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Люстрація як спеціальна процедура притягнення судді до юридичної відповідальності в Україні

Lustration as a Particular Procedure for Bringing a Judge to Justice in Ukraine

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Анотація. У статті представлено особливості застосування люстрації як спеціальної процедури притягнення судді до юридичної відповідальності. Встановлено, що особливості проведення люстрації судді, як спеціальної процедури притягнення судді до юридичної відповідальності в Україні, регулюються положеннями певних нормативно-правових актів і документів. З'ясовано, що люстрація являє собою комплекс юридичних та політичних заходів, які націлені на знешкодження наслідків та дій попереднього режиму, що становить загрозу основоположним правам людини і процесу демократизації в цілому. Доведено, що процедура проведення люстрації в Україні стрімко набула популярності в умовах недовіри суспільства до кримінальної та корумпованої системи правосуддя в період листопада 2013 року по лютий 2014 року, головними ініціаторами якої стали громадські організації. Визначено, що процес організування процедури проведення перевірки суддів безпосередньо покладений на голову суду, де обвинувачений суддя, щодо якого проводять перевірку, обіймає посаду та виконує службові обов'язки. Встановлено, що люстрація як спеціальний вид відповідальності впливає на відновлення соціальної справедливості, а також на реалізацію функцій захисту демократії. З'ясовано, що перспективою подальших досліджень у цьому напрямі є дослідження інших видів спеціальних процедур притягнення суддів до юридичної відповідальності, які у комплексі спільно із процедурою люстрації впливатимуть на перешкоджання суддям вчиняти правопорушення.

Ключові слова: люстрація; суддя; правосуддя; юридична відповідальність; правопорушення.

Abstract. The article presents the peculiarities of using lustration as a particular procedure for bringing a judge to legal responsibility. It is established that the exceptions of lustration of a judge, as a specific procedure for getting him/her to a legal obligation in Ukraine, are regulated by the provisions of particular regulations and documents. Lustration is a set of legal and political measures aimed at neutralising the consequences and actions of the previous regime, which threaten fundamental human rights and the democratisation process in general. It is proved that the lustration procedure in Ukraine quickly gained popularity in the context of public distrust to the criminal and corrupt justice system in the period from November 2013 to February 2014, the main initiators of which were public organisations. It is determined that the process of organising the procedure of inspection of judges is directly entrusted to the chairman of the court, where the accused judge, who is under review, holds a position and performs official duties. It is established that lustration as a particular type of responsibility affects the restoration of social justice, as well as the implementation of the functions of protection of democracy. It was found that the prospect of further research in this area is to study other types of special procedures for bringing judges to justice, which in combination with the lustration procedure will affect the prevention of judges from committing offences.

Keywords: lustration; judge; justice; legal liability; offence.

ВСТУП

Дослідження доводять, що на сьогодні досить поширеною є ситуація, коли судді порушують присягу. В результаті виникають правопорушення, які суперечать принципам верховенства права та законності судового процесу. За таких обставин знижується рівень довіри громад і суспільства в цілому до законності діяльності органів судової влади. Як спосіб підвищення довіри, держава розробляє та реалізує на практиці процедуру очищення влади та притягнення винних до юридичної відповідальності, особливе місце в якій займає процедура люстрації.

З огляду на зазначене вище, актуальність тематики наукової статті націлена вивчення концептуальних засад люстрації суддів як спеціальної процедури притягнення їх до юридичної відповідальності.

Аналіз останніх досліджень і публікацій свідчить про те, що дослідження ключових засад притягнення судді до юридичної відповідальності, зокрема через проведення люстрації, проводять як науковці, так і практики-юристи, а саме Г. Губерт [1], С. Карстедт [2], І. Лавриненко [3], М. Маусс [1], Я. Романюк [4], С. Шевчук [5] та інші.

Поряд з тим, особливості проведення люстрації судді, як спеціальної процедури притягнення судді до юридичної відповідальності, регулюються положеннями таких нормативно-правових актів і документів, як [6, 7, 8, 9, 10, 11].

Водночас встановлено, що проблематика люстрації, як особливої процедури притягнення суддів до юридичної відповідальності, на сьогодні є мало вивченою та потребує проведення ґрунтовніших досліджень в окресленому напрямку.

Метою статті є дослідження особливостей застосування люстрації як спеціальної процедури притягнення судді до юридичної відповідальності.

РЕЗУЛЬТАТИ ДОСЛІДЖЕННЯ

Поняття «люстрація» походить із грецько-римської міфології та буквально трактується як певний ритуал від проявів моральної скверни [1].

На думку українського юриста В. В. Андрієвського, під поняттям люстрація слід розуміти комплекс юридичних та політичних заходів, основна спрямованість яких націлена на знешкодження наслідків та дій попереднього режиму, що становить загрозу основоположним правам людини і процесу демократизації. При цьому люстрація проводиться за умов повної зміни політичної системи в цілому [3].

У структурі процедури люстрації функціонують два елементи або як їх називає німецький професор С. Карстедт – два види публічного провадження. З одного боку люстрація передбачає переслідування кримінальних діянь посадових осіб органів влади, які до того ж займають керівні посади, та представників еліти, а з іншого – відображає процес комплексного розслідування діянь тих, які співпрацюють на добровільній основі із режимом минулих представників державного управління [2].

Підтримує позицію С. Карстедта і С. В. Шевчук, на думку якого люстрація – це процедура досягнення ретроспективної справедливості, в основі якої лежить притягнення винних (правопорушників) до відповідальності за вчинення політико-мотивованих та кримінальних правопорушень (злочинів) [5].

Процедура проведення люстрації в Україні стрімко набула популярності в умовах недовіри суспільства до кримінальної та корумпованої системи правосуддя в період листопада 2013 року по лютий 2014 року. Саме в той час зафіксовано значні протести громадян та суспільства в цілому, результатом яких стало виникнення Євромайдану та фактична перебудова політичного устрою на чолі із зміною керівництва України.

Водночас головними ініціаторами проведення люстрації стали насамперед громадські організації. Що стосується люстрації суддів, то тут завдяки такій процедурі передбачалося викорінити незаконні судові практики, за якими порушувалися права та свободи громадян і суспільства в цілому, а також знизити і у перспективі подолати корумпованість органів державної влади, у тому числі судової влади.

Першоосновою правової регламентації проведення процедури люстрації, зокрема органів судової влади, стало прийняття Закону

України [6]. Положеннями цього Закону передбачається проведення люстрації (спеціальної перевірки з метою притягнення винних до юридичної відповідальності) на правових і організаційних засадах суддів, що займають посади у судах загальної юрисдикції. На цій основі люстрація виступає тимчасовим посиленим заходом із використанням на цій основі інших процедур притягнення суддів, що займають посади у судах загальної юрисдикції, до дисциплінарної відповідальності або звільненням із посади судді судів загальної юрисдикції внаслідок порушення присяги. Це, своєю чергою, підриває авторитет системи органів судової влади в Україні та знижує рівень довіри громадян до справедливості та законності здійснення правосуддя суддями.

З огляду на те, основною метою перевірки відповідно до положень статті 1 «Мета перевірки суддів» Закону України [6] виступає:

1) дотримання принципу верховенства права у суспільстві та принципу законності у професійній діяльності судів;

2) посилення рівня довіри громадян та суспільства в цілому до діяльності органів судової влади в Україні;

3) встановлення фактів, за якими відбулося порушення присяги суддями, а також фактів про наявність підстав про притягнення суддів до дисциплінарної чи до кримінальної відповідальності;

4) дотримання суддями принципів незалежності і неупередженості у процесі виконання службових обов'язків.

Своєю чергою, перевірка суддів здійснюється в період одного року із дня, коли відбулося формування складу Тимчасової спеціальної комісії з перевірки суддів судів загальної юрисдикції, яка була створена у порядку визначеному Законом України [6].

Заяву про призначення проведення перевірки конкретного судді можуть подати як фізичні, так і юридичні особи, у письмовій формі. При чому, така заява повинна насамперед бути направлена до Тимчасової спеціальної комісії в період шести місяців із дня, коли було опубліковане повідомлення у газеті «Голос України» щодо утворення такої комісії . Основними елементами такої заяви мають бути [6]:

– прізвище, ім'я та по батькові фізичної особи чи найменування юридичної особи, яка подала заяву, місце проживання фізичних осіб чи місце розташування юридичних осіб, номери засобів зв'язку, а також адреса електронної пошти;

– прізвище, ім'я та по батькові судді чи суддів відносно якого чи яких має відбуватись проведення перевірки, його чи їх посада;

– повна назва суду, де виконує службові обов'язки суддя, відносно якого має відбуватися проведення перевірки;

– обґрунтування необхідності процедури проведення перевірки відносно конкретного судді чи суддів із визначенням на цій основі зазначених ним чи ними судових рішень, які становлять особливий зміст проведення такої перевірки відносно суддів;

– окремий перелік інших матеріалів, які додаються до заяви.

Наступним документом, який був ухвалений Верховною Радою України та передбачав проведення люстрації в органах судової влади є Закон України [7]. Положеннями цього Закону передбачається проведення процедури очищення влади тобто процедури люстрації на правових і організаційних засадах і дотриманням на цій основі принципів верховенства права, принципів демократичних цінностей та принципу прав людини (громадян) в Україні.

Так, Законом України [7] зазначається, що процедура очищення влади безпосередньо пов'язана із встановленням заборони відповідно до рішення суду окремим фізичним особам на перебуванні на посаді, тобто на службі, в органах державної влади та/чи органах місцевого самоврядування (до прикладу, суддям на посаді у судах).

Положення Закону України [7] базуються на дотриманні принципу законності, принципу верховенства права, принципу відкритості, принципу прозорості, принципу публічності, принципу презумпції невинуватості, принципу індивідуальної відповідальності, принципу гарантування права на захист.

У Законі України [7] зазначається, що службову посаду в органах державної влади протягом 10-ти років не можуть обіймати особи, відносно яких було застосовано процедуру очищення влади.

Відповідно до ч. 4. п. 1 статті 2 «Посади, щодо яких здійснюються заходи з очищення влади (люстрації)» Закону України [7] заходи, націлені на очищення влади, тобто проведення люстрації), здійснюються стосовно:

1) членів Вищої ради правосуддя;

2) членів Вищої кваліфікаційної комісії суддів України;

3) Голови Державної судової адміністрації України;

4) суддів;

5) першого заступника та заступника Голови Державної судової адміністрації України.

Згідно статті 5 «Проведення перевірки» Закону України [7] процедуру проведення люстрації, в основі якої лежить очищення влади, проводить Міністерство юстиції України. Так, Міністерством юстиції України формується спеціальний дорадчий громадський орган з питань люстрації при Міністерстві юстиції України, основна діяльність якого має бути націлена на забезпечення проведення громадського контролю у процедурі очищення влади (тобто у процедурі люстрації). До складу суб'єктів, які будуть здійснювати громадський контроль, повинні бути включені представники засобів масової інформації, а також представники громадськості.

Міністерство юстиції України також розробляє і подає на затвердження в Кабінет Міністрів України [7]:

1) спеціально установлений перелік органів, якими буде проводитись перевірка достовірності певних відомостей стосовно застосування заборон, які передбачені Законом України [7];

2) порядок процедури проведення перевірки, яка визначена Законом України [7];

3) план проведення процедури індивідуально по кожному із органів державної влади, в якому, до прикладу, судді обіймають посади.

Процес організування процедури проведення перевірки суддів безпосередньо покладений на голову суду, де обвинувачений суддя, щодо якого проводять перевірку, обіймає посаду та виконує службові обов'язки [7].

Що стосується процесу організації процедури перевірки членів Вищої ради правосуддя чи членів Вищої кваліфікаційної комісії суддів України, то такий процес безпосередньо покладений на керівника Вищої ради правосуддя чи керівника Вищої кваліфікаційної комісії суддів України [7].

На виконання Закону України [7] Кабінетом Міністрів України було видано кілька підзаконних документів [8, 9], якими регулюються процедури застосування цього Закону.

Так, постановою [8] передбачався порядок проведення процедури стосовно визначення достовірності відомостей на застосування заборон, які визначені окремими положеннями Закону України [7], а також список органів, якими повинно проводитися визначення достовірності відомостей на застосування заборон, які визначені окремими положеннями Закону України [7].

Окрім того, постановою [8] визначено порядок механізму здійснення перевірки достовірності відомостей, які подаються посадовими та службовими особами органів державної влади і органів місцевого самоврядування. Разом з тим, суб'єктами, стосовно яких проводиться перевірка достовірності відомостей, виступають особи, що перебувають на посадах у органах державної влади і органах місцевого самоврядування.

Своєю чергою, наказом [9] передбачається визначення порядку створення і ведення Єдиного державного реєстру осіб, щодо яких застосовано положення Закону України [7]. При цьому, реєстр являє собою електронну базу даних, що містить інформацію про осіб, відносно яких застосовується заборона.

Окрім того, для відновлення довіри суспільства до органів судової влади визначальну роль відіграють стандарти Ради Європи. Так, практичний досвід європейських країн стосовно проведення люстрації системи органів судової влади та відповідно їх посадових осіб засвідчує, що насамперед такі дії проводяться з ціллю знешкодження наслідків комуністичного режиму (до прикладу, в Німеччині, Польщі, Угорщині, Словаччині тощо). Натомість у багатьох країнах Західної Європи суспільство не дуже схвалює люстрацію органів влади. Так, до прикладу у Сербії спостерігалася ситуація, за якої було звільнено багато суддів через результати, отримані внаслідок проведення переатестації. Водночас для виправлення наслідків такої ситуації Європейський суд з прав людини законодавчо зо-

бов'язав уряд Сербії здійснити у більшій мірі поновлення звільнених суддів на посаду. Тут слід відмітити, що Європейський суд з прав людини ґрунтовно вивчає особливості проведення люстрації та законність таких дій і відповідність їх міжнародним стандартам [4].

До прикладу, таким міжнародним стандартом слід вважати Конвенцію про захист прав людини і основоположних свобод [10].

Іншим міжнародним документом, яким проводиться регулювання процесу люстрації органів державної влади, є Резолюція ПАРЄ № 1096 [11]. Відповідно до положень цього документу передбачається, що:

– процес проведення люстрації, а також прийняті на цій основі інші законодавчі документи, мають чітко відповідати під вимоги демократичного устрою держави та загалом будуватися на принципах верховенства права, оскільки метою люстрації має стати досягнення перемін (п. 12 і п. 13);

– випадки вчинення кримінальних правопорушень повинні регулюватися положеннями Кримінального кодексу кожної з держав (п. 7);

– в цілому процедура проведення люстрації повинна бути спрямована на нейтралізацію загроз, якими відбувається посягання на порушення прав та свобод як кожної людини (кожного громадянина) окремо, так і демократії в цілому (проведення люстрації як способу помсти не повинно відбуватися) (п. 12);

– у ході проведення люстрації слід дотримуватися принципу індивідуальності вини, тобто вини, яка має бути визначена і доведена кожному правопорушнику (обвинуваченому). При тому, правопорушникам має гарантуватися презумпція невинності, надаватися право на їх захист, а також право на оскарження рішення за результатами люстрації у суді (п. 7 і п. 12);

– адміністрування процесу люстрації має проводитися спеціально створеною комісією, до складу якої мають входити шановані у суспільстві особи, які до того ж пропонуються главою держави та затверджуються парламентом (п. 2);

– процес люстрації повинен бути обмежений тільки на такі посади, посадові особи яких можуть спричинити загрози правам та свободам людини (громадянина) і демократії в цілому, внаслідок виконання своїх службових обов'язку (п. 4);

– дискваліфікація (усунення) з посади посадових осіб за результатами проведення люстрації має бути не більшою 5-ти років, тому що тут не слід виключати можливість настання позитивних змін (п. 7);

– дискваліфікованими за результатами люстрації можуть бути тільки такі посадові особи, які наказували вчиняти чи вчиняли особисто порушення прав людини і демократії в цілому (п. 8);

– якщо не дотримано проведення процедури люстрації на належному рівні, то тут насамперед порушуються права посадових осіб відносно яких проводиться люстрація, оскільки посадова особа відносно якої проводиться люстрація не може належним чином здобути право на захисника, оскільки той має призначатися на випадок, коли суб'єкт люстрації не має змоги найняти захисника. При цьому, посадова особа відносно якої проводиться люстрація, має мати доступ до доказів обвинувачення, а також до виправдувальних доказів, окрім того, повинна надавати особисті докази своєї невинуватості та вимагати здійснення відкритого процесу проведення люстрації, а також мати можливість оскаржувати рішення у незалежному судовому органі (п. 13).

Позиції Європейського суду з прав людини, які до того ж базуються на правовій основі стосовно люстрації, із однієї сторони чітко опираються на положення Резолюції [11], а з іншої – на підставах та процедурі люстрації, яка має проводитися відповідно до стандартів здійснення незалежного судочинства, які насамперед передбачені у ст. 6 Конвенції [10]. До прикладу, головними правовими позиціями Європейського Суду з прав людини виступають насамперед [12]:

1) документ «Вогт проти Германії» № 17851/91 від 26 вересня 1995 р., яким зазначається, що люстрація не має порушувати права людини, оскільки у демократичній державі від посадових осіб органів державної влади вимагається дотримання принципів лояльності і конституційності у ході виконання службових повноважень;

2) документ «Адамсонс проти Литви» № 3669/03 від 24 червня 2008 р., у якому зазначається, що обмеження, введені законодавчими документами щодо проведення люст-

рації, повинні бути насамперед обґрунтованими та відповідати спеціально установленим вимогам, зокрема законності, наявності легітимності мети та відповідності заходам;

3) документ «Расмуссен проти Польщі» № 38886/05 від 28 квітня 2009 р., яким зазначено, що заявники у справі щодо люстрації повинні мати не тільки чесне ім'я, але і спеціальний статус судді у відставці, оскільки з позиції суду, заявник повинен мати не тільки необмежений доступ до даних про справу, але і одержувати усі копії спеціальних документів;

4) документ «Жданока проти Латвії» № 58278/00 від 17 червня 2004 р., у якому зазначається, що терміни давності щодо застосування процедури люстрації повинні вважатися прийнятними за умов специфіки історико-політичного контексту, оскільки органи державної влади повинні бути значно обізнаними у розгляді індивідуальних справ.

Поширеною серед науковців-правників є думка про те, якою має бути правова природа процедури люстрації. З огляду на те, основними способами вирішення такої проблематики виступає те, що люстрація являє собою:

1) особливий вид притягнення правопорушників до юридичної відповідальності;

2) один із видів соціальної відповідальності;

3) метод захисту демократії від впливу наслідків тотального режиму;

4) метод обмеження прав, якими не визначено ознак юридичної відповідальності.

Вищезазначені способи вирішення проблематики проведення процедури люстрації мають своє індивідуальне право на існування. Однак, тут слід відмітити, що процедурі проведення люстрації насамперед бракує спеціальних сутнісних ознак, за якими би визначався склад правопорушення, оскільки неможливо насамперед попередити настання правопорушення через застосування люстрації. З огляду на те, брак складу правопорушення чи його уставлення попереднім числом свідчить про порушення принципу правової визначеності. Тому найчастіше люстрація проводиться поза рамками належної правової процедури і тільки на підставі закону.

З огляду на зазначене вище, слід відмітити, що ключова особливість правової природи процедури люстрації насамперед націлена на притягнення суддів до соціальної, зокрема до політичної, та юридичної відповідальності. При цьому інститут люстрації суддів в Україні повинен у собі поєднувати ці два види відповідальності.

Окрім того, дослідження доводять, що процедура люстрації на сьогодні є недостатньо зорганізованою, оскільки відсутніми є конституційні ознаки юридичної відповідальності суддів, зокрема:

1) немає складу правопорушення, який визначений законодавством конкретно на момент, коли вчинялося правопорушення, так як він записується попереднім числом;

2) відсутній комплексний набір гарантій, якими має бути визначена належна процедура проведення люстрації суддів.

Люстрація як спеціальний вид відповідальності, впливає на відновлення соціальної справедливості, а також на реалізацію функцій захисту демократії. Опираючись на зазначене, люстрація являє собою особливий виключний вид відповідальності, відповідно до якого втрачають дію процедури очищення влади із втратою на цій основі чинності законодавчих документів, якими регулюється процедура люстрації суддів.

З позиції Венеціанської комісії, Закон України «Про очищення влади» насамперед відрізняється від інших процедур люстрації, прийнятих у інших державах центральної та східної Європи тим, що тут присутня більш ширша сфера застосування. Насамперед застосування процедури люстрації націлене на захист громадян і суспільства в цілому, а також очищення органів державної влади від впливу осіб, які до того ж перебувають на посадах органів державної влади та задіяні до різних корупційних схем.

Водночас, враховуючи твердження Венеціанської комісії, слід відмітити, що зміст поняття «люстрація» з наукової точки зору враховує лише захист громадян та суспільства в цілому [13].

ВИСНОВКИ

За результатами опрацювання літературних джерел представлено особливості застосування люстрації як спеціальної процедури

притягнення судді до юридичної відповідальності. Встановлено, що:

– особливості проведення люстрації судді, як спеціальної процедури притягнення судді до юридичної відповідальності, регулюються положеннями таких нормативно-правових актів і документів, як Закон України «Про відновлення довіри до судової влади в Україні», Закон України «Про очищення влади», Постанова Кабінету Міністрів України «Деякі питання реалізації Закону України «Про очищення влади»», Наказ Міністерства юстиції України «Про затвердження Положення про Єдиний державний реєстр осіб, щодо яких застосовано положення Закону України «Про очищення влади»», Міжнародний документ Ради Європи «Конвенція про захист прав людини і основоположних свобод», Резолюція ПАРЄ № 1096 (1996) «Про заходи щодо позбавлення від спадщини колишніх комуністичних тотальних систем»;

– люстрація являє собою комплекс юридичних та політичних заходів, які націлені на знешкодження наслідків та дій попереднього режиму, що становить загрозу основоположним правам людини і процесу демократизації в цілому;

– процедура проведення люстрації в Україні стрімко набула популярності в умовах недовіри суспільства до кримінальної та корумпованої системи правосуддя в період листопада 2013 року по лютий 2014 року, головними ініціаторами якої стали громадські організації;

– положеннями Закону України «Про відновлення довіри до судової влади в Україні» передбачається проведення люстрації (спеціальної перевірки з метою притягнення винних до юридичної відповідальності) на правових і організаційних засадах суддів, що займають посади у судах загальної юрисдикції;

– положеннями Закону України «Про очищення влади» передбачається проведення процедури очищення влади тобто процедури люстрації на правових і організаційних засадах і дотриманням на цій основі принципів верховенства права, принципів демократичних цінностей та принципу прав людини (громадян) в Україні;

– процес організування процедури проведення перевірки суддів безпосередньо покладений на голову суду, де обвинувачений суддя, щодо якого проводять перевірку, обіймає посаду та виконує службові обов'язки;

– постановою Кабінету Міністрів України «Деякі питання реалізації Закону України «Про очищення влади» передбачається порядок проведення процедури стосовно визначення достовірності відомостей на застосування заборон, які визначені окремими положеннями Закону України «Про очищення влади», а також список органів, якими повинно проводитися визначення достовірності відомостей на застосування заборон, які визначені окремими положеннями Закону України «Про очищення влади»;

– наказом Міністерства юстиції України «Про затвердження Положення про Єдиний державний реєстр осіб, щодо яких застосовано положення Закону України «Про очищення влади»» передбачається визначення порядку створення і ведення Єдиного державного реєстру осіб, щодо яких застосовано положення Закону України «Про очищення влади»;

– люстрація, як спеціальний вид відповідальності, впливає на відновлення соціальної справедливості, а також на реалізацію функцій захисту демократії.

Перспективою подальших досліджень у цьому напрямі є дослідження інших видів спеціальних процедур притягнення суддів до юридичної відповідальності, які у комплексі спільно із процедурою люстрації впливатимуть на перешкоджання суддям вчиняти правопорушення.

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The Establishment and Regulation of the Commercial Security Industry in Kenya and its Constitutionality

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Abstract. The commercial security industry's effective establishment and regulation have been overlooked in many states, including Kenya. The increase of Commercial security firms' involvement in national and transnational business resulted in the United Nations drafting the Convention on the Regulation, Oversight, and Monitoring of Private Military and Security Companies.

This study examines the Commercial Security Industry in Kenya in terms of establishment and regulation, outlining the industry's major issues and challenges. The aim was to demonstrate that laws and practices relating to registration and regulation of the Commercial Security Industry in Kenya are loosely created, weak, and shaky. And up to date, the commercial security industry in Kenya is operating in contravention of the Constitution.

Keywords: commercial security; commercial security firms; security; laws; regulations.

INTRODUCTION

After introducing the neoliberal philosophy, which was an offshoot of Washington Consensus policy, commercialisation hit even areas considered the exclusive domain of the state, such as security. With the trend of commercialising security becoming national and international, the commercialising of security services gained prominence worldwide. In that regard, this investment sector has influenced and has become an area of concern to scholars and policy-makers at national and international levels. The commercial security industry (CSI) comprises enterprises that offer some policing/security services with a profit motive. Commercial security can be described as contracted fee-paying services to protect persons and physical assets [2, 13, 16].

In light of this study, the commercial security industry and private security industry may differ in the nature and range of contracts between the consumers and providers. Therefore, this study will confine itself to the term of the commercial security industry. The CSI has been a fast-developing socio-economic sector, but it seems to have been forgotten by policy and law-makers in Kenya. There is a complete break between commercial security firms (CSFs) and the regulatory framework established to standardise their country's activities.

This paper proposes two main points of views: first, that the Constitution of Kenya does not envision commercial actors in the sphere of policing, consequently sanctioning CSFs to operate in Kenya is an unconstitutional allocation of exclusive authorities of the state and a contradiction to the 'Weberian model of State' which enjoyed the monopoly of the legitimate use of physical violence [10]. Second, non-effective regulated CSI can be compromised by people and groups not registered and licensed, hence constituting a higher security risk for the country.

The commercial security industry has been automated through security associations until late 2016. After that, the PSRA, No 13 of 2016, paved

the way for the formation of an authority to oversee commercial security practice in Kenya.

Research Methodology. The study adopted an explanatory research design. It then used three data collecting methods: library research, internet-based and scheduled interviews.

RESULTS AND DISCUSSION

Laws of Private Security Industry in Kenya. There is a particular piece of legislation or statutory (regulatory) authority that is supposed to govern the CSI activities. However, the commercial security industry is still self-regulating through security associations Kenya Security Industry Association (KSIA) and Private Security Industry Association (PSRA). After that, the PSRA, No 13 of 2016, was expected to pave the way for the formation of an authority to oversee the practice of commercial Security in Kenya.

Establishment and Regulation of Commercial Security Firms. Commercial security firms (CSFs) are registered like other business entities as per the Companies Act 2015. However, there are no special procedural steps the holder of a certificate of incorporation must fulfil to be permitted to provide security services in Kenya. To set up a security business should be quite different from ordinary commercial enterprises. This is because allowing a commercial security firm to operate, several security concerns need to be considered. In addition to conditions under the Companies Act, the applicant must meet other stringent criteria set by the law.

