiman, 11*(2), 100. doi: 10.31815/jp.2016.11.100-109 (in Indonesian).

20. Pramantha, R. Q. (2019). Penataan Permukiman Kumuh Dengan Teknologi Risha Di Kampung Deret Petogogan, Jakarta Selatan [Slum Upgrading with Risha Technology in Kampung Deret Petogogan, South Jakarta]. *Jurnal Ilmiah Desain & Konstruksi, 18*(1), 16–26. doi: 10.35760/dk.2019.v18i1.1955 (in Indonesian).