The foremost concern is that, after a CSF is issued with a license, no government institution or agency is directly in charge of its operations. Besides, most of the CSFs are founded, owned, and operated by current serving members and ex-members of the civil service, disciplined forces most having influential political networks in one way or another, thereby blocking any move towards effective regulation of the CSI. For example, former Judiciary Chief Registrar Gladys Shollei was accused of having used her influence to award a CSF associated with her to earn a government contract []. Coincidentally, she chaired the committee on delegated legislation that recommended the annulment of the Private Security Industry Regulations 2019, which the PSRA Authority had intended for the code of practice and procedures for the industry []. One of the officials of PROSAK a reputable association for security practitioners, had this to say:

"They use their networks to undercut other commercial security firms by offering what is way below market rates, and that way, they pay their personnel peanuts, and the repercussion is the delivery of poor services from unmotivated guards".

This approach would indicate that those who would be expected to ensure that the industry is operating at high moral and professional levels are instead derailing the industry to maximise their profit margins. The repercussions would be, security personnel are inclined in not benefitting as rivalry in the market makes security firms to reduce what they charge for services rendered [1]. In this regard, the commercial security guards will not be encouraged to undertake their obligations to the best of their abilities. They might be compromised to get involved in illegal activities like allowing the exit of unauthorised goods so that they earn a commission from the arrangement.

This shared practice by most of the CSFs contradicts Victor Vroom's theory of expectancy. A worker trusts that the more effort they put in, the superior the performance, and with the outstanding performance, the higher will be the payment [17]. It also challenges Abraham Maslow's theory of the hierarchy of needs that employment is a significant base of monetary security. The better the remunerating career is, the more monetarily secure an individual becomes [6]. It also contradicts another study that commercial security guards should be paid a salary at least within the minimum government requirement [9].

The second concern is how these public officials draw a line between their commercial policing errands (managing their firms) and their public policing responsibilities. Instead, there arise several complications, such as split loyalty, conflict of interest, and the likelihood of using public offices for personal gain. Since CSIs are currently supposed to be regulated by the parliament, self-regulating or by the consumers, within the CSI we have politicians who own CSFs and have access to information concerning CSI, and this may lead to; one misuse of accountability information especially where such information is against their commercial interests.

When the owners of a CSF are the same as the consumers of service due to their position in

Government that makes it possible to award their own firms contracts, thereby compromising their impartiality in creating and implementing decisions relating to the regulation of CSI especially in delivering strategies or advocating for new laws, also, if a CSF owned by a public servant engages in somewhat in a scandal, it may discredit the particular officer. Eventually, the public's confidence in the public servants may dent even further[1]. Two, they may use confidential information against rival firms, and three, for blackmailing prospective consumers to agree to take their services or shield their consumers' interest.

The third concern is that the companies Act does not make any prohibitions on the activities entering into when running a security firm. The repercussions are that firms registered as security companies are providing services and goods that are not related to security include activities like supplies of non-security stationery and even public transportation of passengers. A director of a security firm pointed out that.

"The industry is competitive and challenging, especially when you have not been able to penetrate and established yourself. That makes some of us engage in other activities so as we may be able to cater for our sustenance".

This practice forces the industry to engage in businesses that are not their core business. Even when any dishonour arises due to the malpractice or noncompliance of that firm on meeting its customer obligation, the CSI image is tarnished. The citizens will not be convinced that the firm was engaged in providing other services and goods not related to security, for example, housekeeping.

As we have discussed above, the establishment and regulation process has some weaknesses compared to other international principles of standardising CSFs. The commercialised Security industry and its activities in South Africa's Security are under a code of conduct for security services providers fixed by the Private Security Industry Regulatory Authority (PSIRA): It is the supervisory arm for the South African PSI set up by the Private Security Industry Regulation Act, No. 56 of 2001.

In Russia, regulation over CSFs is implemented by the ministry of the interior and the prosecutor general's office[2]. In Ukraine, the ministry of the interior is in control for the regulation of the commercial security industry, including the issuance and withdrawal of licenses. In Georgia, the retail security industry is weakly regulated, mainly because of the lack of specific CSF legislation. Therefore, it is practically no likelihood of guaranteeing that the principles are upheld throughout the industry in Georgia [4].

An example of self-regulation in the sector is with the British Security Industry Association (BSIA), which has taken actions to inspire some minimum principles and is authorised to administer the current law on the commercial security industry. The BSIA develops the regulations, which afterwards passes it on to the British Standards Institution (BSI) for enhancement as a British Standard[3].

There is no national arrangement on regulation in the USA as the states differ in a significant way in their needs. Some states have no regulatory oversight, whereas some states regulate guards armed with firearms only [15]. Some use indigenous police agencies to control the commercial firms, although others encourage the industry to self-regulate.

The Private Security Industry under the Constitution of the Republic of Kenya. The Constitution of the Republic of Kenya, Chapter 14, Article 239(4) [18] prohibits persons from establishing a military, paramilitary, or similar organisation that purports to promote and guarantee national security, except as provided for by the Constitution or an Act of Parliament of Kenya.

[1] THE PUBLIC OFFICER ETHICS ACT, 2003 prohibits public officers from awarding contracts, or influence the award of a contracts, to themselves, their spouse or relative, or business associate; engage in any occupation or business which might prejudice their status as public servants, and not engage in private business during official working hours.

[2] Law of 11.01.1991 on private detective and guarding activities in the Russian Federation (amended by Federal laws of 21.03.2002, 10.01.2003 and 06.06.2005); Law on licensing particular types of activities (08.08.2001 No 128-fz.), Governmental decree on licensing non-governmental (private) guarding and detective activities (14.08.2002, No 600), order of the Ministry of the Interior regulating the use of fire arms (13.04.2005, No 275) as well as on training (31.12.1999).

[3] British Security Industry Association-overview https://www.bsia.co.uk/Portals/4/Publications/302-bsia-overview.pdf.

It is only the Government that is permissible to recruit and preserve any disciplined forces of various types for resistance and security on the territory and the people. This conception of a state's responsibility falls directly in the 'Weberian' model of a condition that maintains a monopoly on the legitimate use and allocation of legitimate force.

The first question to be probed is whether the CSFs qualify as armed forces under Article 238? Accurately, the CSFs qualify as a disciplined force, although not so explicitly stated under Article 238. This is for the following reasons. First, the state action doctrine, the CSFs qualifies as armed forces (state actors), not because of the arrangement but the function they perform and legitimise directly or indirectly by the state to fulfil public demand for order and security [11]. The state action doctrine does not shield persons' rights to be free of state control but instead protects the citizens' right to democratically decide the kind of social order they would desire to stay in. It is not for the respect of the citizen's rights, but the respect for democracy, which has higher stakes.

Second, the arm of the state theory affirms that whenever a commercial provider acts as an arm of the Government by accomplishing a public call for order and security, that commercial supplier ought to be held to be a de facto state actor [11]. In the Kenyan context, various activities performed by CSFs are more or less comparable to those of the state security agencies. For example, the prevention of law-breaking, protection of people and property, and investigations make CSFs an attachment of the state or de facto state security agency. Incorporation of commercial players in responsibilities, which are the state's jurisdiction, makes that player an arm of the Government [11].

Third, CSFs are abided by the disciplined forces' behaviours, cultures, and principles such as saluting, marching, and parades), usage of accessories of the state security agencies (walkie talkie radio sets, whistles, and lanyards), and undergo upgraded teachings and exercises which program them to have similarities like state security agents [7].

Besides, just like in the disciplined forces, CSFs have an established chain of command of duty, a culture of loyalty, a set of rituals, beliefs, and symbols. This opinion was also held by the American Civil Liberties Union of Virginia, Inc (amicus curiae) in the USA v. Mario Terrell Day[4]. The contention was whether the commercial security guards should be considered state players for the 4th and 5th Amendments of the USA Constitution. The amicus curiae responded to that issue in the affirmative and consequently pronounced that commercial security guards conduct themselves more like state security agents than they behave like a regular citizen. For instance, they have powers to detain persons; they undertake searches and freaks; they investigate incidents and undertake to uphold law and order. Two, commercial security guards are often mistaken for state security agents as they tend to use the indicia (indications) of authorised power to convince citizens' obedience. Three, commercial security guards are officially predisposed to look and act as police officers[5]. Four, commercial security personnel bear the imprimatur (official permission) of the state because protecting the citizens from internal and external threats is a principal obligation of the state[6]. Therefore, CSFs qualify as de facto state security agents because they execute some controls that have been by tradition associated with sovereignty[7].

The second question is, are the existence of CSFs in conformity with the Constitution? Since CSFs qualifies as armed forces as discussed above, the answer is that commercial security firm's presence in Kenya is unconstitutional and illegal due to the following explanations:

First, under chapter 14, Article 239(4) of the Constitution, only the Government is empowered to establish an armed force of any kind as provided for by the Constitution or an Act of Parliament of Kenya. The provision asserts that,

"A person shall not establish a military, paramilitary, or similar organisation that purports to promote and guarantee national security, except as provided for by this Constitution or an Act of Parliament" [18].

[4] F.3d , 2010 WL 60900 (4th Cir. Jan. 8, 2010), on Appeal from the United States District Court For the Eastern District of Virginia Richmond Division.

[5] Ibid.

[6] Loc. cit.

[7] Justice Rehnquist in Jackson v. Metropolitan Edison Co. (1974) 419 U.S. 345.

CSFs as commercial players neither established by the state nor reporting to the state are unconstitutional for violating Article 239(4).

Second, CSFs operate outside the framework of the law. They are taking a precede from Tanzania where judge Mwalusanya in determining the constitutionality of 'traditional army' (sung), held them unconstitutional for operating in a vacuum[8]. Therefore, applying judge Mwalusanya's formulation on commercial bodies that function outside of the legal structure, CSFs come to be unconstitutional as they lack the statutory basis upon which to operate. The Constitution of the United Republic of Tanzania (the Constitution) under Article 147 (1 and 2) prohibits individuals, organisation, or group of persons except for the Government from raising or maintaining an armed force of any kind in the United Republic of Tanzania for the defence and security of the territory and the people of Tanzania[9]. In the South African scenario, the Constitution of the Republic of South Africa Article 199(3) allows armed organisations or services such as CSFs to be in business but under specific national legislation for structure and regulation.

Third, the Constitution of Kenya does not of any kind insinuate the delegation of maintenance of security and policing powers to commercial entities. This premise is supported by the ruling of the Israel High Court of Justice in the Human Rights Program versus the Minister of Finance (alias Academic Center of Law and Business, Human Rights Division versus Minister of Finance)[10]. In this case, the petitioner asked the High Court of Israel to pronounce an Amendment to the Prisons Ordinance[11], illegal for permitting commercialisation of prisons in violation of Article 1 of Israel's Basic Law. The High Court of Israel held for the petitioner by declaring prison's commercialisation scheme null and void in its totality attributable to, one, that conventionally the state has incarceration powers as captured under the social contract principle. Consequently, the state as a voted body and democratically accountable body should hold the monopoly over the exercise of controlled power planned to advance the public's interest, for instance, democratic mandate theory [5]. The state cannot give its legitimate responsibilities of enforcing the law and security of the citizen's safety to commercial players who are guided by profit-making objectives [5, 12]. The Court rejected the state's reasoning that commercialisation (of prisons) is a simple economic strategy that cannot tremble the fundamentals of the organisation of the Democratic Governance and the basic values of the legal system [12].

Fourth and lastly, the security agents in Kenya are held to constitutional accountability by Article 59(2)(d) of the Kenya National Human Rights and Equality Commission. It mandates the commission to monitor, investigate, and report human rights observance in all spheres of life in the Republic, including keeping by the national security organs. It is noted that only the security agents that we recognised in the Republic of Kenya are the national security organs in Article 239(1), names as the Kenya Defence Forces, the National Intelligence Service, and the National Police Service. Commercial security firms are not mentioned anywhere, thereby alluding to the fact that they are not constitutionally recognised. Even with the enactment of the Private Security Regulation Act (PSRA) No 13 of 2016, the Constitution will still have to be amended to make the new entrant of the CSFs legitimate and therefore to receive oversight by the Kenya National Human Rights and Equality Commission. There is an argument that commercial security workers ought to be held to the Bill of Rights [11]. "Both official police and private police functioning as arms of the state should be held to constitutional standards because they have been legitimised,

[8] Misperesi K. Maingu v. Hamisi Mtongori & 9 Others, HC at Mwanza, Civil Case No, 16 of 1988; Geza Geza & 12 Others v. Isa Hamisi & 11 Others, HC at Mwanza, civil Case No. 7 of 1988; Charles Mwita & Another v. Kando Mresi & 10 Others, HC at Mwanza, Civil Case No. 15 of 1988; Charles Charari Maitari v. Matiko Chacha Ghati & 4 Others; and Ngwegwe s/o Sangija & 3 Others v. R., HC at Mwanza, Criminal Appeal No. 72 of 1987 [All cases reported in Peter, C.M. & H. Kijo-Bisimba (2005) Justice and Rule of Law in Tanzania: Selected Judgments and Writings of Justice James L. Mwalusanya and Commentaries. LHRC].

[9] The Constitution of the United Republic of Tanzania, 1977.

[10] 4(2009) HCJ 2605/05 (Israeli Supreme Court sitting as the High Court of Justice) available at: <http://elyon1.court.gov.il/files/05/050/026/n39/05026050.n39.pdf> (in Hebrew). Seven Judges concurred, whilst, Justice Edward Levy dissented, holding that the Court cannot nullify a privatization scheme which is yet to be implemented.

[11] Amendment No. 28 of 2004.

directly or indirectly, by the state, to fulfil a public demand for order and security" [11].

From the perspective of the above argument, the Act of the Kenya government to permit CSFs to be in business violates the legitimate right to security of citizens and property and therefore amounts to the unlawful allocation of public powers to commercial actors. Accordingly, commercial security is the foremost frontier of safeguarding for the citizen and needs to be well regulated [8].

To legitimise the activities of the CSFs in Kenya, the state adopted a model to legitimise them through an Act of parliament. Private Security Regulation Act (PSRA) No 13 of 2016 to ensure that the industry operates responsibly and professionally. However, the authority that was envisioned to oversee the Act's implementation has not had its house in order. It is currently facing a hurdle after parliament annulled the regulations the authority had proposed to implement the Act.

In that regard, unless Article 239 of the Constitution is amended to incorporate other players in the security sphere, the existence and operation of CSFs in Kenya will be illegal. The only way to legalise CSF's activities in Kenya is to constitutionalise them by adopting the South African model. In light of those above, the Private Security Regulation Act (PSRA) No 13 of 2016 will not be perceived as going against Article 239(4) of the Constitution.

CONCLUSION

The Kenyan commercial security industry came into existence in 1980 due to the neo-liberal policies that saw the state security agencies being under-funded and losing the ability to deliver services, including security provision. The guidelines then advocated for the liberalisation of inward foreign direct investment and abolition of regulations that impede market entry. As a result, no law, circular, administrative order, or proclamation made official CSF's activities in Kenya. Introducing key players such as the CSFs without any legislation or regulation was an error that needs correction.

This study evaluated Kenya's commercial security industry and concluded that the industry has some weaknesses in terms of registration and regulation. Above all, the chapter ignites a discussion about the constitutionality or otherwise the legitimacy of CSFs activities in Kenya. Furthermore, laws and regulatory frameworks have not kept pace with the expansion of commercial security. Other stakeholders would be contented that commercial security firms are already being held answerable both criminally and civilly by their clients. But others have argued that commercial security has to be laid open to the same form of democratic controls and accountability as the other state security organs in Kenya. Therefore, the increased 'marketisation of insecurity control' in Kenya requires a constitutionalisation of the commercial security industry's governance.

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Challenges of Students Housing Provision in Malaysia

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Abstract. The world population has been growing tremendously, which surged up the demand and enrolment in educational institutions to unimaginable level globally. Similarly, Malaysia has witnessed tremendous growth in higher education both in the order and establishment of new higher education institutions (HEIs) to match up with the demand. However, there is no commensurate increase in the student housing facilities to match up with the growing enrolment and demand; hence, accommodate a certain proportion of the total students. The paper explored qualitative methodology data from in-depth expert interviews of selected public and private universities in Malaysia; discussed the problems of HEIs student housing provision to four identified themes: student enrolment, government policy, funding and land issues as what exacerbated the issues. Therefore, challenges for student housing provision are enormous; hence HEIs and Government cannot adequately respond and satisfy the demand unless private housing developers actively involved otherwise problems of student housing provision will continue to persist.

Keywords: higher education institution; student housing; student housing provision; student enrolment; higher education.

INTRODUCTION

The world population has been surging especially in the last three decades, and in particular, 100 million people were added to the world population every year between 2014 and 2017 where it stands at 7.2 & 7.5 billion respectively [1, 2]. Authors [3] reported, looking at the world population growth, there is strong growth in student age population (16–39 years old) and postulated that by 2050, the global student age population would reach 1.3 billion. Consequently, this implied a high rise in demand and enrolment in higher educational institutions (HEI). According to [4, 5] global students' number has drastically increased from 98 million in 2000 to 165 million in 2011 with an annual average of 6 million students and postulated student enrolment numbers are to increase by 32 million over the next ten years. Author [6] reported the number of HE students is anticipated to swell up to "263 million" globally by 2025. Similarly, [3] noted, between 2012 and 2017, the total global number of students in higher education institutions has increased by 11 % to exceed 220 million. Indeed, these have shown higher education has been rapidly and steadily growing mainly in the last two decades where many young men were finishing high schools and seeking placement (applying) every year in higher education institutions (HEIs).

In Malaysia, the population has been steadily growing tremendously since 1957. For instance, in 1957, the country's population was 7.3 million; the population doubled to the figures of 13.3 million and 27.0 million by 1980 and 2008, respectively [7]. According to Population Reference Bureau [1, 2], the population of Malaysia in 2015 and 2017 estimated at 30.8 & 31.6 million respectively, this signifies the possibilities of simi-

lar high increase in the demand for higher education (HE).

Malaysia is not different in the development and rapid growth of higher education institutions with over 671 HEIs [8] and recent year's enrolment into institutions of higher learning has increased tremendously. Equally, [9] said in the past decade, Malaysia has witnessed tremendous changes in the HE scenario, both in the demand and establishment of new HEIs in trying to match up with the order. With this development of the education sector, universities and colleges have been receiving an increasing number of students' enrolment each year. Furthermore, HEIs student population in Malaysia has been increasing steadily in the past two decades where enrolment stood at 664,402 in 2002 to a total of 1,325,699 students in 2017. Similarly, it was reported, in Malaysia, there are 1.33 million student's enrolment in 2017 and expected to continue increasing in years to come to hit 2.0 million by 2020 as expected 50 % of the Malaysian youth age 18–25-year-olds would gain access to HEI.

Moreover, the Ministry of Education Malaysia reported student enrolment in public universities alone from 2014–2017 stood at 563,186; 540,638; 532,049 and 538,555 respectively and the total enrolment for both public and private universities in 2017 is 1,104,407 [10]. Table 1 shows the steady growth of HEIs student population. This is a clear testimony that the student population has been increasing dramatically and will continue to grow in the future as more children are graduating from secondary schools. These entire scenarios are by implication, indicating a commensurate increase in pressure on the existing HEIs facilities and tremendous growth in student housing demand.

Table 1 – Higher education institutions students' enrolment from 2009–2017 in Malaysia

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Enrol	1,050,726	1,134,134	1,056,547	1,114,589	1,156,293	1,167,077	1,236,164	1,346,858	1,325,699

Source: Adopted from the [10]

Despite this growth of student population in HEIs, provisions of housing facilities are not proportional to the development of enrolment, especially in the last decade. Shortage in student housing in the HEIs could be attributed mainly to the high demand for HE and no corresponding increase in student housing to meet up the enrolment. Current trends of rapid enrolment changes and insufficient student housing development are impacting on students' daily life such as their housing comfort, convenience, safety and to some extent their academic achievement or performance [11]. Therefore, this paper intends to study the problems of HEIs student housing provision in Malaysia.

Background

Globally, there is progressive growth and demand for higher education following the unprecedented change in the student age demography. HE has been overgrowing in both developing and developed countries, especially in the last three decades, where many young people are graduating from secondary schools and gaining access to HEIs. Despite this growth, the provision of students' housing is not matching with the evolution, which led to the constraints and stretching the existing HEIs housing facilities. As [12] put it, the increase in the number of HEIs students; along with the growth in the size of HEIs have made the provision of student housing a challenge for all post-secondary education institutions. It was reported that many HEIs cities in the UK have sufficient student housing 'shortfalls'. In many HEIs, there is a significant or gross deficit in student housing that compelled many students to rent residential quarters outside their campuses.

Population and demand for HE is the main target for the decision for establishing HEI and other HEI supporting facilities such as student housing. The growing student demand for housing has a significant impact on the decision by any HEI to build student housing. Although, not all HEI students want to live in on-campus students' houses, but preferred to live out of core students' area for their privacy and freedom. To some extent' economic meltdown' of many countries, coupled with high growth in HEIs enrolment, increasingly making it difficult for HEIs to construct more housing units to sufficiently match with and pro-

vide housing accommodation to all students. Therefore, the on-campus students housing remained grossly inadequate [13, 14, 15]. In line with this, it has been noticed that many HEIs with traditional housing facilities only accommodate small proportion about 20–30 % of their total students' population [16, 17, 18] therefore, majority of the students have to go to the private housing market.

Malaysia is not spared in the global trend of increase in student enrolment, in the past two decades, Malaysia has witnessed tremendous change in the HE scenario, one of the changes observed, is the acceleration towards mass education' to absorb the teeming population [19]. Further, [19] reported a total of 1.2-1.5 million students in public and private HEIs in Malaysia, in 2009 and the Ministry of Education Malaysia estimated the figure of the total enrolment of both public and private HEIs to be 2.0 million in 2020. This will increase the pressure on the HEIs existing facilities and derived more demands for learning spaces, residential facilities, recreational and other supporting facilities. Provisions of adequate and safe student housing are equally important. Still, the reality is on-campus housing is grossly inadequate; students have no other option than to seek for housing accommodation elsewhere close to their campuses where available.

The issue of student housing provision has been a challenge of long-standing but increasing concern for HEIs. The facts are, most campuses of public and private HEIs throughout the world and in Malaysia, continued to experience the unprecedented growth in enrolment. At the same time, the construction of on-campus housing options fell precipitously [19]. The inability of the HEIs to increase their housing capacity to match with the enrolled student population adequately has increased the demand for student housing in the private sector market, where students are compelled to search for private accommodation outside the campuses. Getting renting houses in the private market by students in HEI neighbourhoods or towns is problematic because in most cases secret places for renting are either not sufficient in supply or else the rent rate is high, not affordable to many students.

Literature Review

In recent years, student age population 16–29 years old who are finishing secondary schools has been increasing dramatically, which fuelled the demand for HE globally. The people of youth in any given country is the essential element formed the basis for decision making for establishing or expanding HEI. Authors [20] in confirmation reported that globally student enrolment in higher institutions has been increasing in recent times, and it is estimated that there has been 'about 160 % increases in tertiary education globally'. Author [3] reported, in 2017, the total global number of students in higher education institutions has exceeded 220 million. Similarly, students are the main target for the establishment of any university and [21] attested that the increase in the number of university student cohorts fuelled the birth of new universities. Indeed, the global increase in youth population simultaneously increased the demand for HE globally and resulted to the extension of the exiting and establishment of new HEIs in the last three decades in both developed and developing nations [22, 23, 24]. This resulted in spurring up the enrolment, where many HEIs enrolled students more than their student housing carrying capacity, which becomes quite imperative and challenging for the HEIs towns to accommodate the teeming student population.

A global economic recession or rather crisis of 1997 & 2012, has significantly affected HEIs student housing directly or indirectly in many ways and many countries. Author [25] observed, in the recent world economic recession that cut across nations, adversely affected all sectors, including education, particularly HEIs. Similarly, [26] presented that during the financial crisis, both state-supported and private colleges and universities felt the effects; many nation-states cut the amount of increased HEIs costs on non-academic core areas. In conformity to this, [27] argued, due to the restrictions placed on grants to HEIs, government spending did not cover the need for expanded non-core facilities. The economic meltdown of many countries led to budget cut for many sectors including education, coupled with high growth in HEIs enrolment, increasingly making it difficult for HEIs to construct more student housing units to sufficiently match with the enrolment (demand) and provide housing accommodation to students; therefore the on-campus students housing remained exceptionally inadequate [9, 14, 28, 29, 30, 31]. Therefore,

HEIs' tighter capital budgets, obviously turned them incapacitated to provide more student accommodation for the growing students' population and warrant them to focus on building classrooms, research facilities and offices and leaving students housing up to the private sector [14].

For years, providing students with housing in HEIs in many countries of the world has remained a significant challenge to HEIs. Shortage of student housing in HEIs could be attributed mainly to the high demand for HE, which increased dramatically in the past three decades, but with no corresponding expansion of student housing facilities to meet up the enrolment thus, straining the available housing in both public and private HEIs [20, 32]. Suppose such a scenario remains to be ignored. In that case, institutions could be entrapped in providing unfavourable academic environments which are quite unsupportive for students learning culture [33], where students' density in the housing facilities will be high thereby straining intellectual life comfort.

Malaysia is not different in the youth population surging, development and rapid growth of HEIs now with over 671 HEIs [8] and in recent years,' enrolment has increased tremendously. Equally, it has been observed, in the last decade, Malaysia has witnessed tremendous changes in the HE scenario, both in the demand and establishment of new HEIs to match up with the order. However, this increased number of HEIs, universities and colleges have been receiving an increasing number of students' enrolment each year. Furthermore, HEIs student population in Malaysia has been increasing steadily in the last two decades where the "enrolment stood at 664,402 in 2002 to a total of 1,134,134 students in 2010. More so, the Ministry of Education Malaysia reported HEIs student enrolment in 2017 at 1.8 million students [10]. This is because the demand and student population has been dramatically increasing and will continue to grow in the future as more children graduate from high schools and expect 50 % or more of the Malaysian youth would gain access to HEI.

As it has been observed, despite this growth of students' population in HEIs, provisions of housing facilities are not proportional to the development of enrolment, especially in the last two decades. The facts are, most campuses of public and private HEIs in Malaysia will continue to have to experience the unprecedented growth in enrolment. At the same time, the construction of on-campus housing options fell precipitously [19]. Many studies noticed and reported HEIs in many countries to have insufficient student housing and most of the HEIs with traditional housing facilities only accommodate 20–30% of their total students' population. Therefore, the majority of the students are housed in the private housing market. Authors [14] spotted, incongruent growth in students' enrolment and housing facilities, necessitated many students to seek alternative accommodation option in the private housing rental market.

Similarly, researchers [34] observed this shortage of students housing and reported; universities maintained a few traditional hall types of accommodation for a few students. Then the majority had to go into the private rented market. Authors [38] summarised the situation of HEIs students housing shortfalls by the fact that the 'student population increase, has in general, run ahead of the ability of HEIs to accommodate them and has led to a growing reliance on the private rented sector'.

Being many of HEIs students are living in off-campus private rented houses, in many cases are at a disadvantage, because they find it difficult to get housing accommodation in the HEIs' neighbourhoods where the renting places are not sufficient in supply or cost-cap.

Some scholars have reported this circumstance; most off-campus student houses provided by the private rental market are either scarce, not purposely built students houses or somewhat lacked sufficient requisite facilities [13, 35].

Author [24] found that 70 % of private hostels in university neighbourhood are being converted from family residential houses to hostels thus [16, 36] conclude, living off-campus students are necessitated to live in family housing like 'apartment, studio flats, condominium and terrace house'.

These proved that as students flew into the HEI neighbourhood for housing, any available housing with either substandard or else unavailable requisite facilities and services will be used which will not render the house to fulfil the function of modern student housing hence, there is no readily available purposely build student housing.

Another essential problem for student housing provision in HEIs island where many HEIs are faced with land constraints while others with

available land for housing development will offer an opportunity for future student house expansion.

Old HEIs and HEIs that are located in highly dense populated towns would likely have no space for new student housing, possibly all land had been developed, and expansion will not be feasible unless some old buildings give way for further development. Many HEIs have been expanding as demand for HE and enrolment keep on increasing, additional classrooms, laboratories, lecture theatres, workshops, offices, student housing, etc. are needed and are competing for space to match with the current demands and growth. According to [29] typically, the available land for new development that HEI has is limited or not existing and building new dorms is not feasible. Conversely, in the highly densely HEI towns land for further development is scarce unless old buildings will be purchase and demolish for new construction of student housing. Indeed, the cost of such a product is usually prohibitive to especially HEIs [15, 37, 38].

In some cases, land matters such as land laws and regulations may be cumbersome that causes delay in housing development and increase the cost of housing construction. Accordingly, the author [39] noticed technical requirements for land matters, planning, and building plan approval compliance translates into additional fees, and it also creates bureaucratic delays in the approval process. Similarly, the author [40] observed, the complexity of housing development in Malaysia, is due to mandatory compliances with various lands, planning and housing laws that are not all wholly synchronised and integrated. However, land matters sometimes tend to be more stringent and punitive, ostensibly to rein in the housing development as the laws and regulations continued to, instead of being facilitative to housing developments.

Governments of many countries have developed various housing policies to cater to their housing problems. Still, in most cases, governments are silent, and there is no government policy statement on student housing. Housing policies of many countries underscored student housing and not yet declare a policy on the responsibility to house the increasing student numbers, which left to be dealt with by individual HEI. According to [27] in a study in the USA reported there had been few government statements on the responsibility to the housing increasing students' population; it has been viewed as the responsibility of individual institution which instigated student housing problems to have persisted. This responsibility of individual institutions' will not be fulfilled as they were inadequately funded to respond to rapid increases in student populations.

Methodology

The paper is part of a large-scale study of HEIs students housing provision in Malaysia which is directed at providing an in-depth and interpretive understanding of student housing provision problems and paper explored qualitative study in generating data for the research. In this research, expert interview method was used to provide an opportunity for detailed investigation of people's personal opinions and experiences for an in-depth understanding of the contextual issues within which research phenomena are established, and for detailed subject coverage [41, 42, 43, 44].

Semi-structured interview question format was employed to give similar understanding to participants (respondents), and the type of data collection instrument is an in-depth expert interview of 'one-to-one' or 'in-person' that engaged individual participant for inquiring research phenomenon. We think that this method provides an opportunity for detailed investigation of each person's point of views, for an in-depth understanding of the circumstances within which the research phenomenon is situated [45].

Purposive sampling technique was employed where the participants were chosen because they have particular characteristics which will enable detailed exploration and understanding of the central theme as some scholars suggested [46, 47]. Development Officers of universities are chosen as our research participants based on their office responsibilities for providing and maintaining physical facilities visa-vie their knowledge on student housing provision. Three universities are selected for the study, two from public and one private to represent HEIs. We examined the transcripts to the four themes identified for coding and content analysis.

RESULTS AND DISCUSSION

Surging of youth population has tremendously pushed up the demand for HE, which invariably push-up the need for other HE related facilities

such as classes, laboratories, libraries, students housing, and sporting facilities among others. It became clear that HEIs were unable to provide and expand their student housing in line with the rise in student enrolment. Many reasons make HEIs incapacitated in increasing their student's housing to correspond with the teaming population growth of students' enrolment. These were due to high students' enrolment, funding, government policy and land matters which formed the four themes identified.

Students' enrolment

Over the years, students housing in HEIs has become an intractable area of concern by the HEIs administrators as the enrolment out-numbered their housing facilities. The student population in recent year has been increasing and running consistently ahead of HEIs' available students housing facilities to accommodate the teeming students. HEIs provided student housing facilities in Malaysia generally have no vacancies, and each year the number of students enrolled exceeds the available HEIs student housing as in many countries [9, 36, 19, 48]. It was reported that HEIs Students population in Malaysia has been increasing steadily in the past decade and enrolment stood at 1.8 million student enrolments in 2017 [10].

In addition to the local population seeking enrolment in HEIs, the Malaysia Ministry of Higher Education has employed internationalisation as a primary focus in transforming higher education to be able to contest with other global higher education providers. For Malaysia to achieve its aim of becoming an international education hub by 2025, targeted to enrol 250,000 international students in the country's HEIs [48, 49]. The government set a goal of attracting 100,000 international students by 2010; estimates the foreign student population grow to 150,000 by 2015, to 200,000 by 2020 and 250,000 by the turn of 2025 admission [9, 49, 29, 19, 48]. In the years of 2009 and 2017, Malaysian HEIs recorded 80,750 and 170,068 international student enrolments respectively, with a 7.6 % annual increase toward attracting 250,000 international students to become an international education hub by 2025. Furthermore, the targeted 250,000 international students in addition to the local students' enrolment, will also aggravate students' housing problems. These are evidence for the possible increase in demand for HE that will spur up the enrolment, the demand for student housing in the future and turn exacerbate student housing problem in the HEIs. See Table 2 bellow justified the steady growth of international student enrolment in Malaysian HEIs.

Table 2 – International student enrolment in Malaysian higher education institutions (HEI) form 2008-2017

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
No.	69,174	80,750	86,919	N/A	N/A	N/A	135,502	151,979	172,886	170,068

Source: Adopted from the [10]

Similarly, our interview respondents concurred on the significant growth in student population in their respective universities:

"Around 2012, if not mistaken, we have around 10–12,000 students so, now we have nearly 16,000 students and 20,000 students by the year 2017" (Participant No 1).

"In those days around 2000, the total student number was around 20–22,000, but now the total number of our student population is more than 25,000 including KL campus" (Participant No 2).

"I am not very sure, but our students now are around 1,200, and before now, maybe 2 or 3 years back, they are less than 1,000" (Participant No 3).

Therefore, these are clear testimonies that students' enrolment in Malaysian HEIs, like many other countries, has been increasing steadily as propositioned in many studies [3, 4, 5, 10, 20].

Funding

As it has been observed, the global economic recession has substantially shaken HEIs student housing provision in many nations states, and Malaysia is not the exception, which adversely affected educational sector particularly HEIs [26, 25, 27]. This is being felt by limiting budget and restrictions placed on HEIs costs on non-academic core areas like student housing. At the

same time, government spending focuses more on expanding equipment and maintaining existing facilities.

"There is Malaysian Economic Development Plan No 10 (RMK10) then Government realised, they don't have enough money to build what so ever, they introduced Private Finance Initiatives (PFI) & PPP projects. They construct hostels using the PFI model then rent to Government (university) and then to student… for the period of the concessionaire, normally is 20–25 years. After RMK 10 and now RMK11, there is no hostel being built by the Government using the traditional method or conventional way. All HEIs student hostels must be built through PPP" (Participant No 1).

"RMK 10 & 11 no more money from the Government for new development. So, we have to find our initiatives to look for our own money for new development; now, government policy is no funding for new physical development only fund for equipment and maintenance of the existing facilities. Budget for new physical development is for young (new) universities like… but old Universities, no more budget for new physical development" (Participant No 2).

"Our accommodation, well, right now we rent all our accommodations from outsiders. You know, in private university we don't have a grant from the Government, is different from public universities. Our biggest problem is budget (funds) we cannot build students' accommodation, so we rent… we charged student base on the room type as we rent, so is costly" (Participant No 3).

When HEIs are stripped with insufficient funds to invest in non-core areas of their education business coupled with high construction costs, most HEIs will not be able to keep up with mounting housing demand. This confirmed many studies that stringent funds flow to HEIs impact on student housing provision [14, 28, 29, 30, 9, 31, 27]. It is important to note that with a budget cut or cash-stringent, constructing new student housing or take on a significant renovation of the old student house buildings can be cost-prohibitive to many HEIs [27]. However, the Government did not put a restriction on HEIs to make their initiatives on an extra budget or joint venture with private developers to construct new non-academic core-areas. Indeed, many HEIs find it difficult or rather impossible to build new student housing thereby, on-campus student housing remained grossly inadequate, and many students have to depend on the private rental market for their housing accommodation [14]. Therefore, restrictions placed on grants to HEIs impacted negatively on the need for expanding student housing facilities.

Government policy on student housing

Governments of many countries including Malaysian has not yet declared a policy on student housing, most governments are silent, and there is no policy on student housing on the responsibility to house the increasing student numbers [27]. Policy developments underline the general trend viewing student housing as a matter to be dealt with by individual HEI. This responsibility will not possibly be fulfilled as they were not funded to respond to rapid increases in student populations.

Although most of the education policies are more comprehensive in respects of making HEIs more attractive and competitive with those world-class education providers, notably UK and USA, but generally were silent on student housing issues. Despite policy commitment of Government to boost up HE, little attention has been paid to the students housing consequences of expanded student numbers in HEIs.

Malaysian National Housing Policy, in a similar way, has not made a policy statement on students housing although the National Housing Policy goals is "to provide adequate, comfortable, quality and affordable housing to enhance the sustainability of the quality of life of the people". Even the three objectives of the policy did not specifically make any reference to student housing. However, the policy objective number two emphasises on "enhancing the capability and accessibility of the people to own or rent houses" [50]. Further to this, in the Malaysian Housing Development (Control and Licensing) ACT, 1966 (Act 118), student housing was not even mentioned as a matter of policy statement. As [27] presented, the perception is to leave the institutions to take care of their respective housing problems, and no other education stakeholders seem to be concerned and responsible; all these added to the confounding student housing provision problems in Malaysia.

However, these are the manifestations of our respondents about government policies on student housing in Malaysian HEIs:

"Previously our Government has a lot of money, then we are using a conventional method of student housing provision where Government appoint a contractor to construct the hostels then university-run and maintain the hostels themselves. Now Government will not put their liability there… in the sense that, Government will not put themselves or their money in the construction. So, for student housing, we have to find our means. So, that is why Government allowed only 70% in-campus and 30% off-campus, the reason why Government insisted and allowed 70%, is to develop a local economy with the 30%" (Participant No 1).

"Previously, the government gave University some 'education funds'. The Government gave us some money which we built hostels; I thing nine colleges and government policy, say each university can cater for 20,000 students. Still, now our policy changed, no money from Government so, we are borrowing for hostel construction. Government policy now is a university in their initiatives should have funds for funding some projects" (Participant No 2).

On the private universities, it is indicated that government policy on student housing is silent as reported by a participant.

"Our own (private university) is different; Government is concerned with public universities. Private universities, we do our business, if accommodation is available, we give to students, others rent outside" (Participant No 3).

Land Matters

The land is the most critical resource for human habitation and all activities for any development. In many HEIs available land for expansion is limited or not existing, therefore, pose a problem for new growth. HEIs have been expanding as demand for HE and enrolment keep on increasing, additional classrooms, laboratories, lecture theatres, workshops, offices, etc. are needed and are competing for space to match with the current demands and growth. It was found that public universities were having vast land for future expansion when the need arises; on the contrary, the private university does not.

On the other hand, HEIs that are located in highly dense populated towns would likely to have no space for new student housing, possibly all land had been developed, and expansion will not be feasible unless some old buildings were demolished for the further development [12, 15, 37, 38].

For instance, University Heriot-Watt Malaysia located at the highly developed area of Wilayah Persekutuan, Putrajaya typically the available land for new development does not exist and building new student housing is not feasible.

"Our location is a problem because we are in the centre, and we cannot provide student accommodation on our campus. Our student accommodations are off-campus, not here, but within 15–20-minute drive to the campus, we have to provide free-bus service to campus. So, we cannot provide, you see it is complicated to provide student accommodation" (Participant No 3).

However, due to insufficient land in HEIs, new construction may not be possible and frequently, to build new structures, old buildings have to be demolished or parking lots to be removed. Conversely, in the highly densely HEI towns land for further development is scarce unless old residential houses will be purchase and demolish for new construction of student housing. Indeed, the cost of such action is usually prohibitive to especially HEIs [12, 15, 37 & 38].

On the other side, land acquisition law and laws are impediments to the provision of student housing where the process takes a long time for clearance, transfer, change the title and planning approval for development as [39, 40] reported. In respect to land issues, the respondents articulate:

"So, our problem is Land Matters because our land is not the Federal Government land yet is still under state land, so we cannot develop. Yeah! This is a very long process. Like our land here, since 2002 we bought this land, but the 'title' is still not ours, is still a state own, so we cannot lease, we cannot sublease, and we cannot develop. Because the land is state land and the federal don't want to involve in the matter. The state did not transfer the land to us because paying the premium to state is difficult, so we cannot develop the ground because of the case" (Participant No 1).

"Now we are discussing with Putrajaya Holding to building another one (student accommodation). Unfortunately, the site is not yet transferred to them; you see land issues are not easy; we cannot have it now" (Participant No 3).

However, another university is not affected by either of the above land problems because they have acquired a large expanse of land for future

development which is still lying underutilised but are having trouble of conversion and changing title [39 & 40].

"We have a lot of vacant lands (underutilise). So now we are planning to convert some of the lands to commercial. Now in Malaysia, if you want to convert land use from education to commercial, we have to change the land title to commercial. Otherwise, education is not commercial; you cannot do that. You see, changing the land title to commercial is very difficult, not easy" (Participant No 2).

CONCLUSIONS

The need for an effective and conducive student housing facility in HEIs cannot be overemphasised since students are expected to be in a good state of mind to excel in their academic endeavours which can be achieved by a sound student housing system. Students' population growth in HEIs coupled with the incongruent supply of student houses, low level of funding, government policy and land issues will undoubtedly continue to make on-campus student housing to be grossly inadequate and student housing provision problems to persist. It has been observed; many HEIs are faced with land constraints and tighter capital budgets which necessitated leaving student housing provision to the private sector. Therefore, there is need for collaboration between education stakeholders: Government, HEIs and private housing developers in student housing provision. It has become a significant concern and pertinent challenge to ensure private housing developers' participation in the provision of student housing is encourage, to supplements the inadequate students' residential infrastructure provided by the HEIs. Hence, HEIs/government alone cannot adequately satisfy the demand and the responsibility has been shifting solely to the private sector directly or indirectly and or formally or informally in the structure of student housing provision. Consequently, these are serious challenges not only to HEIs but to governments and the private housing developers to gear up for gauging student housing shortage for students' comfort, healthy living environment and achieving their education mission.

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COVID-19 and Quarantine: The Role and Impact of Media in Kosovo's Society

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Abstract. The outbreak of COVID-19 and the quarantine affected Kosovo society by highlighting the media's role and importance in informing and raising citizen's citizens in a pandemic situation. At a time like this, besides the information and citizen's awareness, this situation was accompanied by a lot of fake news, complicating the social and psychological problems of the audience/citizens, leading to fear, anxiety, and social insecurity. Many media were driven by the desire of material interests, especially the online portals, social networks, etc., offering fake or false news to the public for the sole purpose of their material gain. This study aims to research the Kosovar media's role and impact during the pandemic and quarantine time. For this research, we have used the online questionnaire (Google Form) during July and August 2020. The target group was the population over 15 (N=908) in Kosovo's entire territory. T-test, analysis of variance (ANOVA), and other methods were used to analyze the data. The study results show that 51% of Kosovar citizens informed about COVID-19 during the pandemic and quarantine had used social networks. More than 63.7% of citizens were heavily influenced and, on average, by fake news. Fake news and misinformation from the media in Kosovo society hurt specific society categories, especially those with lower levels of education and social and economic problems, causing fear, social anxiety, and social insecurity.

Keywords: media; role; impact; Kosovo; COVID 19; quarantine.

INTRODUCTION

The COVID-19 outbreak affects all segments of societies. It is particularly detrimental to members of those social groups in the most vulnerable situations, continues to affect institutions, including people living in poverty situations. In this situation, the role and impact of the media are at their peak. The media is considered to be the primary agent of socialization after family and school. The development of the media took place after the Second World War, especially with science, technology, and informatics. Today it is difficult to imagine life without media because of the role and influence they have in society on the one hand and the impact on social changes on the other hand. The media is considered a product of globalization. The manifestation of 'fake news' has caused the media through social networks and mostly fictitious portals to increase social anxiety and social insecurity and increase populism worldwide, thus threatening the democratic system. Many countries (Singapore, Russia, European countries), realizing the media's influence, have passed laws against fake news. With the outbreak of COVID-19, "misinformation in the public domain becomes an infodemic, i.e., a pandemic of incorrect information, posing great risks to global health. Misinformation, disinformation, and conspiracy theory claim that Coronavirus is a bio-weapon, a spy operation, a medico-business strategy, a population scheme, or a religious mission" [6]. Disinformation led to social disharmony, even inconsistencies with public health measures, the experience of political and social conflicts, discrimination, adverse psychological and social effects. This situation becomes even more difficult in times of pandemics.

As the number of COVID-19 cases increased, the public interest in the media to learn more about COVID-19 increased. The new COVID-19 seemed

very contagious and has quickly spread globally. As of April 03, 2020, there has been a minimum of 52,869 deaths, and quite 10.10.066 confirmed cases of this coronavirus pandemic. On September 13, 2020, demonstrated cases increased to 28 637 952 with deaths of 917 417 in 2016 countries" [23]. The COVID-19 situation and quarantine have further increased media-society interaction, leading the latter to a dependence on the media and especially on social media to obtain information about COVID-19. However, in such a situation, where fear, panic, and social anxiety are high and in such less emancipated, educated societies, fake news's effects come to the force more than anywhere else. In Kosovo, as in many other countries, the media "have played an important role in informing and raising public awareness regarding the global COVID-19 pandemic, safeguards, physical distance and everything else regarding COVID-19, but at the same time during this time, false news appeared which consequently led to fear, panic, anxiety and social insecurity and this whole situation have led to an increase in domestic violence in Kosovo". Such media built many conspiracies, which consequently had the citizen's distrust in the existence of COVID-19, making it even more difficult for institutions to deal with COVID-19. The aims of this study were (a) the most frequented media in the time of COVID-19 and quarantine, (b) the influence of citizens from the fake news regarding COVID-19, and (c) the media and public awareness regarding COVID-19- 19 and the interrelationship of several variables to impacts.

Literature review

The 21st century is considered to be the era of globalization and post-modernity, a century in which man, as a social-biological being, has almost reached the highest pedestals in its development. Undoubtedly, the development of science and technology has given its results, especially the invention of the 'magic wand' has made the world communicate from one end to the other. For sociologists, the media are socialization agencies that have, among other things, the educational role of citizens. On the other hand, they can have negative impacts that can produce deconstructive situations and cause a breach society's balance. According to Francis Bacon, the media is considered the fourth power; after the legislative, executive, and judicial branches. Whereas, according to Noam Chomsky, there are two theories, "which support the media's fundamental role. He considers the first role based on the traditional (Jefferson) model, which implies the media apparatus as a balance of power apparatus. According to this model, the media in its contents creates a balance not only informative but also cultural. The second role of the media is based on the propaganda model, with which the government and the journalist are seen as 'servants and supporters of the power structures" [3]. Louis Althusser has grouped the media with the family, the church, and the education system under the heading of 'ideological state apparatuses' [2]. Today, several theories talk about their relationship with society. Another view commonly used by the media is symbolic interaction, which asserts "that the self is derived from and develops through human interaction. This means the way you act toward someone or something is based on its meaning for a person or thing. To communicate effectively, people use symbols with shared cultural meanings. Symbols can be constructed from just about anything, including material goods, education, or even how people talk. Consequentially, these symbols are instrumental in the development of the self" [15]. This concludes that media power is high enough to create symbols in itself, which was evident in COVID-19 and quarantine. With this theory's help, researchers can look at how the media influences society's familiar characters and, in turn, the impact of these symbols on society. While, according to media dependency theory, "during a severe social disruption, there is an unusually high need for information and sense-making by individuals and the mass media are generally perceived to satisfy these needs best. Specifically, the public relied heavily on the media to obtain information regarding operationalized guidance to the public, the response of organizations, and exchanging views with others. One of the reasons people usually need more information in crisis events is to reduce the anxiety caused by uncertainty in the crisis event. Research showed that uncertainty and uncontrollable feelings in the H1N1 epidemic were positively related to stress and anxiety. Therefore, people actively engage in information-seeking from a variety of sources to reduce uncertainty in a crisis event to ease their anxious feelings" [14]. As well, "many studies have found that media exposure during critical public events may further cause psychological trauma and anxiety, indicating that the media's vicarious traumatization effect may play an important role. After the 9/11 attack, people exposed to more

television images of people falling or jumping to their death reported a higher posttraumatic stress disorder (PTSD). Thompson and colleagues also argued that media exposure to mass violent events could fuel a cycle of distress" [14]. Such a situation has occurred with the global COVID-19 pandemic and quarantine situation. In Kosovo's case, interest in the media during the pandemic increased, and "Numerous and different disinformation has been spread since the Coronavirus was first reported, mainly on social media. In Kosovo, social media such as Facebook is one of the main sources of information and, at the same time as a source of disinformation. Citizens have been exposed to a wealth of misinformation that has above all caused panic among citizens and, as a result of citizens' tendency to disseminate any information they read, unverified and often false, they have penetrated an even wider public" [7].

METHODS

In the study participated a total of 908 respondents (N = 908). The study was conducted from July to August 2020 (July 27 – August 23, 2020). The participants in the survey are resident citizens of Kosovo, adults (over 15 years old). Among them, about 68% of women and 32% were men. Regarding the age-groups involved in the study, it varies from 15 to 79 years old. Age-group 15 – 20 years is represented by 7% of respondents, 21 – 30 years is represented by 34%, 31 – 40 years is represented by 36%, 41 – 50% is represented by 16%, the group – age 51 – 60 years is represented by 5% and the age group over 61 is represented by 2% of the total number of respondents. The respondents' average age (male and female) was 39 years (SD = 8.9). The respondents' education level was: with primary education 1.1%, secondary education 18.2%, and higher education (bachelor, master, and Ph.D.) 80.7%, with an average of 15.1 (SD = 3.3). 30% from rural areas and 70% of urban regions participated in the study. Of the respondents, 60% lived at home while, 40% lived in the apartment. Of the total number of respondents included in the survey, 12% were infected with COVID-19. Before starting to complete the questionnaire, respondents had information and instructions for completing the instrument.

Table 1 – Descriptive analysis of study respondents

Number of respondents, total – 908	%
Gender	Male 32 Female 68
Age group	15 – 20, 7 21 – 30, 34 31 – 40, 36 41 – 50, 16 51 – 60, 5 Over 61, 2
Education level	Primary school 1.1 Secondary school 18.2 University studies (Bch., MSc. Ph.D.) 13
Rural-Urban	Rural 30 Urban 70
Residential	Home 60 Flat 40

The study was comprehensive and with a representative sample. Based on the sample number (N=908), the inclusion, and the representative sample, we can conclude.

The authors designed the instrument, and was implemented online (Google Form), distributed to the respondents electronically via the Internet and social media. The questionnaire consists of three sections. At the beginning, where the demographic and social questions; how much do the citizens know about global endemics and pandemics (COVID-19) and civic trust in the media in Kosovo. The last section was questioned about media attendance, media and awareness, and the impact of fake news. Participants were asked to rate each question on a Likert scale: (4) a lot, (3) average, (2) a little, and (1) not at all. The questionnaire was standardized and enabled conclusions drawn regarding the media's role and influence in pandemic times. The statistical package used in this study was SPSS Version 20.0.

RESULTS AND DISCUSSION

Since the appearance of COVID-19 in Wuhan, the capital of Hubei province in China, in December 2019, the media all around the world reported on a new, invisible, and unknown enemy. In addition to this situation, we were exposed to false news and disinformation, spread mainly through social media (social networks), which have become a global trend. The International Telecommunication Union's latest report revealed that 53.6% of

the worldwide population, or 4.1 billion people, uses the Internet till the end of 2019" [9].

This implies that all are using the Internet. In fact, "according to a survey, there is 87% of the increase in social media usage during lockdown" [18] worldwide. Therefore, the media are the primary source of public information during the global pandemic. However, there was also 'fake news,' which negatively affected society worldwide, spreading fear and panic among the citizens. This spread of terror and misinformation about COVID-19 is otherwise known as *'Misinfodemics'*. According to the UNESCO report on 'Journalism, Freedom of the Press and COVID-19', in terms of timely information and misinformation of the pandemic, such as:

a) Based on a machine learning analysis of 112 million public social media posts, in 64 languages, related to the COVID-19 pandemic, researchers at the Bruno Kessler Foundation found 40% of posts came from unreliable sources,

b) Another study using machine learning techniques, by the Foundation's COVID-19 Infodemic Observatory, found that bots produced almost 42% of over 178 million tweets related to COVID-19, and 40% were "unreliable",

c) Roughly 1/3 of social media users have reported seeing false or misleading information about the Coronavirus, says a study by the Reuters Institute in six countries. Research by Pew suggests that people who receive their news primarily through social media are more likely to be exposed to false content,

d) In March, about 40 million problematic posts related to COVID-19 on Facebook were identified (and had warnings placed next to them), according to the company. "Hundreds of thousands of pieces of misinformation about the virus that could lead to imminent physical harm" were also removed, it added,

e) Approximately 19 million out of nearly 50 million (38%) tweets related to COVD-19 analyzed using artificial intelligence by Blackbird.AI were deemed to be "manipulated content",

f) Newsguard identified 191 websites in Europe and North America that have published false information about the virus,

g) The Coronavirus Facts Alliance has discovered – and disproved – more than 3,500 false or misleading pieces of information, in more than 70 countries and more than 40 languages" [21].

During the quarantine period, the only source of information for the citizens was the media. According to these data, part of the story was not knowledge but disinformation, which caused psychological and social confusion. The Coronavirus outbreak has also produced several conspiracy theories, which have been readily accepted by various social groups. The invention of the vaccine by the Bill Gates Foundation, the origin of COVID-19 as a product from China, and the placement of 5G antennas are just some of the conspiracies that have circulated the world. Even "in Britain, dozens of 5G mobile phone towers have been set on fire; police say many of the attacks were motivated by a false belief that this technology is linked to the coronavirus pandemic.

Several studies conducted by (Kings) College in London and the survey company IPSOS MORI, show a strong link between the belief in such conspiracy theories and reliance on social media as a source of information, including Facebook, YouTube, Twitter, and WhatsApp. These groups of people prefer to avoid television or print media. Among those who believe that the Coronavirus does not exist at all, about 56% cited Facebook as their primary source of news – information. "Facebook, Twitter, and YouTube say they have removed hundreds of thousands of videos and posts containing disinformation about COVID-19 with immediate harmful consequences" [22].

Such conspiracies have been circulating almost all the time in Kosovo, taking into account the fact of high use of the Internet by Kosovars where, "in 2017 the percentage of households that had Internet access was 88.8% while in 2018 it increased by 4.4 % compared to 2017 wherein 2018 it reached 93.2% while in 2019 no changes were observed in the percentage of households accessing the Internet at home, from any device, while in households that did not have Internet access in houses, from any equipment, compared to 2018 there was a decrease of 0.55%" [1].

In Kosovo's context, during the last decade, they have made a 'revolution' in themselves, especially after the Internet's massification, which has already become a need not only of the media but also the general public. This is due to its use by the new generations, which in sociological language are also known as the "generation of globalization" [11]. This massification of information technology has made the media, primarily through virtual platforms, increase. According to the Independent Media Commission, in 2018, Kosovo has

20 television stations, 83 radio stations, 61 program service providers, and 38 distribution operators. There are five daily newspapers in Kosovo, while the number of online media remains unknown" [4]; these media are increasing day by day. But what were the most frequented media by the citizens during the quarantine?! From the findings of the study, we understand that the most frequented media for March to August 2020 by Kosovars are: social networks (51%), television (33.3%), portals (14.1%), press (1.5%), and radio (0.1%)

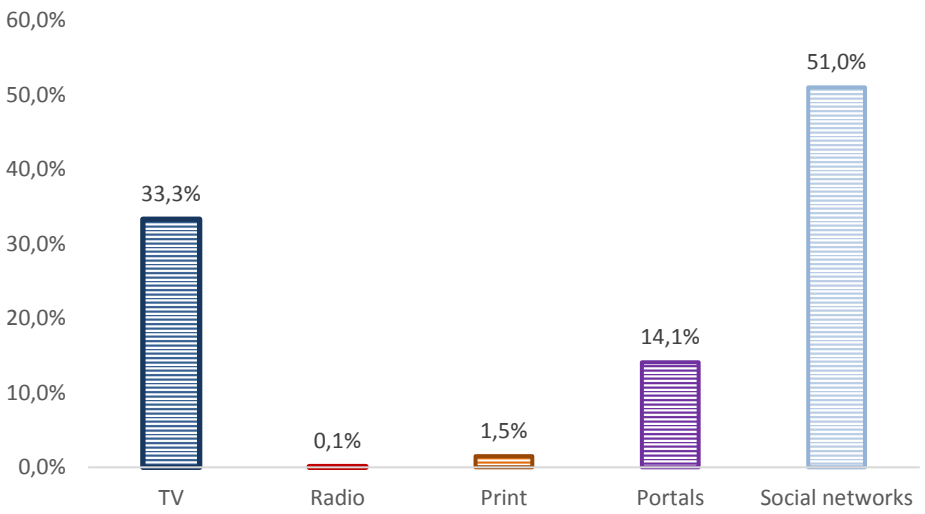

Figure 1 – Attendance/frequent of media during the pandemic COVID-19

The fact that social networks are more frequented and unconfirmed data or information is placed in them makes the situation more difficult to manage and creates confusion and insecurity among people. During the period between March and August 2020, according to the site 'Google Trends', Kosovars have requested the most information for three keywords, such as Coronavirus, COVID-19 and Virus, while, according to cities such as: "in the city of Gjakova the word the most requested key is (86%) coronavirus, COVID-19 (10%) and Virus (4%), in the city of Peja with 82% was the word coronavirus, 15% COVID-19 and Virus 3%, in Prizren 81% the word coronavirus, 15% COVID-19 and 4% Virus, as well as in Prishtina 80% coronavirus, 17% COVID-19 and Virus 3" (Google-Trends, 2020). This shows that citizens during Covid-19 and quarantine were very active in seeking information in the media about the situation of COVID-19. "The interest of citizens in scientific research on the words virus, COVID-19 and coronavirus come as a result of the lack of information on global epidemics and pandemics (COVID-19) by citizens and for 61.2% of citizens (N=908) had believed" Few "or" did not "believe that such a pandemic (COVID-19) could occur in Kosovo.

Citizen awareness and fake news in Kosovo

The COVID-19 has continuously been reported in the media. In this regard, the media have played an essential role in informing the situation, keeping the public updated, but there has been a massive presence of fake news during this time. Since the pandemic outbreak, over 1500 phoney information has been distributed all over Kosovo [13], and this number may already be much higher in reality. Some of the headlines that have been reported by social media or in portals are:

"The Coronavirus is an alternative biological weapon deployed by China, the US, the United Kingdom or even Russia (to destroy the EU and NATO), the Coronavirus did not explode in Wuhan, China – the US is hiding its true origin, which is American laboratories or US property worldwide. Migrants cause the spread and migrants landing in the EU, Coronavirus is linked to 5G (e.g., Wuhan as a 5G testing ground), EU has failed to address the crisis – the EU is a disaster for Europe, The EU is not ready to provide urgent support to Member States – on the contrary, they should rely on external support (example Italy), with China most often cited as the source of such assistance, China is coming to save EU as Brussels abandons EU member states, Schengen no longer exists – Europeans are quarantined. Still, migrants can move freely; Coronavirus

is a joke, it does not exist, the EU can impose mass vaccinations, Kura: claims that natural remedies exist to cure the virus, which is often combined with anti-vaccine stories, Various conspiracy theories: historical predictions about the pandemic, the plagues that hit the planet, the secret "Deep State" efforts to control population growth, the pandemic caused by chemical weapons or leading to World War III" [12].

Fake news has created confusion among people and increased their distrust in the public and government institutions. We found a significant correlation between fake news and social insecurity (N=908)= .001 for both groups (male and female). Often fake news is used as a means for material gain. Even though there is a legal framework in Kosovo that regulates such an issue, however, during the pandemic, there is no report on the single case when someone was interrogated, investigated, or arrested for any fake news. Realizing the consequences of fake news in our society, a group of young people in Pristina has recently created a platform, "No Fake News," which aims to combat false (fake) and no real news. To understand how much the fake news during the pandemic (quarantine) has affected the Kosovar society, the study focuses on the respondents' direct question: How much did the fake news from the media influenced during the pandemic time? We found that fake news and the media, in general, have had a high impact on citizen's lives.

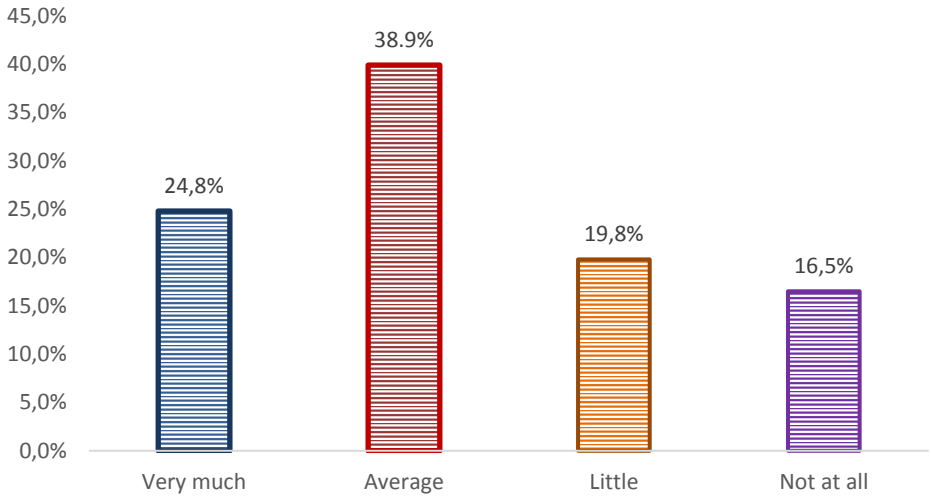

Figure 2 – Impact of fake news on the citizens

The results show that 24.8% of citizens were affected by fake news, 38.9% were moderately affected, 19.8% were slightly affected, and 16.5% were not affected. Overall, more than two-thirds of citizens are affected by fake news in pandemic times. Fake news mostly affects citizens with a low education level (91% primary school) and high school (67%). There is a significant relationship p (N=908) = .0001 between the low level of education of the citizens involved in the study and the impact of fake news. As we mentioned above, the media plays a vital role in raising public awareness. Social isolation during the COVID-19 pandemic (quarantine) for 75.1% of respondents was "very" and "moderately" stressful. In such a situation, the media plays an essential role in overcoming this situation and raising public awareness of COVID-19. Our findings show that in 43.3% of citizens, the media had a massive impact on cognition. In 39.9% of citizens, the media had a moderate effect. For 9.5% of citizens, the impact of the media on awareness of COVID-19 was small.

Whereas, about 7.3% of the citizens in Kosovo, the media in pandemic times did not positively affect awareness of COVID-19. Based on our study's findings, we understand that the media have an essential role in raising citizens' attention to face social and other causes, such as COVID-19.

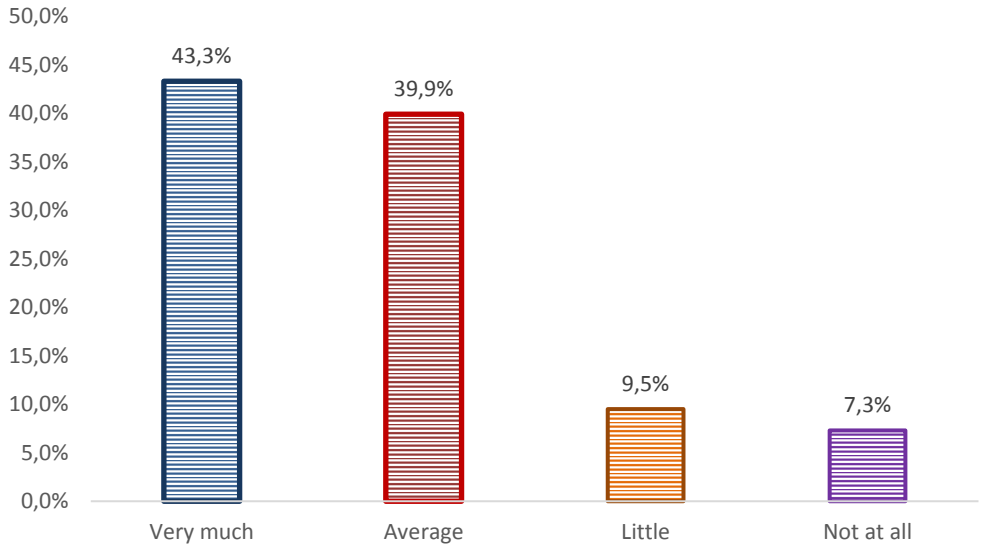

Figure 3 – The impact of the media on citizens' awareness of COVID 19

Psychological and social effects of fake news

We are witnesses of "the growing popularity of digital information platforms and the sharp decline in newspaper circulation, and network news ratings have led many scholars to speculate that new media would eventually replace traditional sources of news and information" [9]. In this regard, the role of the media in society is enormous. On the one hand, they inform the public and are the first channels of information. On the other hand, through reporting, the media can reveal irreparable consequences for society and specific social categories. In the case of the global pandemic, as a result of media reports, contemporary society is even more immersed in psychological confusion. The studies show that "within days of onset of the COVID-19 outbreak in China, the 'social media panic' characterized by a relentless plethora of fake information as well as negatively skewed misinformation metastasized faster than the Coronavirus itself. The director-general of WHO has referred to this to "coronavirus infodemic" which is breeding fright and panic by laying out rampant mind-boggling rumours, flamboyant news propaganda, and sensationalism" [5]. Such news has caused many confusions in society, caused stress, social anxiety, and social insecurity, and this led to the depression. In fact, this "these invite several overwhelming mental burdens in the form of anxiety, phobia, panic spells, depression, obsession, irritability, delusions of having symptoms similar to COVID-19 and other paranoid ideas. Healthcare seekers are too much perplexed, catastrophized, and morbidly worried about COVID-19 symptoms that the normal running of healthcare systems may get disrupted to address the mass anxiety owing to massive disinformation" [19]. The pandemic situation of COVID-19 for the citizens of Kosovo has caused fear (60.9%), panic (45.7%), anxiety (34.8%), and social insecurity (76.3%). This situation has had negative consequences, among them have caused panic and insecurity among citizens. For example, US citizens have had a problem with toilet paper because there was a lack of them; in the Netherlands, this is manifested by the lack of marijuana. In this country, marijuana is legal.

In contrast, in the Western Balkans, including Kosovo, this form of panic is manifested by a lack of essential foods. Other consequences that this misinformation has caused are the use of various medications to reflect on people's mental health, even leading to suicide due to lack of social stability. Do other studies talk about why infodemics can make the pandemic worse? Listing some reasons, such as

a) makes it hard for people, decision-makers, and health workers to find trustworthy sources and reliable guidance when they need it. Seeds may be apps, scientific organizations, websites, blogs, "influencers," and more,

b) People may feel anxiety, depression, overwhelmed, emotionally drained, and unable to meet essential demands,

c) It can affect decision-making processes when immediate answers are expected and not enough time is allotted to analyze the evidence deeply,

d) No quality control on what's published, and sometimes, on what's used to take action and make decisions,

e) Anybody can write or publish anything on the web (podcasts, articles, etc.), in particular on social media channels (individual and institutional accounts)" [17].

There is also a connection with the theory of Dyrkem, who claims that social connection is a critical factor in emotional health and social stability, which shows a correlation between misinformation, social strength, and social relationships. Therefore, it is evident that misinformation has caused various phobias, anxiety, depression, psychosis, and neurosis in psychological terms. In the social aspect, they have raised the great fear in the society of what the future will produce.

CONCLUSION

Based on the findings, analysis, and comparison of data taken from this survey, we conclude that the media had a huge impact and role in informing and raising awareness of citizens in the global pandemic situation (COVID-19). The media had an enormous impact on informing the citizens about the extent of the Coronavirus spread. The relevant institutions take the steps and measures to prevent the further spread of COVID-19, the quarantine situation, and all other issues related to the COVID-19 pandemic. False news hurts society, especially on different categories of society. A lower level of education, young age group, and the elderly have caused psychological confusion and produces fear, social anxiety, panic, and social insecurity. Fake news (38.9%) and misinformation have affected the health of citizens. Fake news has also hurt public awareness. The most common false information comes in the form of conspiracy theories such as COVID-19 does not exist, it has interconnection with 5G antennas, this is a war of great powers (US, Russia, China), and the great forces invented the Coronavirus. Fake news is a challenge for Kosovar society and severe media in the country. As in many countries worldwide, in Kosovo, the media, in most cases, through misinformation, have produced adverse effects because people tend to believe and share information, especially when the pressure on them is high. Therefore, these effects have also influenced the increase in domestic violence in Kosovo.

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COVID-19 and Quarantine: Indicators of Domestic Violence in Kosovo

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Abstract. Like many other countries in the world, Kosovo has faced a severe public health situation as a result of COVID-19. Kosovar society has been quarantined to protect it from the spread of COVID-19. Putting the community into quarantine has had a positive effect on stopping the spread of COVID-19; however, it has harmed domestic violence in Kosovar society, increasing the number of cases. This study aims to show the extent of violence and the causes of domestic violence in Kosovar society. The survey results show that domestic violence in Kosovo has increased (by 19.75 %) during the COVID-19 pandemic compared with the same months in the previous year (2019). The leading causes of domestic violence are stress (18.9 %), socio-economic insecurity (11.4 %), and a lack of physical space in the house/apartment (4.4 %).

Keywords: COVID-19; quarantine; violence; family; causes; Kosovo.

INTRODUCTION

The global society during 2020 has faced the unusual phenomenon of COVID-19. The spread of COVID-19 in Wuhan, China, in late 2019 seemed a priori to be the localized disease. Still, it spread rapidly in early 2020 to many parts of the world, alerting contemporary society that it faces an invisible, unknown enemy that will produce unforeseen consequences. Epidemics and pandemics have accompanied humanity throughout the developmental stages to the present day.

According to the World Health Organization (WHO), a pandemic is spreading a new disease across the world. A pandemic occurs when an epidemic spread between countries; in the case of COVID-19 specifically, the WHO claimed that it is the first pandemic caused by a coronavirus [1]. Also, "a pandemic is the highest possible level of disease or a measure of how many people have contracted a particular disease and how widespread it is. However, before a common disease can reach pandemic proportions, it must overcome several other levels, which according to the Centers for Disease Control and Prevention (CDC) are: sporadic, endemic, epidemic and pandemic" [1].

Pandemics have appeared and taken the lives of millions of people, changed the histories and geographies of many early civilizations, and occurred from time to time to the present day. Despite warnings from health experts about the possible spread of COVID-19, few countries believed that such a SARS could reach developed countries like those in Europe. On the one hand, this left many European countries unprepared to deal with such a pandemic; on the other hand, society and institutions ignoring this SARS resulted in many cases of infection and fatalities.

In Kosovo, the first cases of COVID-19 were identified in March 2020. Immediately after the identification of COVID-19 issues, Kosovo institutions put in place measures to prevent it from spreading, leading to the halting of teaching in school institutions and working (apart from essential staff) in the public and private sector, the closure of the hospitality industry, the stopping of other

cultural, sports, and political activities and quarantine. During this period, the spread of COVID-19 cases was under institutional control and management; however, other social problems emerged in families and Kosovar society at this stage. The emergence of domestic violence was one of the social issues that the Kosovar organization was facing, and it was continually growing.

Domestic violence is a universal phenomenon to which individuals of all ages and genders are exposed in all communities and cultures. The social infrastructure of violence is also robust to the point of violent behaviour being accepted within a society because the community's culture in which an individual life reveals expectations regarding how he or she will behave, think, or act [6]. According to the World Health Organization, violence as "the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community, which either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment, or deprivation [9]". In 1993, the United Nations General Assembly designated violence against women as an act of gender-based violence that results in or is likely to cause physical, sexual, or mental harm or suffering to women, including threats of such acts, coercion, or arbitrary deprivation of liberty, whether occurring in public or private life [8]. Studies have shown that violence against women and children increases with alcohol and drug use, mental health issues, and inadequate housing [5, 3].

Within months, the local epidemic became a global pandemic that forced governments worldwide to demand social distancing and, ultimately, quarantine [4]. Quarantining the society has increased the number of cases of domestic violence. In quarantine, life has become more difficult for many Kosovar families because they face social-economic insecurity, stress, anxiety, and violent family members, who make their lives as dangerous as the pandemic itself.

This study aims to analyze, compare, and reflect on the dynamics of the increase in domestic violence in general and the causes of domestic violence in Kosovar society in a time of quarantine (COVID-19). The study does not focus on a particular type of domestic violence because this is not the task's interest; it concentrates more on the presence of domestic violence during quarantine and the issues that lead to domestic violence in Kosovo.

Statistics of domestic violence in Kosovo

Recent studies have shown an increase in the number of domestic violence cases in many parts of the world. India, Canada, and the UK have witnessed a surge in violence against women, especially domestic violence, in the context of the COVID-19 pandemic lockdown [2]. According to the most recent update, in India, in the first four phases of lockdown (between March 25 and May 31, 2020), 1,477 complaints of domestic violence were made by women. This 68-day period recorded more complaints than those received between March and May in the previous ten years. However, reports have indicated that this alarming rise is just the tip of the iceberg as 86 % of women who experience domestic violence do not usually seek help in India [2]. There is a similar situation in Canada. The federal government stated that there had been a 20 to 30 % increase in gender-based violence. The police in Toronto reported that domestic incidents have increased by between 18 and 22 %. The Native Women's Association of Canada conducted a nationwide, grassroots consultation and found that one in five indigenous women had been a victim of violence over the previous three months of the pandemic. Indigenous women reported being more concerned about domestic violence risks than those of COVID-19 [2].

In the UK, in the first four weeks of the lockdown, the number of domestic killings doubled – 13 women and four children. London's Metropolitan Force reported that calls about domestic abuse had risen by about a third. Its officers were making around 100 arrests a day for such offences in the six weeks of the lockdown leading up to April 19; more than 4,000 arrests were made across London. West Yorkshire Police reported that, during the lockdown period between March 17 and April 19, it had responded to 6,704 domestic abuse calls – a rise of 1.2 % compared with the previous month [2].

At the time when Kosovo entered quarantine, the number of cases of domestic violence increased. From March to June 2020, 691 cases of domestic violence were registered with the Kosovo Police. Compared with the same period in the previous year (2019), the number of domestic violence cases increased by 19.75 %. Domestic violence has affected all age groups, but, unlike last year, there has been an increase in the number of violence cases among children and young people (0–18 years old) and age groups over 71 years old.

The fact that domestic violence has increased among children and the elderly remains a matter of concern. Cases of violence against children have increased by about 276.9 %, and these statistics show an alarming situation in Kosovar society. See the chart below.

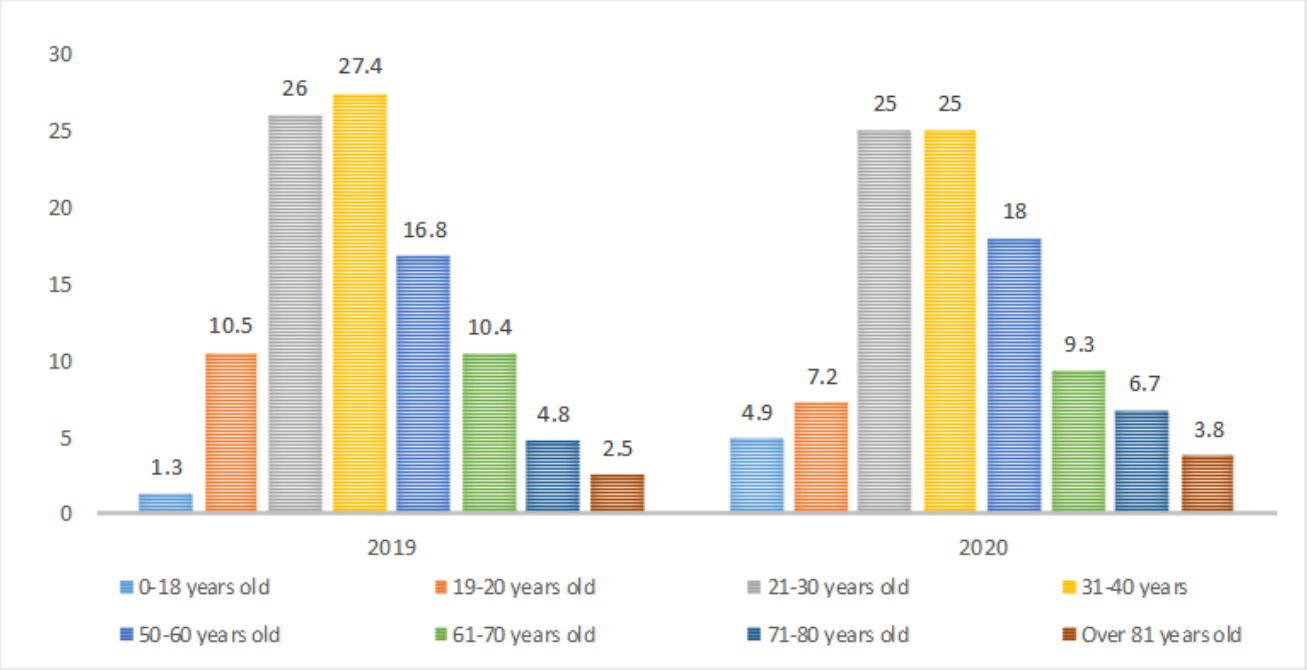

Figure 1 – Cases of domestic violence in Kosovo by age group (in percentages), from March to June 2019 and 2020

Source: Kosovo Police (data were received in an email dated August 20, 2020)

The statistics show that domestic violence has mainly affected women. In 2019 (March to June), 80.5 % of violence cases were registered with the Kosovo Police by women, while, in the same period in 2020, 73.6 % were recorded by women, showing a slight decrease (6.9 %). The statistics indicate that, during the quarantine period, there was an increase in the number of cases of domestic violence among men (from 19.5 % in 2019 to 26.4 % in 2020 or an increase of about 7 %).

Of the total number of domestic violence cases in Kosovo, during the pandemic (March to June 2020), 42 % of violence cases occurred between spouses, and 28.1 % of patients were between parents and children; other issues involved brothers and sisters and other family members. Cases of domestic violence have affected all structures of society and have occurred throughout the country. The Pristina region leads with the largest number of cases, followed by Ferizaj and other areas.

METHODS

A total of 908 respondents participated in the study, which was conducted from July 27 to August 23, 2020. The survey participants are resident citizens of Kosovo and adults (over 15 years old); 68 % are women, and 32 % are men. Regarding the respondents' age included in the study, it varies from 15 to 79 years old. The age group of 15–20 years is represented by 7 % of participants, that of 21–30 years is represented by 34 %, that of 31–40 years is represented by 36 %, that of 41–50 years is represented by 16 %, that of 51–60 years is represented by 5 %, and the age group over 61 is represented by 2 %. The mean age of the respondents (male and female) is 39 years (SD=8.9).

The respondents' level of qualifications is the following: primary education: 1.1 %; secondary education: 18.2 %; and higher education (necessary studies, master's, and Ph.D.): 80.7 %. The average is 15.1 (SD=3.3). Of the survey participants, 30 % are from rural areas, and 70 % are from urban areas. Furthermore, 60 % live in a house, while 40 % live in an apartment. Of the total number of

respondents included in the study, 12 % have been infected with COVID-19. Before starting to complete the questionnaire, the respondents received information and instructions for completing the instrument.

Table 1 – Descriptive analysis of study respondents

Number of respondents, total – 908	%
Gender	Male 32 Female 68
Age group	15 – 20, 7 21 – 30, 34 31 – 40, 36 41 – 50, 16 51 – 60, 5 Over 61, 2
Education level	Primary school 1.1 Secondary school 18.2 University studies (Bch., MSc. Ph.D.) 13
Rural-Urban	Rural 30 Urban 70
Residential	Home 60 Flat 40

The study was comprehensive and was conducted with a representative sample. Based on the sample number (N=908) and the inclusion, we can reach conclusions.

The authors designed the instrument and implemented online (Google Form), distributed via the Internet and social media. The participants were asked to rate each question on a Likert scale – (4) a lot, (3) average, (2) little, and (1) not at all – and in some cases to select one of the given solutions. At the end of the instrument, open space was left where the respondents could express their free opinion. This part helped us considerably in understanding the respondents' thoughts and experiences. According to Cronbach's alpha score, we have good questionnaire reliability, with 820. The statistical package used in this study was SPSS Version 20.0.

RESULTS AND DISCUSSIONS

Many social topics related to epidemics and global pandemics have been discussed, and one of those topics has undoubtedly been domestic violence. Domestic violence has had an important place since it has been influenced by the pandemic's new situation (COVID-19). Citizens were not prepared for the changes in the way of life resulting from the pandemic and had difficulty accepting these social changes, leading to increased domestic violence cases.

Of course, this situation has brought many unknowns to society. To understand more about society's awareness of global epidemics and pandemics and their discipline in facing the constraints that prevent the spread of COVID-19, the study starts with a specific question: do you know about global epidemics and pandemics? In those countries where there was a lack of awareness and discipline of citizens and in those societies that did not act in time to prevent the spread of COVID-19 or ignored this need, COVID-19 spread rapidly, and consequently; there were many cases of infection and fatalities (Italy, etc.). The study's findings show that 24 % of citizens in Kosovo have basic knowledge about global epidemics and pandemics, 64.1 % of citizens have the average ability, and about 12 % of citizens have little or no understanding of global epidemics and pandemics.

The study results show a high average level of knowledge about global epidemics and pandemics among citizens; however, this highlights the fact that most of the survey participants are highly educated, and it is natural to some extent for the results to be above average. The results show that 12 % of citizens have little or no knowledge of global epidemics and pandemics. Between those who have no understanding of global epidemics and pandemics and those who do not believe in the existence of COVID-19, there is a significant positive correlation: $r = .267^{**}$, $p < 0.01$. Of the total number of study participants (N=908), 11.9 % do not believe in or do not have an attitude toward the existence of COVID-19. Citizens' doubt about COVID-19 makes it more difficult for public institutions to work since this category of society follows the guidelines of institutions aimed at preventing the spread of COVID-19 only partially or not at all and thus has a direct impact on the space of COVID-19 to society.

About two-thirds of citizens before the COVID-19 pandemic did not believe that a pandemic (COVID-19) could occur in Kosovo. Citizens associated the disbelief that COVID-19 could not arise in Kosovo because it is part of Europe. This is the 21st century, when science, medicine, and technology have evolved so much that they can prevent global pandemics like COVID-19. According

to them, pandemics like COVID-19 can occur in the poorest countries but not on the European continent. The appearance of the first cases in Europe (Italy) and later in Kosovo (March 2020) led Kosovar institutions to take preventive measures to maintain public health by imposing restrictions on travelling to and from work, closing schools, maintaining personal hygiene and physical and social distance, and putting the country into quarantine. Quarantining, the government changed the course of ordinary life, and society is facing many unknowns in the social, economic, and political fields and the central area of public health. Circumstances like these have caused fear, social anxiety, and stress among citizens. The study results show that the quarantine (blocking) has been very stressful for Kosovar society.

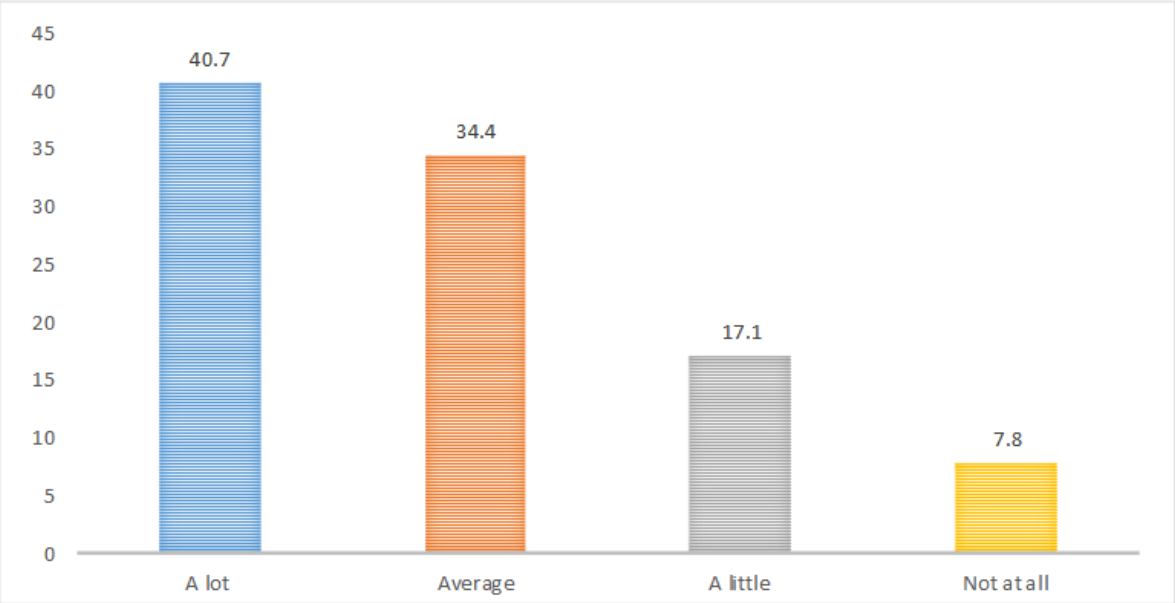

Figure 2 – Has social isolation (quarantine) been stressful for you?

The study results show that, for 41 % of citizens, the period of social isolation (quarantine) was very stressful. For 34 %, it was moderate, and for about 25 % of citizens, it was a little or not at all stressful. Stressful situations cause fear, panic, social anxiety, and depression and affect domestic violence manifestation. However, to the extent that domestic violence was present during the pandemic in Kosovar society, the study results show that 42 % of the study participants during the quarantine period experienced domestic violence (conflicts) in the family.

For 4.1 % of the study participants, domestic violence (conflicts) was very present. In contrast, for 8.9 % of the study participants, there were average family conflicts, 29.1 % had few cases of domestic violence (clashes), and for 58 % of the participants, the results of the study show that there was no domestic violence (conflicts) in the family during the quarantine period. Thus, the results show that more than 40 % of the study participants experienced domestic violence (matches) in Kosovo during the quarantine. Based on the study's findings and the statistics of the Kosovo Police on domestic violence in Kosovo, we find that domestic violence is present at a high rate and, compared with last year's statistics for the same period, it has increased (19.75 %).

The causes of domestic violence are different and vary in time and space. They also change as a result of the new social circles in society. The study results show that stress is among the leading causes of domestic violence in Kosovo (18.9 %).

Stress is one of the main issues that led to domestic violence in Kosovar society during the quarantine. Many citizens, facing high unemployment rates, poverty, and economic instability on the one hand and COVID-19 on the other, have experienced stress. Stress (18.9 %), financial insecurity (8.5 %), a lack of physical space (4.4 %), the division of duties and responsibilities among family members (4.4 %), and other problems are the main issues that have led to domestic violence in Kosovo.

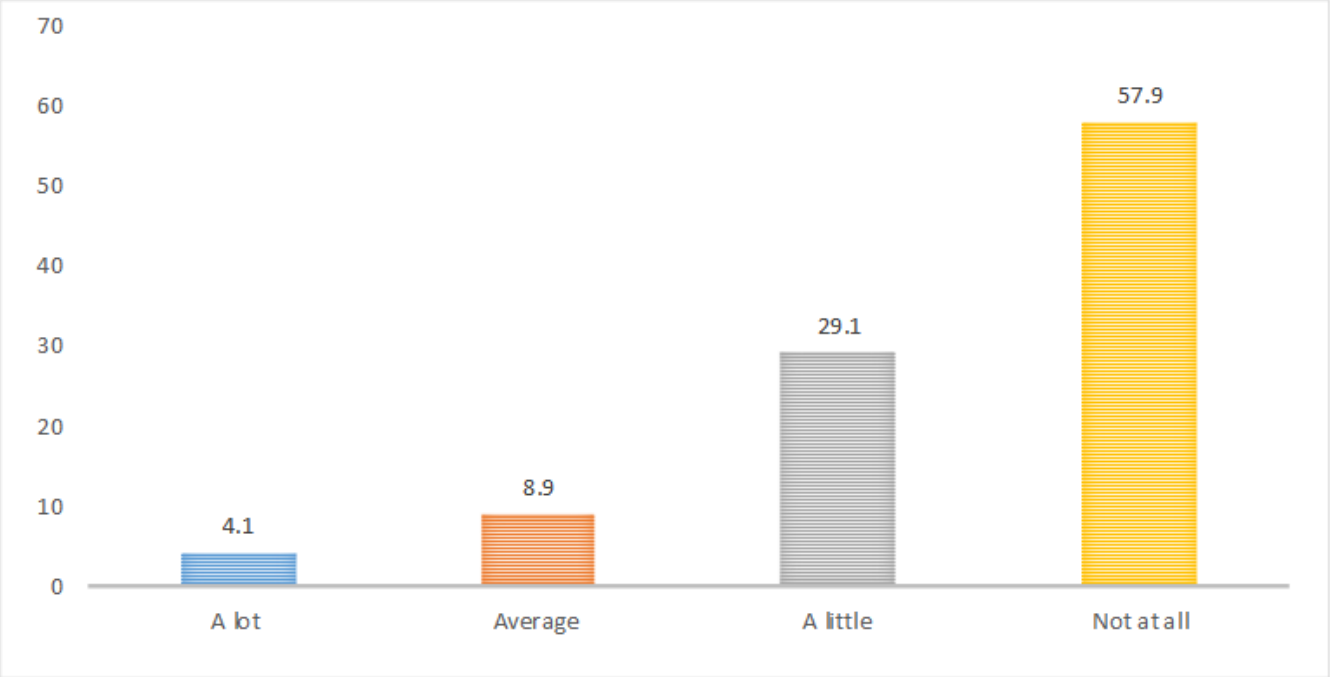

Figure 3 – Were there any cases of domestic violence in your family during quarantine (Covid-19)?

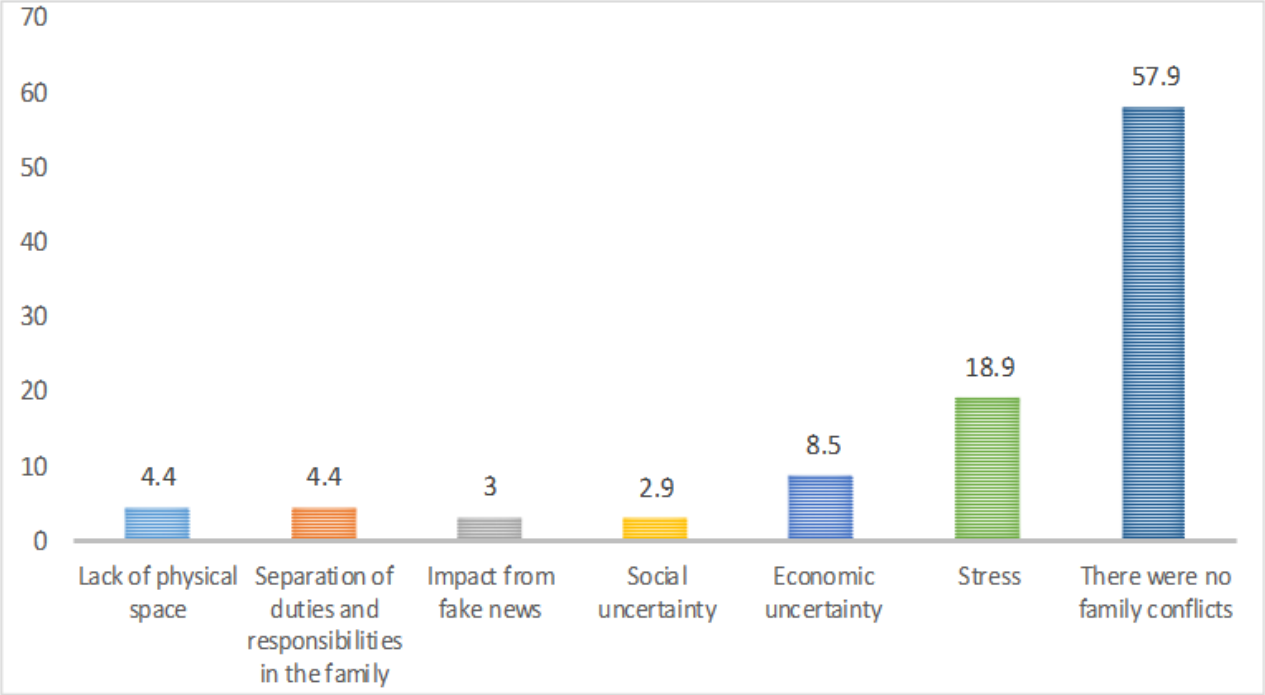

Figure 4 – What were the leading causes that led to domestic violence (conflicts)?

Quarantine has introduced many unknowns into the Kosovar society, leading to stress, socio-economic insecurity, and a lack of separation of duties and responsibilities in the family. All these have led to domestic violence.

CONCLUSIONS

Domestic violence is not new; it has accompanied society through all the stages of its development. In many conservative institutions and the Kosovar community, topics such as domestic violence have been taboo. However, with the increase in the level of education and social emancipation in

general and the liberation of women in particular, domestic violence is being discussed more and more, and cases of domestic violence are increasingly being denounced in the relevant institutions.

Domestic violence in Kosovo increased (by 19.75 %) during quarantine (COVID-19) compared with the same months (March to June) of last year (2019). Domestic violence has affected all social structures; however, it has mainly affected people aged 20 and 40 and women. Domestic violence against women during the quarantine period marked a slight decrease compared with the same months last year. Otherwise, the number of domestic violence cases during the time of quarantine has increased among men (male victims). Based on the study results, every third interviewee in Kosovo experienced domestic violence during quarantine (COVID-19).

The causes of domestic violence in Kosovar society are many and varied. Increased stress, socioeconomic insecurity, the division of duties and responsibilities among family members, and the lack of physical space (housing) are the main issues that have led to domestic violence in Kosovo.

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Виробничі впровадження перманганату натрію (Carusol) для покращення якості питної води на очисних спорудах комунального підприємства «Житомирводоканал»

Production Implementation of Sodium Permanganate (Carusol) for Improving the Quality of Drinking Water at the Treatment Facilities of the "Zhytomyrvodokanal" Utility Company

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Анотація. В статті представлені результати досліджень, які були отримані в процесі виробничого впровадження нового реагенту – окисника перманганату натрію (торгова марка *Carusol*) в технологію водопідготовки на очисних спорудах водопроводу КП «Житомирводоканал». Метою даної роботи було визначити ефективність видалення із складу водопровідної води таких забруднюючих речовин, як окиснюваність перманганатна, марганець, фітопланктон, а особливо, хлороформ та покращення її якості за органолептичними показниками. Даний експеримент був проведений в літній час для визначення технологічної та екологічної ефективності використання реагенту при високих температурах води, оскільки саме в літній час джерело водопостачання м. Житомира характеризується підвищеним рівнем органічного забруднення, що спричиняє утворення понаднормативних концентрацій хлороформу, наявністю високих концентрацій марганцю та фітопланктону. Виробничий експеримент показав, що ефективність очищення води реагентом *Carusol* в теплий період року при підвищених температурах води за показником кольоровості достатньо висока; за показником окиснюваності перманганатної має місце, хоча для нормативної якості питної води не достатня та потребує застосовувати додатково активоване вугілля для більш ретельного видалення органічного забруднення; відзначається висока технологічна та екологічна ефективність очищення питної води від вмісту хлороформу, в деякі експериментальні дні ефективність була на рівні до 60-70%; окислення марганцю відбувалося на 60-90%; видалення фітопланктону за допомогою реагенту характеризувалося високою ефективністю та було на рівні 90% і більше.

Ключові слова: *Carusol*, перманганат натрію, якість питної води, хлороформ, марганець, перманганатна окиснюваність, фітопланктон.

Abstract. The article presents the results of the research, obtained during the production of a new reagent - sodium permanganate oxidant (Carusol trademark) in the technology of water treatment at the treatment plant of the «Zhytomyrvodokanal» utility company. The purpose of this work is to determine the effectiveness of removal from the composition of tap water of such pollutants as permanganate oxidation, manganese, phytoplankton, and especially chloroform and improve its quality by organoleptic parameters.

This experiment was conducted in summer to determine the technological and environmental efficiency of the reagent at high water temperatures, because it is in summer that the water supply source in Zhytomyr is characterized by the increased levels of organic pollution, which causes excessive concentration of chloroform, high concentration of manganese and phytoplankton. The production experiment showed

that the efficiency of water purification with Carusol reagent in the warm period of the year at increased water temperatures in terms of chromaticity is quite high; according to the oxidation index of permanganate, although it is not sufficient for the normative quality of drinking water and requires the use of additional activated carbon for more thorough removal of organic pollution; there is a high technological and environmental efficiency of purification of drinking water from chloroform, in some experimental days the efficiency was up to 60-70%; oxidation of manganese occurred by 60-90%; removal of phytoplankton with the reagent was characterized by high efficiency and was at the level of 90% or more.

Keywords: *Carusol*; sodium permanganate; drinking water quality; chloroform; manganese; permanganate oxidation; phytoplankton.

ВСТУП

Стан водних екосистем України стрімко наближується до критичного, оскільки, як відомо, прісноводні ресурси в нас обмежені і в них спостерігається тенденція стрімкого погіршення якості води [1].

Майже всі водні ресурси на території України потерпають від антропогенного навантаження, прямо чи опосередковано. І цей вплив призводить до їх виснаження, забруднення, деградації і, в результаті, їх безповоротного зникнення [2]. Навіть той факт, що за останні 25 років кількість населення України та об'єми більшості видів виробництв значно скоротилися, не вплинув на негативну тенденцію погіршення якості водних ресурсів [3].

В умовах сьогодення, пріоритетним та надважливим завданням, що постає перед будь – яким водопостачальним підприємством України є вирішення проблем, пов'язаних із забезпеченням населення якісною водопровідною водою. Такі рішення неодмінно потребують впровадження нових, більш ефективних методів та реагентів, оскільки з кожним роком якість води у джерелах водопостачання катастрофічно погіршується. Це відбувається внаслідок необачного та нерозсудливого ставлення людини до водних ресурсів, що, в результаті, призводить до невідворотного їх забруднення. Використання застарілих технологій та неефективних реагентів для очищення поверхневої води, яка за своїм складом відноситься до 3-4 класу згідно ДСТУ 4808:2007 є недостатнім для гарантування населенню отримання якісної питної води з крану [4]. Для очищення та покращення якості води на комунальному підприємстві «Житомирводоканал» нами був запропонований новітній реагент – окисник перманганат натрію (торгова марка *Carusol*).

Довгий час перманганат вироблявся більшістю підприємств – постачальників реагентів у вигляді калієвої солі ($KMnO_4$), що являє собою стійкий кристалічний порошок високої чистоти (мінімум 95%). Але з кінця 1990 – х років виробник *Carus* (США) почав виготовляти перманганат у рідкому концентрованому вигляді – перманганату натрію ($NaMnO_4$) [5].

«Перманганат натрію ($NaMnO_4$) – це окисник, який володіє такою ж природою дії, як і перманганат калію. Використовується для передокислення, як альтернатива хлору і діоксиду хлору та виключає можливість утворення у питній воді побічних продуктів хлорування – тригалогенметанів. Використання перманганату натрію забезпечує ефективне вирішення таких нагальних проблем, як окислення та видалення з води неорганічних речовин – заліза, марганцю, миш'яку, радію, окислення природних органічних речовин, що містяться у джерелі водопостачання, видалення присмаків та запахів води, покращення кольоровості води» [5, 6]. Більш детально про реагент надана інформація у попередній статті [6].

Історія запровадження у технологію водопідготовки перманганату натрію почалася із використанням в якості реагенту для очищення води перманганату калію.

У 1915-1916 роках доктор Едвард Хегелер Карус вперше виготовив перманганат калію у університеті у Вісконсині за допомогою саморобного обладнання. А вже у 1918 році був побудований завод по виробництву перманганату калію в місті Ласаль штат Іллінойс. У 1959 році М. Боуком Карусом був розроблений та вперше впроваджений метод очищення питної води від водоростей та фітопланктону за допомогою перманганату калію. А у 1999 році на ринок був представлений рідкий перманганат натрію *Carusol* С [7].

Використання перманганату калію для окислення органічної речовини, яка є попередником для утворення хлорорганічних сполук, було вперше досліджено в США м. Цинциннаті, штат Огайо. Багаточисленними дослідженнями, які проводилися на воді з річки Огайо, виявили зниження концентрації ТГМ на 5-20 % при додавання перманганату калію у дозах від 0,7 до 5,0 мг/л, а при обробці дозою 10 мг/л досягалося зниження на 40 %. Було доведено, що введення перманганату у технологію водопідготовки без переміщення точки вводу хлору, не призведе до зниження концентрації ТГМ у питній воді. Згідно доповіді представників водопостачального підприємства м. Франкфурт, що у Західній Німеччині, через зміну точки хлорування і додавання перманганату у сиру воду, було досягнуто скорочення утворення ТГМ на 50 % [8].

В Україні, першими, хто застосував *Carusol* в технологію очищення води, були спеціалісти ТОВ «БІЛОЦЕРКІВВОДА» у 2014 році. Метою їх впровадження реагенту було усунення неприємного присмаку та запаху питної водопровідної води, які обумовлені присутністю в природних водах річки Рось незабарвлених органічних молекулярних речовин, до яких належать продукти внутрішньо водних біологічних процесів (карбонові кислоти, феноли та інші) [9, 10].

Протягом 2015-2018 рр. в лабораторії КП «Житомирводоканал» нами були успішно проведені лабораторні експериментальні роботи по впровадженню реагенту – окисника Carusol в технологію водопідготовки [6, 11, 12], після чого було прийняте рішення провести виробничі випробування реагенту.

Впродовж виробничого впровадження проводилося відбирання зразків води та визначення показників її якості за загальноприйнятими методиками: температура води – відповідно до паспорту термометру ТЛС-4; органолептичні показники: кольоровість, каламутність вимірювали за методикою – ГОСТ 3351-74; окиснюваність перманганатна – ГОСТ 23268.12-91; марганець – «Методика виконання вимірювань масової концентрації алюмінію, заліза, кадмію, кобальту, марганцю, міді, молібдену, нікелю, свинцю, стронцію, хрому та цинку у питній воді», для атомно-абсорбційного спектрофотометру «Сатурн-3-П1»; хлороформ – методичні вказівки № 0052-98 «Газохроматографічне визначення тригалогенметанів (хлороформу) у воді»; фітопланктон – «Методика визначення фітопланктону, зоопланктону та детриту у воді. СТП-32-19-01». Оцінку якості питної води проводили шляхом порівняння фактичних даних із нормативами ДСанПіНу 2.2.4-171-10 «Гігієнічні вимоги до води питної, призначеної для споживання людиною». Схема дозування реагенту – окисника *Carusol*, за якою був проведений виробничий експеримент в літній час представлена на рисунку 1 [6].

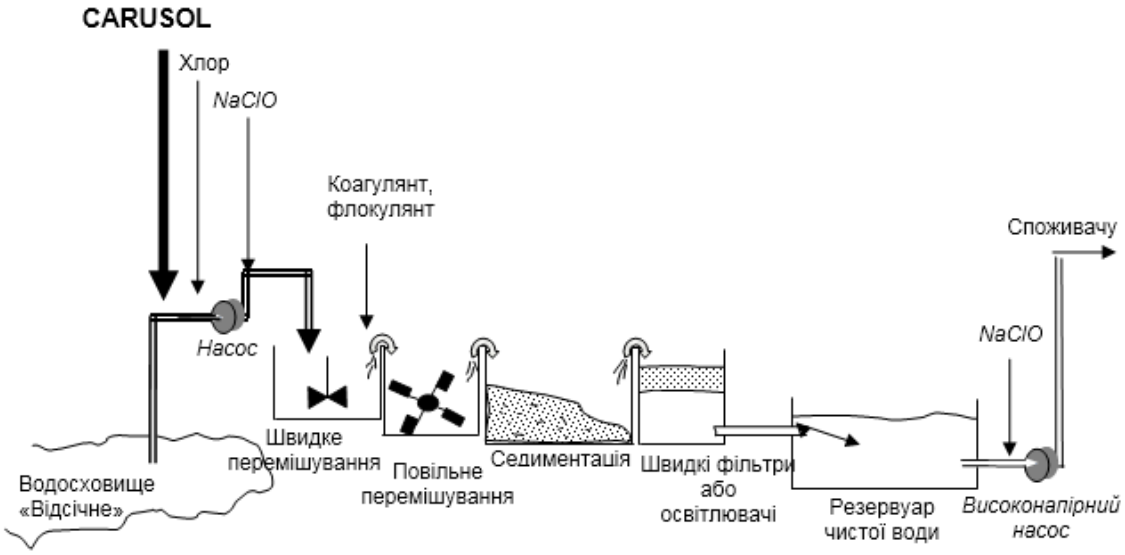

Рисунок 1 – Схема вводу реагенту *Carusol* в технологію водопідготовки на водопровідних спорудах КП «Житомирводоканал»

Точка вводу реагенту знаходилася у водоприймальній камері, одразу після підйому води з водосховища.

РЕЗУЛЬТАТИ ДОСЛІДЖЕННЯ

Після успішно проведених довготривалих лабораторних експериментальних робіт по використанню реагенту – окисника перманганату натрію в технології водопідготовки, які тривали протягом 2015–2018 років [6, 11, 12], виробничі впровадження реагенту *Carusol* для очищення води на водопровідних спорудах КП «Житомирводоканал» проводилися впродовж двох сезонів 2018-2019 років – літній (16.07–06.08.2018) (таблиця 1) та зимовий (18.02–1.03.2019). Таке рішення було прийняте з метою визначення технологічної та екологічної ефективності використання реагенту при різних умовах застосування, а саме, відмінних температурах води. В даній статті ми розглянули результати виробничого впровадження, яке відбувалися у літній період.

Послідовність введення реагентів у виробничому впровадженні в літній час була наступною: *Carusol* (1 підйом) + через 2 хвилини хлор, через 2 години гіпохлорит натрію (2 підйом), через 30 секунд коагулянт, через 30 секунд флокулянт.

За лабораторних умов нами була визначена найбільш ефективною та оптимальною дозою *Carusol* для використання в технології водопідготовки доза 0,2 мг/дм^3 [12]. У даному експерименті використовувалися реагенти: флокулянт аніонний на основі поліакриламіду – *EXTRAFLOCK* P-70 з фіксованою дозою 0,3 мг/дм^3, алюмовмісний коагулянт – (масова частка Al_2O_3 – 16 %) – доза 30 мг/дм^3, доза Carusol – 0,2 мг/дм^3, доза хлору на першому підйомі коливалася в межах 7,27-13,19 мг/дм^3, доза гіпохлориту натрія на другому підйомі коливалася в межах 2,95-6,42 мг/дм^3.

Таблиця 1 – Результати виробничого впровадження реагенту – перманганату натрію *Casurol* в технології водопідготовки на водоочисних спорудах КП «Житомирводоканал» протягом 16.07-06.08.2018 р.

Дата та місце відбору проб води	Каламутність, мг/дм^3	Кольоровість, град.	Окиснюваність, мг/дм^3	Марганець, мг/дм^3	Залізо, мг/дм^3	Залишковий алюміній, мг/дм^3	Хлороформ, мг/дм^3	Фітопанктон, тис. кл/дм^3
16.07.2018								
Водосховище «Відсічне», *t* води – 20 °С	7,4	44	10,08	0,234	0,38	відс.	Відс.	334,425
Водовод	4,5	24	8,8	0,308	0,24	відс.	0,089	22,5
РЧВ 5 тис м^3	0,5	7	6,08	0,122	0,1	0,17	0,134	6,64
РЧВ 20 тис м^3	0,7	8	5,92	0,098	0,1	0,14	0,122	3,68
17.07.2018								
Водовод	5,2	24	8,64	0,337	0,3	відс.	0,048	88,28
РЧВ 5 тис м^3	1,1	6	6,24	0,059	0,1	0,21	0,091	6,64
РЧВ 20 тис м^3	1,0	9	6,4	0,063	0,1	0,15	0,083	7,72
18.07.2018								
Водовод	6,2	32	8,32	0,351	0,27	відс.	0,045	142,52
РЧВ 5 тис м^3	1,4	7	5,74	0,107	0,1	0,3	0,049	7,8
РЧВ 20 тис м^3	1,4	11	6,4	0,117	0,1	0,2	0,045	9,32
19.07.2018								
Водовод	6,0	28	8,96	0,322	0,3	відс.	0,051	69,99
РЧВ 5 тис м^3	1,2	9	5,6	0,073	0,1	0,2	0,036	6,14
РЧВ 20 тис м^3	1,4	11	6,4	0,059	0,1	0,14	0,045	10,36
20.07.2018								
Водовод	6,2	32	9,76	0,332	0,3	Відс.	0,066	209,475
РЧВ 5 тис м^3	1,0	7	6,4	0,098	0,1	0,21	0,068	4,48
РЧВ 20 тис м^3	1,2	12	6,72	0,056	0,1	0,15	0,093	5,54
23.07.2018								
Водосховище «Відсічне»,	9,9	36	11,04	0,434	0,43	відс..	відс.	166,28

Дата та місце відбору проб води	Каламутність, мг/дм³	Кольоровість, град.	Окиснюваність, мг/дм³	Марганець, мг/дм³	Залізо, мг/дм³	Залишковий алюміній, мг/дм³	Хлороформ, мг/дм³	Фітопанктон, тис. кл/дм³
t води – 21 °С								
Водовод	7,1	28	9,92	0,381	0,32	відс.	0,021	107,66
РЧВ 5 тис м³	1,6	11	6,08	0,073	0,1	0,2	0,031	10,64
РЧВ 20 тис м³	1,7	13	6,72	0,158	0,11	0,14	0,036	9,18
24.07.2018								
Водовод	5,9	28	9,12	0,582	0,33	відс.	0,017	89,02
РЧВ 5 тис м³	1,3	12	6,24	0,112	0,11	0,21	0,054	4,78
РЧВ 20 тис м³	1,3	14	6,56	0,192	0,12	0,15	0,059	6,12
25.07.2018								
Водовод	6,8	32	8,8	0,52	0,32	відс.	0,028	101,38
РЧВ 5 тис м³	1,4	18	5,92	0,107	0,11	0,09	0,054	7,86
РЧВ 20 тис м³	1,4	18	5,74	0,11	0,1	0,11	0,057	10,2
26.07.2018								
Водовод	8,3	48	8,32	0,525	0,22	відс.	0,076	224,14
РЧВ 5 тис м³	1,7	28	5,28	0,148	0,1	0,11	0,09	3,16
РЧВ 20 тис м³	1,7	28	5,12	0,158	0,1	0,14	0,102	1,48
27.07.2018								
Водовод	8,3	56	8,48	0,368	0,33	відс.	0,032	295,38
РЧВ 5 тис м³	1,4	18	5,6	0,128	0,1	0,09	0,023	3,82
РЧВ 20 тис м³	1,3	22	5,6	0,11	0,11	0,1	0,023	5,28
30.07.2018								
Водосховище «Відсічне», *t* води – 22 °С	8,4	56	11,52	0,663	0,51	відс.	відс.	359,22
Водовод	7,6	36	10,76	0,56	0,4	відс.	0,045	178,08
РЧВ 5 тис м³	1,4	24	6,24	0,191	0,14	0,14	0,086	4,06
РЧВ 20 тис м³	1,3	26	5,92	0,253	0,1	0,16	0,087	4,94
31.07.2018								
Водовод	8,0	48	9,52	0,583	0,38	відс.	0,053	174,72
РЧВ 5 тис м³	1,3	14	5,92	0,216	0,18	0,33	0,052	5,4
РЧВ 20 тис м³	1,7	18	6,24	0,138	0,12	0,18	0,055	8,64
01.08.2018								
Водовод	9,0	56	9,92	0,501	0,37	відс.	0,16	72,18
РЧВ 5 тис м³	1,4	16	5,74	0,064	0,17	0,4	0,197	4,64
РЧВ 20 тис м³	2,0	26	6,72	0,206	0,13	0,35	0,206	9,24
02.08.2018								
Водовод	7,6	56	10,4	0,626	0,39	відс.	0,123	164,66
РЧВ 5 тис м³	1,4	16	5,6	0,038	0,16	0,28	0,173	6,0
РЧВ 20 тис м³	2,0	26	7,2	0,196	0,12	0,21	0,197	9,8
03.08.2018								
Водовод	6,9	48	8,8	0,583	0,39	відс.	0,088	156,24
РЧВ 5 тис м³	1,4	18	4,48	0,009	0,19	0,32	0,077	5,64
РЧВ 20 тис м³	1,8	24	5,92	0,208	0,13	0,2	0,114	7,22
06.08.2018								
Водосховище «Відсічне», *t* води – 23 °С	9,8	56	12,0	0,379	0,48	відс.	Відс.	277,16
Водовод	5,7	36	10,72	0,414	0,38	відс.	0,084	69,04
РЧВ 5 тис м³	1,7	18	6,08	0,049	0,15	0,33	0,165	4,82
РЧВ 20 тис м³	1,7	16	7,04	0,189	0,13	0,22	0,176	12,78

Виробничий експеримент почався в той момент, коли температура води у водосховищі «Відсічне» складала 20 °С, органолептичні показники відповідали: каламутність – 7,4 мг/дм³, кольоровість – 44 °; концентрація марганцю становила – 0,234 мг/дм³, заліза –

0,38 мг/дм³, окиснюваність перманганатна була на рівні 10,08 мг/дм³, фітопланктон – 334,425 тис. кл/дм³, хлороформ у воді був відсутній. Оскільки ми визначили, що найбільш проблемними показниками для питної водопровідної води є окиснюваність, марганець, хлороформ та фітопланктон, в дослідженнях приділяли найбільшу увагу саме їм.

В першу чергу, під час лабораторних досліджень якості питної води визначали органолептичні показники – каламутність та кольоровість, щоб з'ясувати чи не вплине впровадження нового реагенту на погіршення якості води за органолептикою. Як видно на рисунку 2, каламутність води у водосховищі «Відсічне» впродовж виробничого експерименту коливалася від 7,4 мг/дм³ до 9,9 мг/дм³. При цьому, після введення *Carusol* на 1 підйомі, якість води за показником каламутності не погіршувалася, а, навпаки, відбувалося її зниження при досягненні 2 підйому (Водовод) на 0,8-4,1 мг/дм³ або на 10–42%. Каламутність варіювала в межах значень 4,5–9 мг/дм³, розраховане середнє значення відповідало 6,83±1,24 мг/дм³. Далі, в процесі технологічного очищення води на водоочисних спорудах, вміст каламутності вже перебував в рамках нормативного значення 2,031 мг/дм³ [13].

Концентрація каламутності за період експерименту змінювалася в межах: РЧВ 5000 м³ – 1,32±0,29 мг/дм³, РЧВ 20000 м³ – 1,47±0,35 мг/дм³, а значення, які найбільше зустрічалися протягом всього виробничого експерименту були: РЧВ 5000 м³ – 1,4 мг/дм3, РЧВ 20000 м³ – 1,7 мг/дм³.

Що стосується кольоровості води, то вона у водосховищі протягом експерименту також підвищилася з 44 до 56 ° (рисунок 3). Однією з причин такого збільшення кольоровості та каламутності є підвищення температури води у «Відсічному» з 20 до 23 °С, оскільки нами вже було попередньо доведено тісний зв'язок між зміною температури та органолептичними показниками [14]. Кольоровість варіювала в межах 24–56 °С, а середнє значення за час експерименту було на рівні 38±12 С.

Отже, після першого введення реагенту 16.07, кольоровість води у водоводі зменшилася у 2 рази, а після технологічного очищення досягла нормативної якості 7–8 С. В наступні дні експерименту відбувалося також достатнє зниження кольоровості у водоводі: 23.07 – на 8 ° або на 22 %, 30.07 та 06.08 – на 20 ° або на 36 %. Але наголошую, що на 1 підйомі додатково після введення *Carusol* проводили дозування і хлору, тому такий результат, це об'єднана дія двох реагентів.

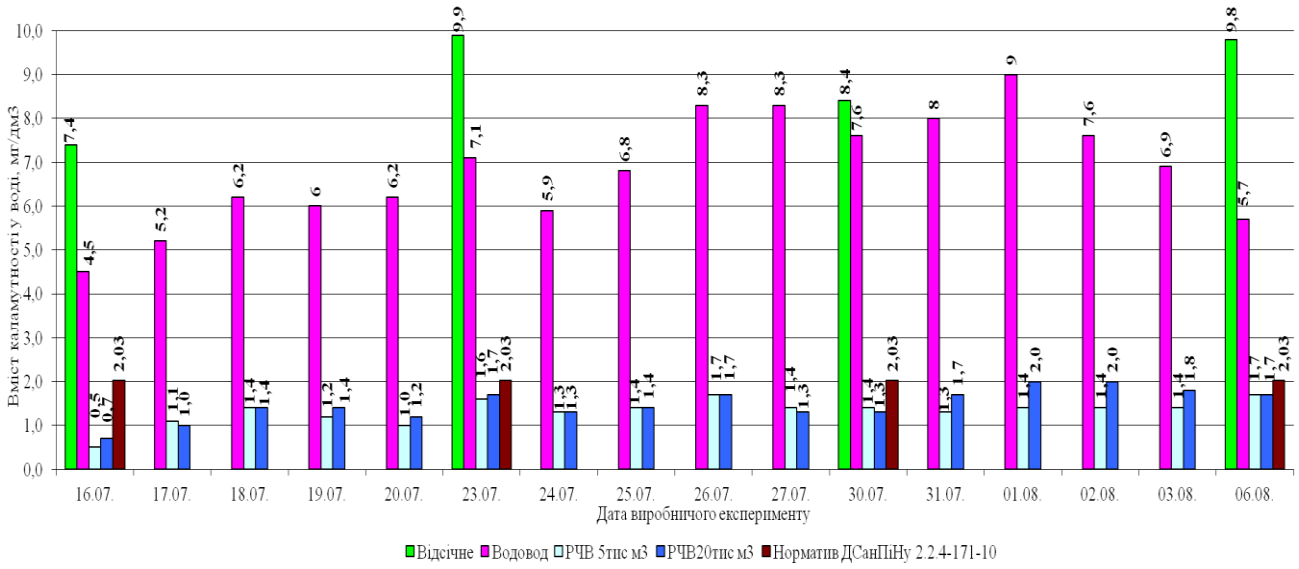

Рисунок 2 – Динаміка зміни якості води по вмісту каламутності при введені *Carusol*

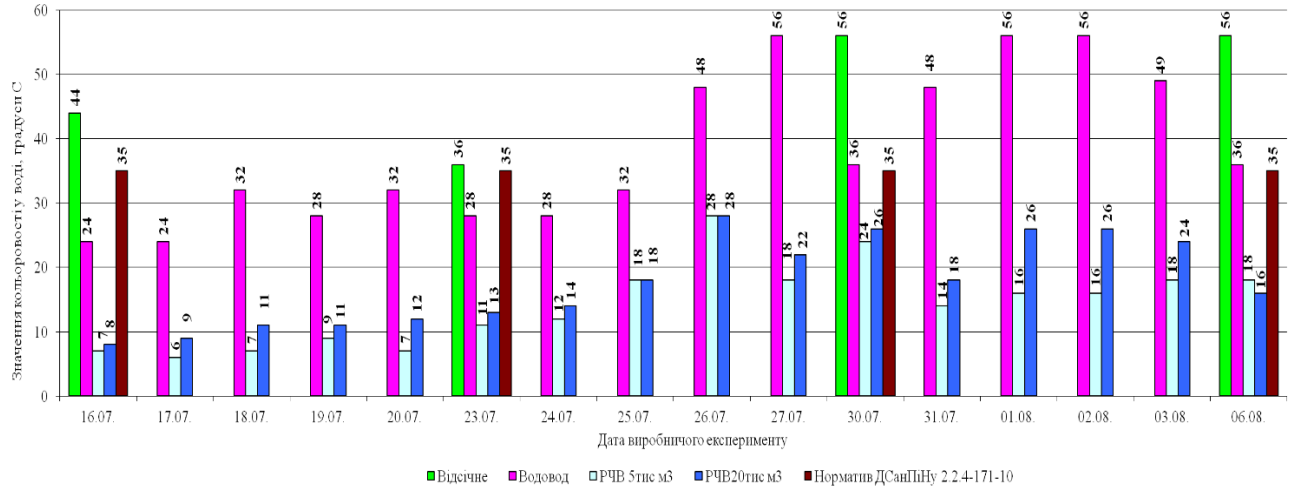

Рисунок 3 – Динаміка зміни якості води по кольоровості при введені *Carusol*

Як ми знаємо, застосування перманганату натрію в технології водопідготовки ефективно впливає на процес коагуляції та дозволяє зменшити дозу коагулянту, яка використовується для очищення води. Так, за дози коагулянту 30 мг/дм³ (хоча найчастіше в літній період використовується доза 45 мг/дм³ і вище), відбулося достатнє очищення за кольоровістю. Після водоочисних споруд питна вода в резервуарах по кольоровості мала значення нижче за нормативне. За період виробничого впровадження кольоровість варіювала в межах: РЧВ 5000 м³ – 6–28 °, РЧВ 20000 м³ – 8–28 °, розраховане середнє значення було на рівні: РЧВ 5000 м³ – 14±6 °, РЧВ 20000 м³ – 18±9 °.

Нами визначено, що ефективність очистки води у резервуарах (приймалося до уваги найменше значення кольоровості з двох резервуарів) по відношенню до якості води у водоводі складала: першу неділю – 68-78 %, другу неділю – 42-68 %, третю – 33-63 %. Можна зробити висновок, що ефективність очищення води реагентом *Carusol* в теплий період року за показником кольоровості достатньо висока.

Оскільки водосховище «Відсічне» характеризувалося високим рівнем органічного забруднення впродовж періоду нашого спостереження 2005-2018 рр., то якість питної води досить тривалий час за показником окиснюваності перманганатної не відповідала встановленому нормативу [14]. На момент введення *Carusol*, а саме 16.07, значення окиснюваності у водосховищі відповідало 10,08 мг/дм³ та впродовж експерименту зросло на 2,08 мг/дм³ (06.08) до 12 мг/дм³ (рисунок 4).

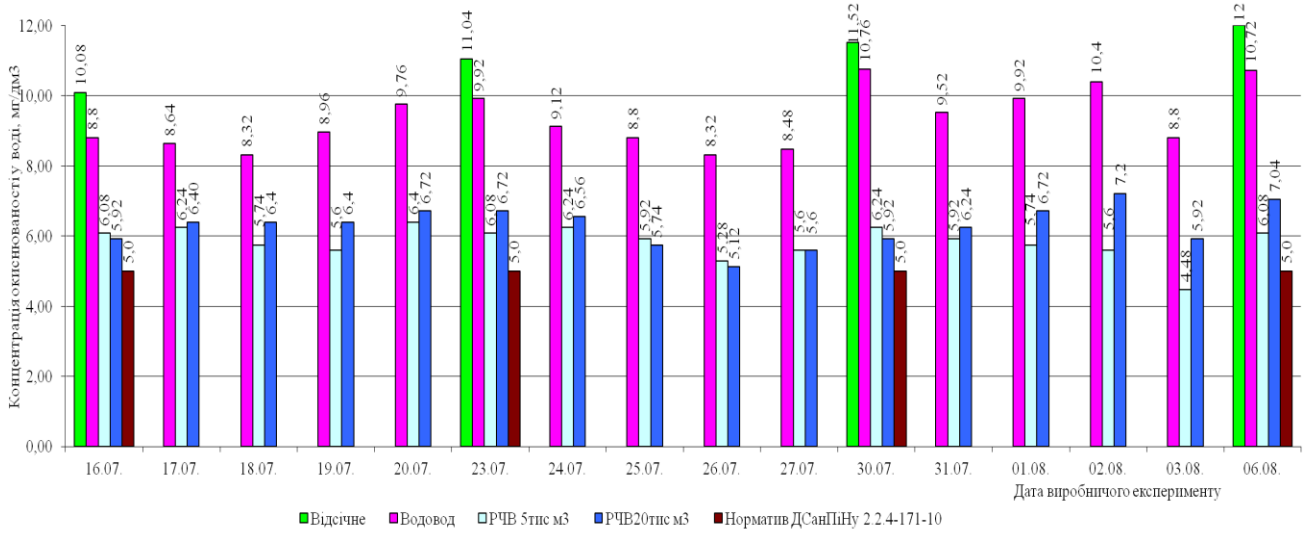

Рисунок 4 – Динаміка зміни якості води по окиснюваності перманганатній при введені *Carusol*

Після введення реагенту, у водоводі сирої води окиснюваність поступово знижувалася, але не на багато, на 0,76–1,28 мг/дм^3, а далі, після очищення на фільтрах та освітлювачах, досягала значень 4,48 (03.08) – 7,2 мг/дм^3 (02.08). Окиснюваність впродовж часу спостереження змінювалася в межах 8,32–10,76 мг/дм^3, значення, які частіше зустрічалися становили 8,8 мг/дм^3, а розрахована середня концентрація була на рівні 9,33±0,44 мг/дм^3 ($p<0,05$).

Як видно з діаграми на рисунку 4, 16.07 відбулося очищення води в резервуарах по відношенню до якості води у водосховищі на 4 та 4,16 мг/дм^3, тобто на 40 і 41% відповідно; 23.07 – на 4,96 та 4,32 мг/дм^3 або на 45 і 39 %; 30.07 – 5,28 та 5,6 мг/дм^3 або на 46 і 49 %; 06.08 – 5,92 та 4,96 мг/дм^3 або на 49 та 41 % відповідно. Але нормативного значення окиснюваність під час експерименту досягла лише 03.08 – 4,48 мг/дм^3 та 26.07 – 5,12 мг/дм^3, за весь період експерименту вона варіювала в діапазоні 4,48 – 7,2 мг/дм^3. Це говорить лише про те, що необхідно, все ж таки, для повного очищення води від органічного забруднення додатково застосовувати активоване вугілля, або як засипку для фільтрів, або проводити дозування порошкоподібного вугілля.

Розраховане середнє значення окиснюваності становило: РЧВ 5000 м^3 – 5,83±0,25 мг/дм^3, РЧВ 20000 м^3 – 6,29±0,3 мг/дм3 ($p<0,05$), що не відповідало встановленому ДСанПіНом нормативу (5,0 мг/дм^3).

Отже, ефективність очищення води від окислюваності перманганатної має місце, хоча і не достатньо висока. Для більш ретельного видалення, все ж таки, необхідно застосовувати активоване вугілля.

Попередньо проаналізовані нами результати власного дослідження доводять, що очищення та дезінфекція води, яка має високий ступінь органічного забруднення, хлором, призводить до утворення хлороформу у високих концентраціях [15].

Як видно з рисунку 5, з 16.07 по 01.08 завдяки дозуванню *Carusol* на 1 підйомі та зменшенню дози хлору (7,5 мг/дм^3), що використовувалася додатково, окислення органічної речовини відбулося із утворенням меншої концентрації хлороформу у воді водоводу. Завдяки цьому, вміст хлороформу з 0,089 мг/дм^3 почав знижуватися та досяг свого мінімуму 23–25.07 і становив 0,017–0,028 мг/дм^3. Відбулося його зменшення майже на 80 %, а взагалі, впродовж експерименту фіксувалося зниження хлороформу у водоводі в порівнянні із першим днем дозування *Carusol* на 15% (26.07) – 64 % (27.07). При цьому, починаючи вже з 18.07 відбувається суттєве зменшення утвореного хлороформу і у резервуарах питної води. В окремі дні (18-19.07, 23-25.07, 31.07) його концентрація відповідає встановленому ДСанПіНом 2.2.4.-171-10 нормативному значенню 0,06 мг/дм^3.

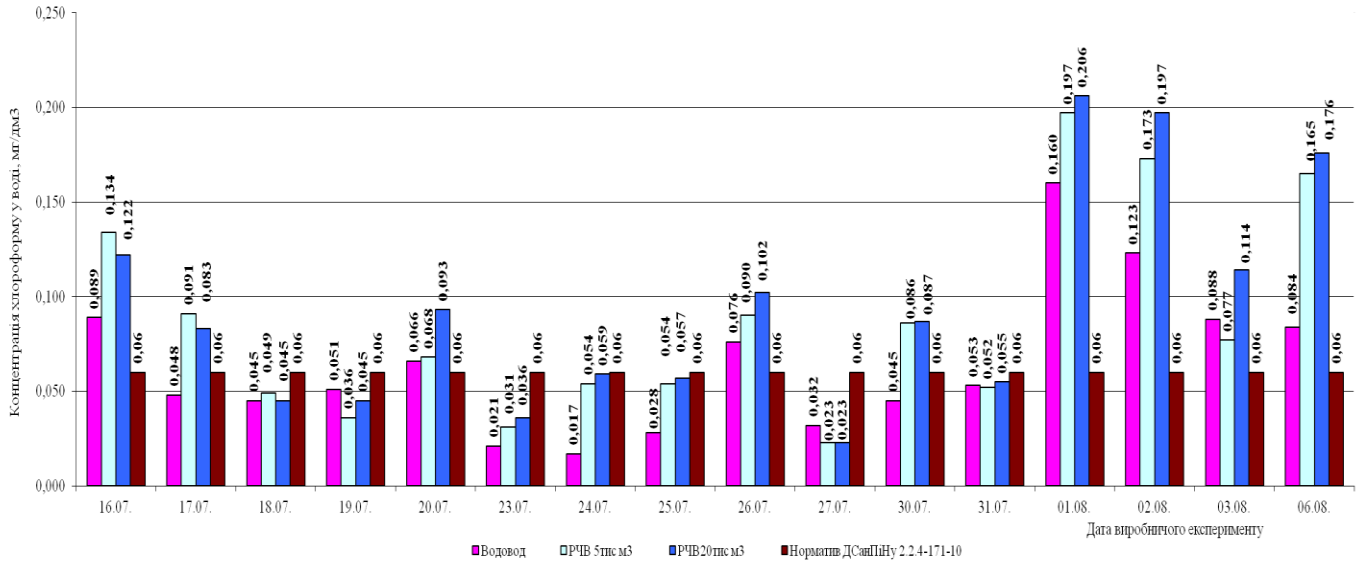

Рисунок 5 – Динаміка зміни якості води по хлороформу при введені *Carusol*

Якщо проводити порівняння ефективності видалення утвореного хлороформу у резервуарах у перший день експерименту 16.07.2018 (0,134 та 0,122 мг/дм^3) з наступними днями, то ми отримуємо наступні дані:

17.07.2018 (0,091 і 0,083 мг/дм^3) – відбулося зменшення у РЧВ 5000 м^3 на 0,043 мг/дм^3 або на 32%; у РЧВ 20000 м^3 на 0,039 мг/дм^3 або на 32%;

18.07.2018 (0,049 і 0,045 мг/дм^3) – відбулося зменшення у РЧВ 5000 м^3 на 0,085 мг/дм^3 або на 64%; у РЧВ 20000 м^3 на 0,077 мг/дм^3 або на 63%;

19.07.(0,036 і 0,045 мг/дм^3) – відбулося зменшення у РЧВ 5000 м^3 на 0,098 мг/дм^3 або на 73%; у РЧВ 20000 м^3 на 0,077 мг/дм^3 або на 63%;

20.07.2018 (0,068 і 0,093 мг/дм^3) – відбулося зменшення у РЧВ 5000 м^3 на 0,066 мг/дм^3 або на 49%; у РЧВ 20000 м^3 на 0,029 мг/дм^3 або на 24%;

23.07.2018 (0,031 і 0,036 мг/дм^3) – відбулося зменшення у РЧВ 5000 м^3 на 0,103 мг/дм^3 або на 77%; у РЧВ 20000 м^3 на 0,086 мг/дм^3 або на 70%; і т. д.

За перші дві неділі експерименту концентрація хлороформу змінювалася в рамках значень: водовод – 0,017-0,089 мг/дм^3, РЧВ 5000 м^3 – 0,023-0,134 мг/дм^3, у РЧВ 20000 м^3 – 0,023-0,122 мг/дм^3. Розраховане середнє значення концентрації було на рівні: водовод – 0,047±0,014 мг/дм^3, РЧВ 5000 м^3 – 0,064±0,02 мг/дм^3, у РЧВ 20000 м^3 – 0,067±0,019 мг/дм^3 ($p<0,05$).

З 01.08. паралельно із дозуванням *Carusol* відбулося збільшення дози подання хлору на 1 підйомі (12,6 мг/дм^3) і це одразу позначилося на кількості утвореного хлороформу у воді водоводу, і, як результат, у резервуарах питної води (рисунок 5). Концентрація хлороформу зросла в порівнянні з 31.07 у водоводі на 0,107 мг/дм^3 або в 3 рази; у РЧВ 5000 м^3 на 0,145 мг/дм^3 або у 3,8 разів; у РЧВ 20000 м^3 на 151 мг/дм^3 або у 3,7 разів. Вже до кінця експерименту концентрація хлороформу залишалася на рівні, що набагато вищий за нормативне значення. За ці дні виробничого експерименту концентрація хлороформу варіювала в межах: водовод – 0,084-0,16 мг/дм^3, РЧВ 5000 м^3 – 0,077-0,197 мг/дм3, у РЧВ 20000 м^3 – 0,092-0,206 мг/дм^3. Розраховане середнє значення концентрації було на рівні: водовод – 0,113±0,056 мг/дм^3, РЧВ 5000 м^3 – 0,153±0,083 мг/дм^3, у РЧВ 20000 м^3 – 0,173±0,066 мг/дм^3 ($p<0,05$).

За весь період виробничого впровадження реагенту – окисника концентрація хлороформу змінювалася: водовод – від 0,017 до 0,16 мг/дм^3, РЧВ 5000 м^3 – 0,023-0,197 мг/дм^3, у РЧВ 20000 м^3 – 0,023-0,206 мг/дм^3. Розраховане середнє значення концентрації було на рівні: водовод – 0,064±0,02 мг/дм^3, РЧВ 5000 м^3 – 0,086±0,028 мг/дм^3, у РЧВ 20000 м^3 – 0,094±0,03 мг/дм^3 ($p<0,05$).

Отже, можна стверджувати про достатньо високу ефективність очищення питної води за допомогою використання в технології водопідготовки реагенту перманганату натрію, оскільки в деякі дні вона складала 60-70%.

Наступним показником якості води, на який варто було звернути увагу під час виробничого впровадження, був показник концентрації марганцю у воді (рисунок 6).

Як свідчать отримані нами результати дослідження, концентрація марганцю у водосховищі «Відсічне» впродовж експерименту з 16.07 по 31.07 зросла майже у 3 рази: з 0,23 до 0,663 мг/дм^3. Під час експерименту у водоводі відбувалося незначне окислення марганцю: 23.07 – на 12 %, 30.07 – на 15 %. При цьому вміст марганцю коливався в межах 0,308-0,626 мг/дм^3, а середнє розраховане значення було на рівні 0,456±0,061 мг/дм^3 ($p<0,05$). Але, в підсумку, в резервуарах питної води марганець окислювався до значення, яке було нижче нормативу ДСанПіНу (0,5 мг/дм^3). Так, на першій неділі експерименту у резервуарах по відношенню до водоводу відбувалося видалення марганцю на 61-82 %, на другій – на 70-80%, на третій – на 66-98 %. Як ми вже знаємо, на останній (третій) неділі експерименту було збільшено дозу подачи хлору, тому такий результат, скоріше за все, спільна дія обох реагентів. Впродовж дослідження якість води по марганцю варіювала в рамках: РЧВ 5000 м^3 – 0,009-0,216 мг/дм^3, у РЧВ 20000 м^3 – 0,056-0,253 мг/дм^3. Розраховане середнє значення концентрації було на рівні: РЧВ 5000 м^3 – 0,0996±0,029 мг/дм^3, у РЧВ 20000 м^3 – 0,144±0,032 мг/дм^3 ($p<0,05$).

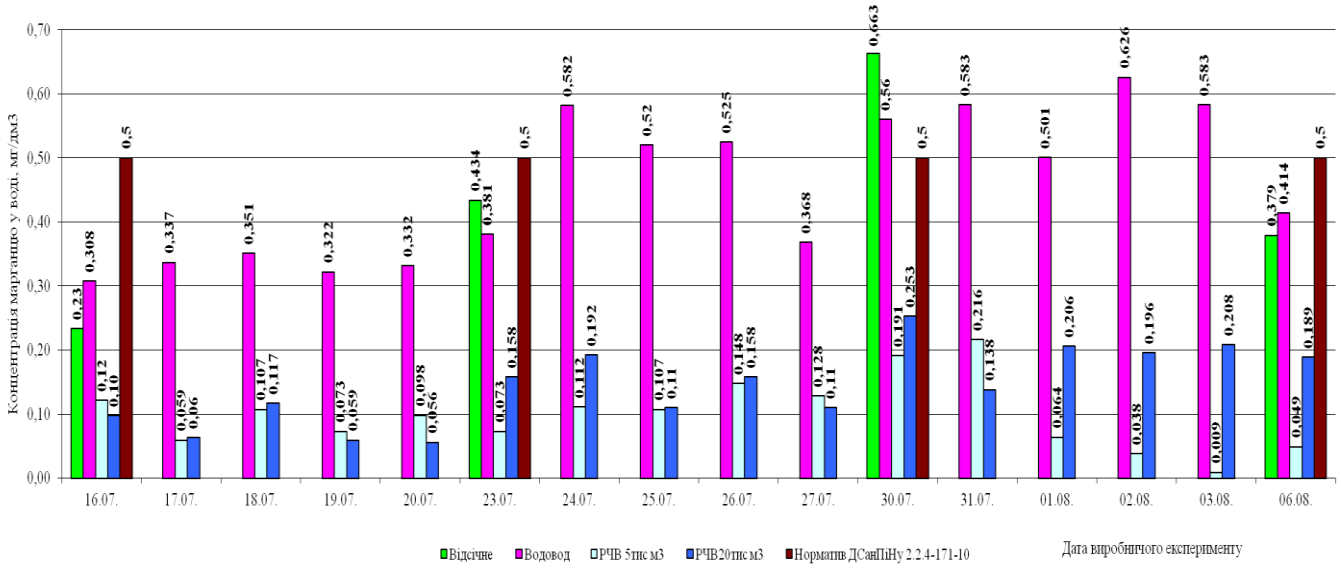

Рисунок 6 – Динаміка зміни якості води по марганцю при введені *Carusol*

Відтак, ефективність видалення марганцю за допомогою *Carusol* в літній час при температурі води більше 20 °С має місце. Це підтверджено експериментально.

Останнім показникам, який потребував нашої уваги під час проведення виробничого впровадження, був показник наявності фітопланктону (рисунок 7), оскільки особливо в літній час кількість клітин фітопланктону у водосховищі «Відсічне» може досягати біля 2 млн. клітин.

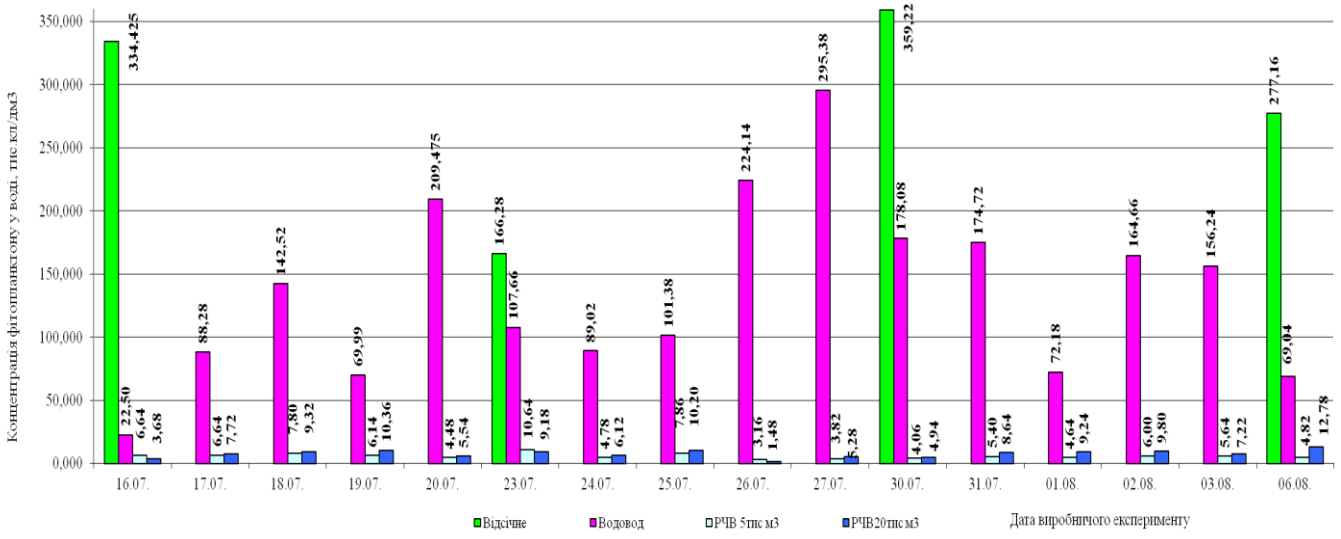

Рисунок 7 – Динаміка зміни якості води за вмістом фітопланктону при введені *Carusol*

Лабораторно нами було доведено ефективність використання перманганату натрію для зниження концентрації фітопланктону. Оптимальна доза реагенту *Carusol* тоді була запропонована 0,2 мг/дм^3.

За період експерименту якість води по фітопланктону коливалася в межах: водовод – 22,5-295,38 тис кл/дм^3, РЧВ 5000 м^3 – 3,16-10,64 тис кл/дм^3, у РЧВ 20000 м^3 – 0,1,48-12,76 тис кл/дм^3. Розраховане середнє значення концентрації було на рівні: водовод – 135,33±37,78 тис кл/дм^3, РЧВ 5000 м^3 – 5,78±0,99 тис кл/дм^3, у РЧВ 20000 м^3 – 7,59±1,55 тис кл/дм^3 ($p<0,05$).

Як свідчать отримані нами дані, в перший день експерименту відбулося окислення фітопланктону у водоводі у 15 разів або на 93%. Відповідно при цьому у резервуарах фітопла-

нктон окислився у РЧВ 5000 м^3 – на 98%, у РЧВ 20000 м^3 – на 99%. Якщо аналізувати щоденні результати по фітопланктону у резервуарах отримані впродовж першої неділі по відношенню до концентрації у водоводі, то відбулося видалення на 91-95%, другої неділі – 92-99%, третьої неділі – 94-98%. Отже, підтверджується висока ефективність окислення фітопланктону за допомогою реагенту *Carusol* за умов високої температури води.

ВИСНОВКИ

По заключенню проведеного виробничого експерименту можна зробити наступні висновки: в літній період за високої температури води у джерелі водопостачання відмічається достатньо висока технологічна та екологічна ефективність очищення питної води за допомогою реагенту – окисника *Carusol* за такими показниками, як органолептичні показники, фітопланктон та хлороформ. Ефективність очищення води від окислюваності перманганатної має місце, хоча і не достатньо висока. Для більш ретельного видалення необхідно застосовувати активоване вугілля. Окислення марганцю також має місце на достатньому рівні.

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Screening of Kunun-zaki for Methicillin-Resistant *Staphylococcus aureus* (MRSA), Vancomycin-Resistant *Staphylococcus aureus* (VRSA) and Extended-Spectrum Beta-Lactamase (ESBL) Producing *Salmonella* spp.

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Abstract. Kunun-zaki is an indigenous, fermented, non-alcoholic cereal-based beverage produced and consumed primarily in Northern Nigeria. Due to its high nutritional and moisture content, it provides an ideal environment for the growth of foodborne pathogens. This study determined the presence of Methicillin resistant *Staphylococcus aureus* (MRSA), vancomycin resistant *Staphylococcus aureus* (VRSA) and Extended spectrum beta lactamase (ESBL) producing *Salmonella* spp in Kunun-zaki sold in Umuahia metropolis, Nigeria. Out of the 40 Kunun-zaki samples examined, *Salmonella* spp was detected in 19 (47.5%), whereas *S. aureus* was detected in 22 (55%) of the samples. The total *Salmonella* count ranged from 1.90×10^5-9.70×10^6 (CFU/ml), whereas the total *S. aureus* count ranged from 3.40×10^4-7.50×10^6 (CFU/ml); these microbial counts do not conform to the standard limits of detectable microbes in ready-to-eat food samples as stipulated by the Center for Food Safety. All the isolates were subjected to antibiotic susceptibility testing using the modified Kirby Bauer disc diffusion method. On the one hand, most of the *Salmonella* spp were resistant to the beta-lactam class of antibiotics used (IMP 58%, MEM 90%, AMP 53%). On the other hand, the *Salmonella* isolates showed the highest sensitivities to ceftazidime (95%) and ofloxacin (90%). The *S. aureus* isolates revealed high susceptibility to ofloxacin (96%), and major resistance to oxacillin (41%) and the oxyimino-cephalosporin antibiotics used (CAZ 55%, CTR 41%). MRSA, VRSA and ESBL producing *Enterobacteriaceae* are amongst the most critical multidrug-resistant bacterial pathogens. In this study, 26% of the *Salmonella* spp isolates were confirmed to be ESBL producers, whereas 41% of the isolates were MRSA, 23% were VRSA, and 68% were Vancomycin intermediate *Staphylococcus aureus* (VISA). Hence, the Kunun-zaki could constitute a reservoir for the dissemination of multidrug-resistant foodborne pathogens if not correctly quality controlled.

Keywords: Kunun-zaki; *Staphylococcus aureus*; *Salmonella* spp; Extended spectrum beta-lactamase (ESBL); Methicillin-resistant *Staphylococcus aureus* (MRSA); Vancomycin-resistant *Staphylococcus aureus* (VRSA); Multidrug resistance (MDR).

INTRODUCTION

Kunun-zaki is a fermented, non-alcoholic, non-carbonated and refreshing cereal-based beverage widely consumed in Nigeria, particularly in Northern Nigeria [1]. Kunun-zaki gets its appeal from the distinctive sweet-and-sour taste characteristic of African food products fermented by Lactic Acid Bacteria (LAB) [2], as well as its purported medicinal, nutritional, and thirst-quenching properties [3, 4, 5].

Traditionally, the production procedure of Kunun-zaki varies depending on the taste and culture of the producers and consumers, thus leading to variation in the quality and stability of the Kunun-zaki. Generally, Kunun-zaki is produced from the following cereal substrates; millet, maize, wheat, rice, *acha* (*Digitaria exilis*) and sorghum, but millet is mostly used for commercial production [3, 6]. It is usually flavoured with a combination of spices such as ginger, cloves, black pepper, cinnamon, red pepper and sweeteners such as sugar and honey, together with small quantities of saccharifying agents such as paste of sweet potato tubers, malted rice and malted sorghum [6]. Kunun-zaki is relatively cheap to purchase because the ingredients and cereals used in its production are locally sourced as they are grown throughout the savannah belt of West Africa [7].

The preparation method for Kunun-zaki involves cleaning the grains of the cereals and steeping them in water for 1-3 days. This is then followed by grinding the steeped grains into a mash. The mash of cereals is then divided into two portions in a ratio of about 1:2, the larger portion is gelatinized with hot water whilst, the smaller portion is mixed with spices and the saccharifying agent. These ingredients are usually not quantified [8]. The two parts are then combined at 70-75 ^{o}C, and the mixture is left to ferment at room temperature for 18-24 hours. The product is filtered, and sweeteners are added to the filtrate to taste, and the Kunun-zaki is now ready for consumption [3, 9]. The drink is usually packaged and sold in 500ml plastic bottles (obtained from used water or carbonated drinks) and at times, even tied in some disposable polyethene bags [10].

Kunun-zaki has a concise shelf life of about 24 hours [2], readily undergoing microbial spoilage due to poor keeping conditions. Attempts to improve the shelf-life have been met with some success; pasteurization of packaging bottles followed by refrigeration storage of the Kunun-zaki prolonged the shelf life to 8 days [11], whilst using sodium benzoate (a known preservative) followed by refrigeration extended the shelf to 21 days [12].

Studies have shown that Kunun-zaki has an essential role in the dietary pattern of its consumers owing to its richness in carbohydrates, vitamins, minerals, and moisture content. However, it is low in total protein content [4, 5]. The health benefits of Kunun-zaki includes but is not limited to: reduction of risk associated with diabetes, lowering of blood cholesterol, prevention of blood clotting [13], and increased lactation in nursing mothers [14].

Considering that Kunun-zaki is a nutritionally enriched food product with a very high moisture content and lacks standardization and quality control in both sourcing of cereals, processing, storage, handling, packaging, and delivery to customers, Kunun-zaki provides an ideal environment for the growth of foodborne microbial pathogens which include members of the *Enterobacteriaceae*, *Staphylococcus aureus*, and *Bacillus cereus*, among others, hence, predisposing consumers to serious health risks [15, 16].

S. aureus is a normal flora of the human skin, throat, nasal passage, fingernails, and hair. However, *S. aureus* is implicated in several infections, including meningitis, septicemia, pneumonia, endocarditis and osteomyelitis [17]. When ingested with food, *S. aureus* can cause food poisoning due to its ability to produce several enterotoxins. Also, *S. aureus* may even cause scalded skin syndrome and toxic shock syndrome through the production of different toxins [18]. *S. aureus,* in general, is sensitive to many antibiotics; however, in the last few decades, many strains of *S. aureus* have developed resistance to these antibiotics. *S. aureus* resistance to methicillin is of severe public health concern due to its high morbidity and mortality [19]. Methicillin-resistant *Staphylococcus aureus* (MRSA) occurs as a result of the acquisition of Staphylococcal Cassette Chromosome *mec* (SCC*mec*) genes by methicillin-sensitive *S. aureus*. The SCC*mec* is a mobile genetic element which carries the *mec*A or *mec*C gene which encodes the penicillin-binding protein (PBP2a) that confers resistance to all beta-lactam antibiotics [20-22]. The SCC*mec* also contains site-specific recombinase genes (cassette chromosome recombinase (*ccr*)) *ccr*AB or/and *ccr*C which mediates integration and excision of SCC*mec* into or from the chromosome. In addition, the SCC*mec* contains a few other genes and various other mobile genetic

elements such as insertion sequences, transposons, and plasmids [23, 24]. With the emergence of MRSA, vancomycin has been utilized as the treatment of choice for MRSA infections, and its excessive use has led to the emergence of Vancomycin Intermediate and Vancomycin-Resistant *S. aureus* (VISA and VRSA) [25].

Contamination of food by *Enterobacteriaceae* is usually through faecal water contamination, and cross-contamination may occur during further processing and preparation. The *Enterobacteriaceae* consists of some essential public health pathogens that produce extended-spectrum beta-lactamases (ESBL), which are a group of enzymes conferring broad resistance to beta-lactams: oxyimino-cephalosporins (such as cefotaxime, ceftriaxone, ceftazidime or cefepime) and monobactams (aztreonam) but not carbapenems [26, 27]. The enzyme generally results from a point mutation in the genes of broad-spectrum beta-lactamases, TEM-1 and SHV-1, by one to four amino acid changes which form the bases of resistance [28]. ESBL enzymes are usually located on plasmids that often carry other resistance genes that confer reduced susceptibility to other unrelated classes of antimicrobials making it difficult to treat infections caused by ESBL producing bacteria [29, 30], and resistance can be easily transmitted among members of the *Enterobacteriaceae* through plasmid-mediated transfer. An essential member of the *Enterobacteriaceae* is *Salmonella* spp, which typically resides in the intestinal tract of animals and humans and are shed through faeces.

In developing countries like Nigeria, control over the processing and sales of hawked foods have not been achieved presumably because most of the vendors and sellers lack adequate knowledge of food processing and handling practices. As a result, extensive studies have been conducted on the nutritional and microbial quality of Kunun-zaki and other hawked indigenous drinks and beverages to increase public awareness, and draw the attention of the relevant food authorities to the health risks and hazards associated with the consumption of such contaminated food products [15, 31-34]. Following up from our previous study [15], in this study, we aimed to determine the presence of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Staphylococcus aureus* (VRSA) and extended-spectrum beta-lactamase (ESBL) producing *Salmonella* spp in Kunun-zaki drinks sold in Umuahia metropolis, Nigeria.

MATERIALS AND METHODS

Sample collection

Forty (40) samples of Kunun-zaki were purchased randomly from different hawkers within Umuahia metropolis, Nigeria. The samples were transported to the laboratory in an icebox within an hour of collection and were preserved in a refrigerator at 4 °C before being analyzed. The samples were analyzed within two hours of collection.

Media used

All the media used for this study were obtained from Titan Biotech Ltd. Rajasthan, India. The media were prepared according to the manufacturers' instructions.

Salmonella spp identification and characterization

An aliquot of each sample (1 ml) was enriched in a 1:10 ratio of peptone water at 37°C for 24 hours. The enriched samples were serially diluted up to 10^5 and 0.1ml of the appropriate dilutions were spread plated on *Salmonella Shigella* Agar (SSA) and incubated at 37°C for 24 hours. Presumptive distinct colonies (SSA: black-centred colonies) were counted and expressed as *Salmonella* spp colony forming unit per millilitre (CFU/ml) of each Kunun-zaki sample. Single colonies of *Salmonella* spp were sub-cultured for 24 hours at 37°C on nutrient agar to obtain pure cultures for biochemical identification and antimicrobial testing. Presumptive colonies were tested for the biochemical properties of *Salmonella* spp (oxidase reaction, citrate utilization test, indole production test, urease test, triple sugar iron test and H_2S production).

Staphylococcus aureus identification and characterization

An aliquot of each sample (1 ml) was enriched in a 1:10 ratio of peptone water at 37 °C for 24 hours. The enriched samples were serially diluted up to 10^5 and 0.1ml of the appropriate dilutions were spread plated on Mannitol-salt Agar (MSA) and incubated at 37°C for 24 hours. Presumptive distinct colonies (MSA: yellow colonies with yellow zones) were counted and expressed as *S. aureus* colony forming unit per millilitre (CFU/ml) of each Kunun-zaki sample. Single colonies of *S. aureus* were sub-cultured for 24 hours at 37°C on

nutrient agar to obtain pure cultures for biochemical identification and antimicrobial testing. Presumptive colonies were tested for the biochemical properties of *S. aureus* (catalase reaction, coagulase test, citrate utilization test, oxidase reaction, urease, and indole production test).

Salmonella spp antibiotic resistance profiles

To assess the antibiotic resistance profiles of the *Salmonella* isolates, standard inoculums of the isolates were prepared from the pure cultures of *Salmonella* spp as described by Cheesbrough [35]. Standardized inoculums (one loopful) of each of the samples were subjected to susceptibility testing on Mueller Hinton Agar against 12 antimicrobial agents according to the Clinical and Laboratory Standards Institute (CLSI) protocol and criteria [36]. The following antibiotics were used: ceftazidime (CAZ; 30µg), cefuroxime (CRX; 30 µg), gentamicin (GEN; 10 µg), ciprofloxacin (CPR; 5 µg), ofloxacin (OFL; 5 µg), augmentin (AUG; 30 µg), nitrofurantoin (NIT; 300 µg), ampicillin (AMP; 10 µg), aztreonam (ATM; 30 µg), ceftriaxone (CTR; 30 µg), imipenem (IMP; 10 µg) and meropenem (MEM; 10 µg) (Rapid labs. Ltd. Colchester, Essex, United Kingdom).

Staphylococcus aureus antibiotic resistance profiles: Methicillin-resistant *Staphylococcus aureus* and Vancomycin-resistant *Staphylococcus aureus*

To assess the antibiotic resistance profiles of the *S. aureus* isolates, standard inoculums of the isolates were prepared from the pure cultures of *S. aureus* as described by Cheesbrough [35]. Standardized inoculums (one loopful) of each of the samples were subjected to susceptibility testing on Mueller Hinton Agar against ten antimicrobial agents according to the Clinical and Laboratory Standards Institute (CLSI) protocol and criteria [36]. The following antibiotics were used: ceftazidime (CAZ; 30 µg), ceftriaxone (CTR; 30 µg), gentamicin (GEN; 10 µg), ciprofloxacin (CPR; 5 µg), ofloxacin (OFL; 5 µg), augmentin (AUG; 30 µg), erythromycin (ERY; 5 µg), vancomycin (VAN; 10 µg), oxacillin (OXA; 5 µg) and cloxacillin (CXC; 5 µg) (Rapid labs. Ltd. Colchester, Essex, United Kingdom).

Detection of Extended spectrum beta-lactamases (ESBL) producing *Salmonella* spp

For detection of ESBL producing *Salmonella* spp, isolates with zones of inhibition (in diameters) of <25 mm, <22 mm and <27 mm for ceftriaxone (CTR; 30 µg), ceftazidime (CAZ; 30 µg) and aztreonam (ATM; 30 µg) respectively from the antibiotic resistance profiling were regarded as potential ESBL producers according to the Clinical and Laboratory Standards Institute (CLSI) criteria [37], and subjected to a confirmatory Double Disc Synergy Test (DDST). The DDST confirmatory test was carried out as described by Jarlier et al. [38] using two oxyimino-cephalosporins (CTR and CAZ) and a monobactam (ATM) all placed at 20 mm distance apart center to center from an AUG disc placed at the center. Positive DDST result is indicated by an enhancement of inhibition zone of the cephalosporins and monobactam towards the central augmentin disc [39, 40].

RESULTS AND DISCUSSION

Presence of Foodborne Pathogens

To assess the presence of selected bacterial foodborne pathogens, forty (40) hawked Kunun-zaki samples were examined for *Salmonella* spp and *S. aureus*.

Salmonella spp were detected in 19 (47.5%) out of the 40 Kunun-zaki samples examined (Figure 1), and the total *Salmonella* spp count (CFU/ml) ranged from 1.90×10^{5}-9.70×10^{6} (Table 1).

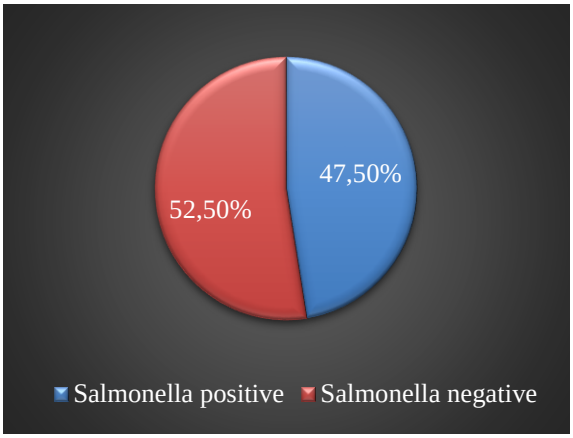


Figure 1 – Percentage occurrence of *Salmonella* spp isolates from the Kunun-zaki

Table 1 – The *Salmonella* spp count (CFU/ml) and *S. aureus* count (CFU/ml) in the Kunun-zaki samples

Kunun-zaki samples	*Salmonella* spp count (CFU/ml)	*S. aureus* count (CFU/ml)
KZ1	1.27×10^6	3.40×10^5
KZ2	-	4.50×10^5
KZ3	-	5.90×10^5
KZ4	8.30×10^6	3.70×10^5
KZ7	7.70×10^5	5.60×10^5
KZ8	8.00×10^5	-
KZ9	6.70×10^5	-
KZ10	-	6.40×10^5
KZ11	-	3.60×10^5
KZ12	-	5.90×10^6
KZ13	5.50×10^5	1.58×10^6
KZ14	-	6.40×10^6
KZ16	7.60×10^5	-
KZ18	1.90×10^5	-
KZ19	3.60×10^6	6.90×10^5
KZ20	7.40×10^5	-
KZ21	3.40×10^5	1.37×10^6
KZ22	-	7.50×10^5
KZ24	3.20×10^5	-
KZ25	-	6.80×10^5
KZ27	6.30×10^5	-
KZ28	-	7.40×10^5
KZ29	-	3.40×10^4
KZ30	9.10×10^5	6.50×10^5
KZ31	-	1.28×10^6
KZ33	1.12×10^6	-
KZ34	7.30×10^5	7.80×10^5
KZ35	7.40×10^5	1.46×10^6
KZ36	-	5.70×10^5
KZ38	1.78×10^6	-
KZ39	9.70×10^6	-
KZ40	-	7.50×10^6

Notes: KZ= Kunun-zaki sample

Previous reports have shown varying percentage rates of incidence. For instance, Gyar et al. [41] reported the recovery of *Salmonella* in 7 (28%) out of 25 Kunun-zaki samples examined in Keffi Metropolis, Nigeria; whilst Braide et al. [42] reported the recovery of *Salmonella* from 12 (75%) out of 16 Kunun-zaki samples bought and examined in Owerri, Nigeria. More so, Aboh and Oladosu [43] reported the recovery of *Salmonella* from 1 (2.4%) out of a total of 41 Kunun-zaki samples examined in Abuja, Northern Nigeria. The disparity in the number of *Salmonella* isolates may be due to the differences in the number of Kunun-zaki samples studied, the isolation procedures implemented and the cultural habit of the population; as well as discrepancies in the quality control standards in the processing, preparation, storage, packaging and delivery of the Kunun-zaki.

According to the Center for Food Safety [44], there should be no detectable *Salmonella* spp in any mg/ml of any processed food substance ready and fit for human consumption. *Salmonella* spp are a significant cause of foodborne diseases and may colonize the intestinal tract of a large number of mammals and birds causing symptoms such as nausea, vomiting, abdominal cramps, diarrhoea fever, and headache [45].

Going forward, *S. aureus* was detected in 22 (55%) out of the 40 Kunun-Zaki samples (Figure 2), and the total *S. aureus* count (CFU/ml) ranged from 3.40×10^4-7.50×10^6 (Table 1).

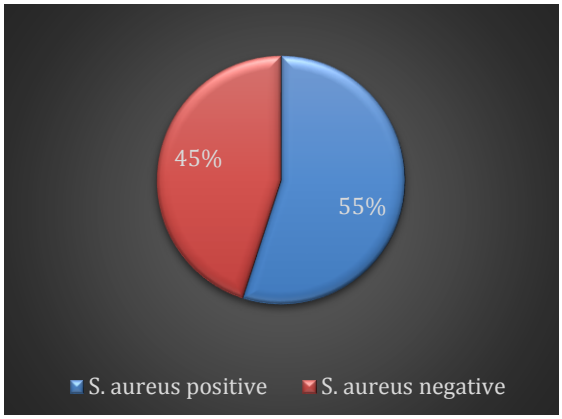


Figure 2 – Percentage occurrence of *S. aureus* isolates from the Kunun-zaki samples

Similar results have been reported in previous studies, although with a higher percentage rate of incidence. For instance, Gyar et al. [41] reported that 18 (72%) out of the total 25 Kunun-zaki samples examined in Keffi metropolis, Nigeria, were contaminated with *S. aureus*, whilst Braide et al. [42] reported the recovery of *S. aureus* from 11 (69%) out of the 16 Kunun-zaki samples examined in Owerri, Nigeria. Aboh and Oladosu [43] reported a much lower incidence rate in Abuja, Nigeria (6 (14.6%) *S. aureus* positive samples out of the total 41 Kunun-zaki samples examined).

Again, the discrepancies in the number of *S. aureus* isolates reported might be attributed to the differences in the number of Kunun-zaki samples examined, the isolation procedures implemented and probably, the cultural habit of the population; as well as the discrepancies in the quality control standards in the processing, preparation, storage, packaging and delivery of the Kunun-zaki.

According to the Center for Food Safety [44], the satisfactory limit for *S. aureus* detection in food is <20 CFU/ml with a borderline of 20 - $\leq 10^4$ CFU/ml, above which the food is deemed unsatisfactory. Hence, the *S. aureus* count revealed that the Kunun-zaki drinks were unfit for consumption. *S. aureus,* as a foodborne pathogen has the potential to cause food poisoning or intoxication through the production of several enterotoxins.

The presence of *Salmonella* spp and *S. aureus* in Kunun-zaki samples might result from both direct contamination from the food handlers at the various stages of the unit operations; and indirectly from the water and containers used in its preparation and packaging, the substrates and ingredients used for preparation, and the environment where the Kunun-zaki samples are processed and hawked [46].

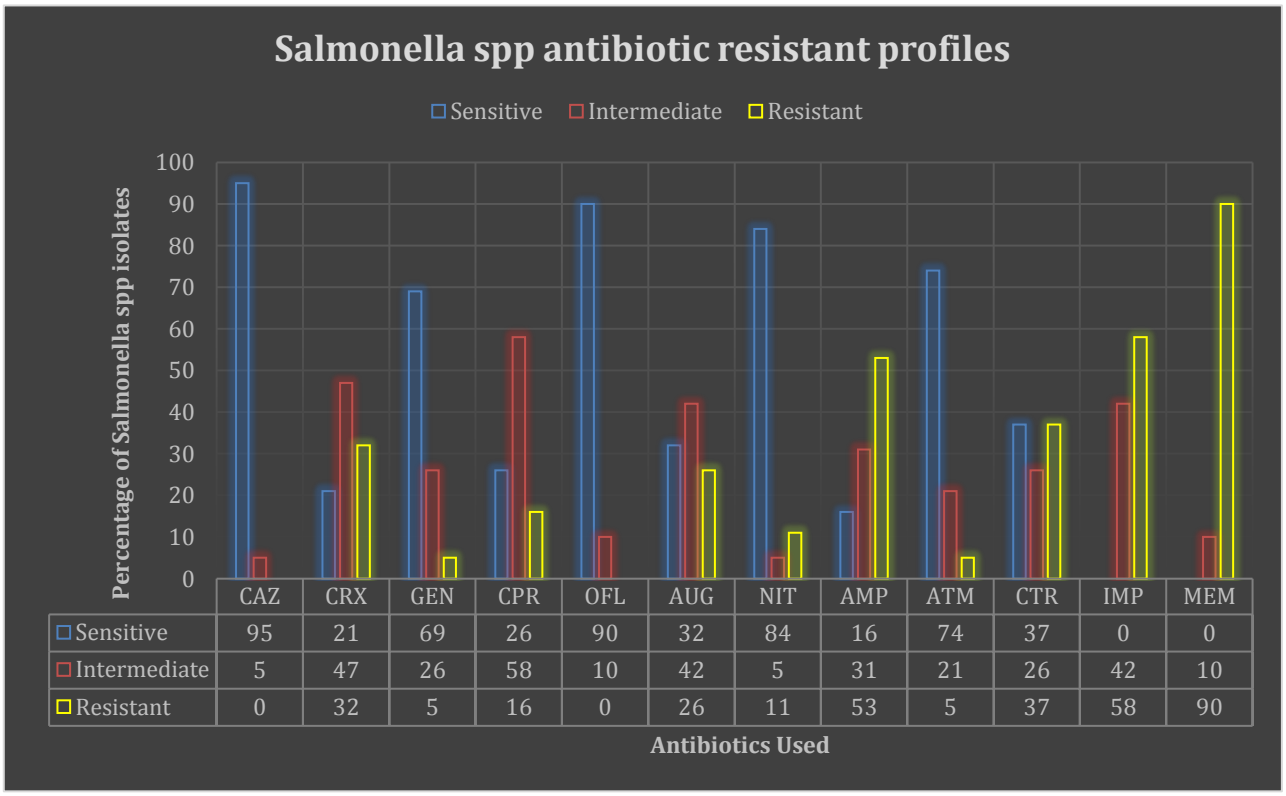
Furthermore, since the preparation process of Kunun-zaki involves pasteurization, a process that could eliminate both *Salmonella* spp and *S. aureus*, the other media through which the drinks can be contaminated would be the sugars, sweeteners and / or water added to the drink after cooling, just before packaging.

Antibiotic Resistance

Modified Kirby Bauer disc diffusion test of the isolates revealed varying levels and patterns of susceptibility to the antibiotics tested (Figure 3 and Figure 4). The *Salmonella* spp were resistant to the beta lactam class of antibiotics used (IMP 58%, MEM 90%, AMP 53%) (Figure 3).

The *S. aureus* isolates revealed high resistance to oxacillin (41%) and the oxyimino-cephalosporin antibiotics used (CAZ 55%, CTR 41%) (Figure 4). Interestingly, 91% of the *Staphylococcus aureus* isolates were classified as multidrug resistant because they were MRSA and / or non-susceptible to at least one antimicrobial agent in three or more antimicrobial categories as defined by [47] (Table 2).

The persistent and indiscriminate exposure of bacterial strains to a multitude of antibiotics has led to the development of multidrug resistant bacteria [48]. Another possible medium for the development of MDR is through plasmid mediated resistance [49]. However, over 90% of the foodborne pathogens isolated from this study were susceptible to treatment with ofloxacin. This increased sensitivity to ofloxacin may stem from the fact that the antibiotics are not frequently used in therapeutic or prophylaxis therapy due to its high cost [49].



	CAZ	CRX	GEN	CPR	OFL	AUG	NIT	AMP	ATM	CTR	IMP	MEM
Sensitive	95	21	69	26	90	32	84	16	74	37	0	0
Intermediate	5	47	26	58	10	42	5	31	21	26	42	10
Resistant	0	32	5	16	0	26	11	53	5	37	58	90

Figure 3 – Antibiotic-resistant profiles of the *Salmonella* spp isolates

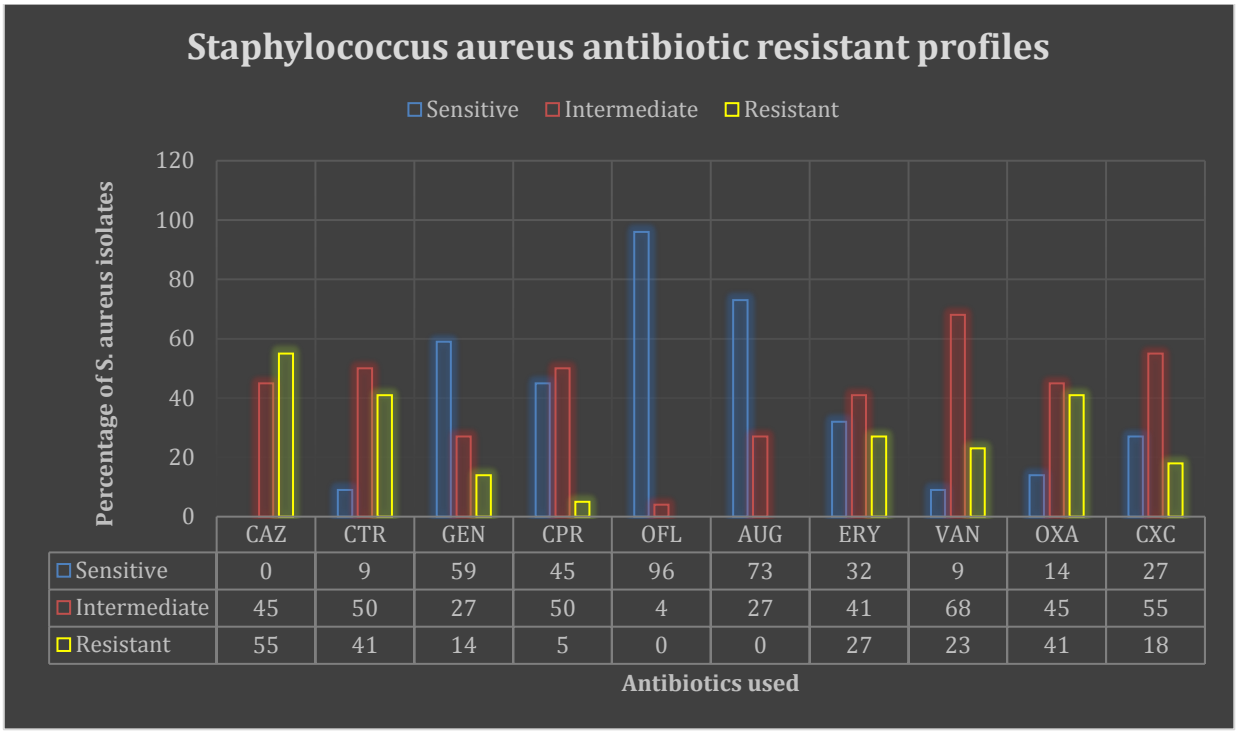


Figure 4 –Antibiotics resistant profiles of the *Staphylococcus aureus* isolates

Table 2 – Multidrug resistance in the *Staphylococcus aureus* isolates

S. aureus isolates	Antimicrobial category					MDR status
	Aminoglycosides (GEN)	Fluoroquinolones (CPR)	Macrolides (ERY)	Glycopeptides (VAN)	Anti-Staphylococcal Beta Lactams (OXA)	
KZ1	S	NS	S	NS	NS	MDR
KZ2	S	NS	S	NS	NS	MDR
KZ3	NS	S	S	NS	NS	MDR
KZ4	NS	S	NS	S	NS	MDR
KZ7	S	S	NS	NS	NS	MDR
KZ10	S	S	NS	NS	S	NO MDR
KZ11	S	NS	S	NS	NS	MDR
KZ12	S	S	NS	NS	NS	MDR
KZ13	S	S	S	NS	S	NO MDR
KZ14	S	NS	NS	NS	NS	MDR
KZ19	NS	NS	NS	NS	S	MDR
KZ21	S	S	NS	NS	NS	MDR
KZ22	NS	S	NS	NS	NS	MDR
KZ25	NS	NS	NS	NS	NS	MDR
KZ28	NS	NS	NS	NS	NS	MDR
KZ29	NS	NS	NS	NS	NS	MDR
KZ30	NS	S	S	NS	NS	MDR
KZ31	S	NS	NS	S	NS	MDR
KZ34	S	NS	NS	NS	NS	MDR
KZ35	S	NS	S	NS	NS	MDR
KZ36	NS	S	NS	NS	NS	MDR
KZ40	S	NS	NS	NS	NS	MDR
MDR Incidence Percentage						91%

Notes: S=susceptible, NS=non-susceptible

With regards to antibiotic resistance, MRSA, VRSA and ESBL producing *Enterobacteriaceae* are currently of particular public health concern. In this study, 41% of the isolates were MRSA, 23% were VRSA and 68% were VISA (Figure 4). In addition, 26% of the *Salmonella* spp isolates were confirmed to be ESBL producers based on the DDST (Figure 5).

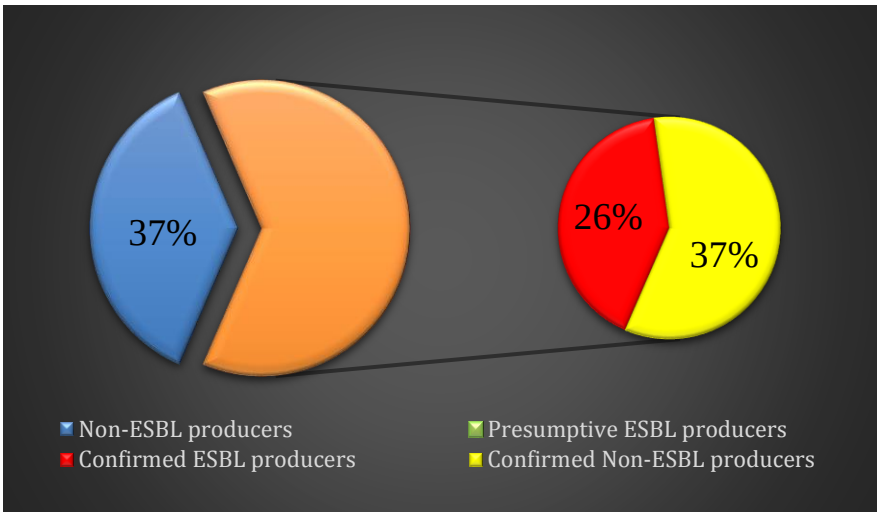


Figure 5 – Percentage occurrence of ESBL producing *Salmonella* spp based on the phenotypic breakpoint and Double Disc Synergy Test (DDST)

Previously, vancomycin has been widely utilized for the treatment of MRSA infections and this has led to the emergence of VRSA and VISA [25]. Following treatment of MRSA patients with vancomycin, VISA isolates emerged as a result of mutations in MRSA isolates [50].

CONCLUSION

The results obtained from this study revealed that Kunun-zaki sold in Umuahia metropolis, Nigeria, is contaminated with important bacterial foodborne pathogens, and whose counts do not conform to the standard limits of detectable microbes in ready-to-eat foods as stipulated by the Center for Food Safety. Hence, the consumption of these products may constitute serious public health concerns if not correctly quality controlled. From this study, it is evident that this product could include a source of ESBL producing *Salmonella*, MRSA and VRSA, amongst other pathogenic microbes which were not detected in the study but have been previously reported. Whilst consumption of Kunun-zaki is encouraged due to its health and nutritional benefits as registered from recent and previous studies, its production, processing and packaging should be regulated appropriately, and strict compliance with acceptable hygiene practices during any step of preparation, storage and distribution to the final consumer are essential to prevent contamination with foodborne pathogens and any health complications that may result thereof.

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Information Resources Economy in Satellite Systems based on New Microwave Polarizers with Tunable Posts

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Abstract. One of the fundamental problems of modern digital telecommunications is the economy of digital information and frequency resources, which are highly limited. The introduction of novel telecommunication systems and 5G networks requires searching for principal solutions for the economy and reusing the frequency spectrum. Therefore, modern wireless mobile, terrestrial, and satellite systems use various new technologies to increase communication channels' information capacity for the economy of limited frequency resources. One of the most effective ways to reuse the information system's operating frequency band is to apply antennas with polarisation signal processing. Such systems provide the possibility to transmit and to receive simultaneously signals with different types of polarisation.

Consequently, the application of electromagnetic waves with two orthogonal polarisations improves wireless systems' information characteristics for various purposes. This allows doubling the information capacity of mobile, terrestrial, and satellite communication channels. Also, polarisation processing is carried out in meteorological and radar systems to receive, transmit, and process information. The essential elements of such systems are microwave polarisers and orthomode transducers. The electromagnetic characteristics of these devices affect the aspects of the whole system significantly. Main electromagnetic factors include phase, matching, and polarisation parameters. The article presents the development of a compact tunable polarizer based on a square waveguide with three posts. The developed polariser operates in the X-band from 8.0 GHz to 8.5 GHz. Created a mathematical model of the polariser is based on the scattering and transmission matrices. To verify the developed theoretical model's correctness, the calculation of all characteristics was also performed numerically using the finite integration technique. The developed compact polariser based on a square waveguide with three posts allows tuning it's matching and polarisation characteristics by changing all posts' heights. The developed polariser's main advantages are small dimensions, tuning options, and aspects of polarisation transformation.

Keywords: information resources; satellite systems; circular polarization; microwave polarizer; waveguide polarizer; tunable polarizer; frequency spectrum; differential phase shift; cross-polar discrimination; axial ratio.

INTRODUCTION

Nowadays, the increase in communication channels' information capacity and their energy efficiency are essential crucial problems. In particular, in 5G networks, this problem resulted in the occurrence and widespread application of D2D direct connection technologies [1, 2], M2M technologies [3], and OFDM technology [4, 5]. In modern satellite systems and radars, polarisation signal processing is effectively applied to reuse the frequency resources [6, 7].

The key elements of antenna systems engaged in dual-polarization signal processing are microwave devices of feeds. Namely, polarisation processing is carried out by waveguide polarizers in combination with orthomode transducers. Polarisers introduce the necessary phase shift and convert circular polarisations into linear ones. In turn, the orthomode transducer separates linearly polarised signals and directs them to two highly isolated waveguide channels [8, 9]. The modern designs

of polarizers are realized in the form of waveguide structures with irises [10, 11, 12], ridges [13, 14, 15, 16, 17], posts [18, 19, 20, 21, 22, 23, 24], thin metal septums [25, 26] and slots [27, 28]. The waveguide polarizers with posts and irises operate similarly to the post and iris waveguide phase shifters applied in phased array antennas and other systems [29, 30, 31, 32, 33, 34, 35, 36].

In paper [8], the authors presented the design and simulated characteristics of a novel high-performance coherent ortomode transducer for new antenna designs with polarisation processing of radio signals. Developed orthomode transducer provides the following features in the operating satellite frequency bands 3.4–4.2 GHz and 10.7–12.8 GHz: VSWR for the main modes of horizontal and vertical polarisations are less than 1.06, the differential phase shift is within the range 90°±1º, the XPD is higher than 70 dB. The author of the article [9] developed a broadband coherent orthomode transducer based on a coaxial quad-ridged waveguide for the operating frequency range 3.4–5.4 GHz. The orthomode transducer's reflection coefficient does not exceed −24 dB; the cross-polar discrimination (XPD) exceeds 38 dB. Developed orthomode transducer is used in dual-polarization multiband antennas.

The article [10] proposes a new waveguide polarizer with irises for the operating C-band. The 30% operating fractional bandwidth provides a reflection coefficient of −40 dB and a cross-polar discrimination level of −35 dB. In articles [10, 11], a polarizer based on a square waveguide with irises for the Ku-frequency band was developed. The square waveguide polarizer with four irises provides VSWR less than 1.24. Its differential phase shift is 90°±3.5°. The axial ratio is less than 0.53 dB. The XPD is higher than 30.3 dB. In [13], the authors used the transverse-modal matching technique in partial regions to analyze coaxial ridged waveguides used to develop the polarisation processing devices. The article [14, 15] is devoted to considering eigenmodes of coaxial quad-ridged waveguides utilizing integral equations. This method allows taking into account the singular behavior of the fields on the edges of waveguides. Calculations confirm the reliability of the obtained results based on the finite differences technique. The article [16] presents the feed system's design for reflector antennas of dual circular polarisation satellite communication appliances. The feed system has been optimized for the operation in extended C-band 3.4–4.8 GHz. VSWR of the development system is less than 1.14, and its XPD is higher than 30 dB. Paper [17] contains the development of a mathematical model of sectoral ridged waveguides using the integral equation technique.

The article [18] contains wave propagation in periodically loaded waveguide structures with cylindrical posts. Theoretical and experimental investigations of semi-periodic systems and their scattering matrices are performed. Article [19] offers the results of testing and numerical simulation of the reactance of posts in a circular waveguide. The reactance is a function of the waveguide and post dimensions and frequency, and the results presented are useful in the design of a variety of circular waveguide devices. The paper [20] shows scattering characteristics of a radially directed thin post in a circular waveguide using moments. Electric-type dyadic Green's function has been used to compute the scattered field in a circular waveguide considering the current variation in the post's axial direction. In the article [21], the authors analyzed three transverse cylindrical posts in a rectangular waveguide. It is shown that a relatively large shunt reactance range is achievable compared to that from a single variable-length post. The authors of [22] proposed a high-speed electromagnetic analysis of substrate integrated waveguides and substrate integrated slab waveguides. The developed method is used for the accurate and fast analysis of structures composed of metallic and dielectric posts in a parallel-plate waveguide environment. The article [23] analyzed functional post-wall waveguides formed by periodically distributed dielectric centers. The developed formulation is accurate and numerically very fast. Our investigations' final goal is to realize the available dielectric post-wall waveguide-based filters, which are expected to have a practical application in the THz region. A compact circular waveguide polarizer with a higher-order input mode (TM01) is presented in this paper [24]. The proposed design consists of a triangular metallic plate for TM01-TE11 (linearly polarised) mode conversion and metallic posts loading for linear TE11 to circular TE11 polarisation conversion.

The article [27] presents a polariser's design in a circular waveguide with irises realized using slots. The polariser can be reconfigured by rotating the irises relative to each other, providing the polarisation plane's rotation up to cross-one. Being relatively narrowband, the polarizer has a longitudinal dimension $\lambda_0/50$-$\lambda_0/10$. Article [28] presents the design, development, and characterization of compact wideband three-dimensional

(3-D) printed circular waveguide-based polariser operating in Ka-band (28-34 GHz). The polariser structure is investigated using fundamental and higher-order modes, based on which a simplified equivalent structure is derived, giving physical insight into its mechanism of operation. The design consists of a pair of radially opposite grooves inside a circular waveguide and excited using a coaxial probe, making the design simple and highly compact compared to other conventional circular polarizers.

The article [25] presents a novel broadband septum polariser with a relative bandwidth of 37.8%. It is enabled by using an equilateral triangular standard port waveguide, which guarantees the most extensive possible frequency range between fundamental and next higher-order mode cutoff. The authors developed polarisers in the field of 75-110 GHz and 18-26 GHz. Such polarizers provided the axial ratio remains below 1.3 dB, whereas the input port isolation and the input return loss exceed 17 and 15 dB, respectively. The authors [26] developed and optimized Q- and K-band waveguide polarizers with longitudinal septums of constant thicknesses. The optimal designs and their electromagnetic performance were analyzed for fractional bandwidths from 5% to 20% using the frequency domain's finite element method.

Article [29] presents a new phase shifter with two waveguide posts based on substrate integrated waveguide technique. Phase shifting is achieved by changing the diameter and metallic inductive positions inserted in the substrate integrated waveguide substrate. In article [30], a tunable phase shifter's design in a waveguide-based on two metal posts is proposed. The measured return loss and phase performances of this prototype are compared with the phase shifter's simulated full-wave response. The proposed waveguide component shows a great application potential in beam steering phased arrays implemented in waveguide technology.

The performed review demonstrates that polarisers based on a waveguide with posts is the simplest from the design point of view and provides the tuning option. It can improve the economy of information resources in satellite antenna systems. Therefore, this article is devoted to developing a new mathematical model for a polariser based on a square waveguide with three posts. Such a model allows performing the analysis and optimization of matching and polarisation characteristics.

RESULTS

Mathematical model of tunable waveguide polarizer

The design of the waveguide polarizer is shown in Figure 1. The structure contains two posts of height h_1 and diameter d, one position of height h_2 and diameter d, the distance between the centers is l. Moreover, the height of the central post h_2 is greater than the other posts h_1.

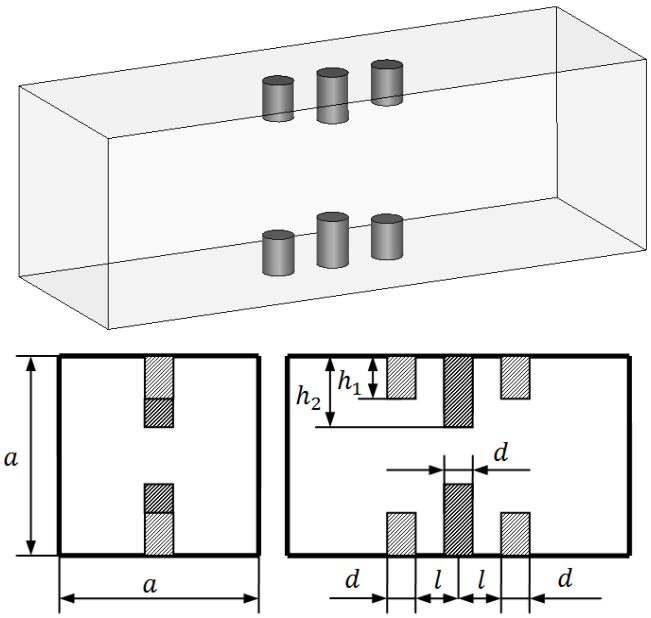


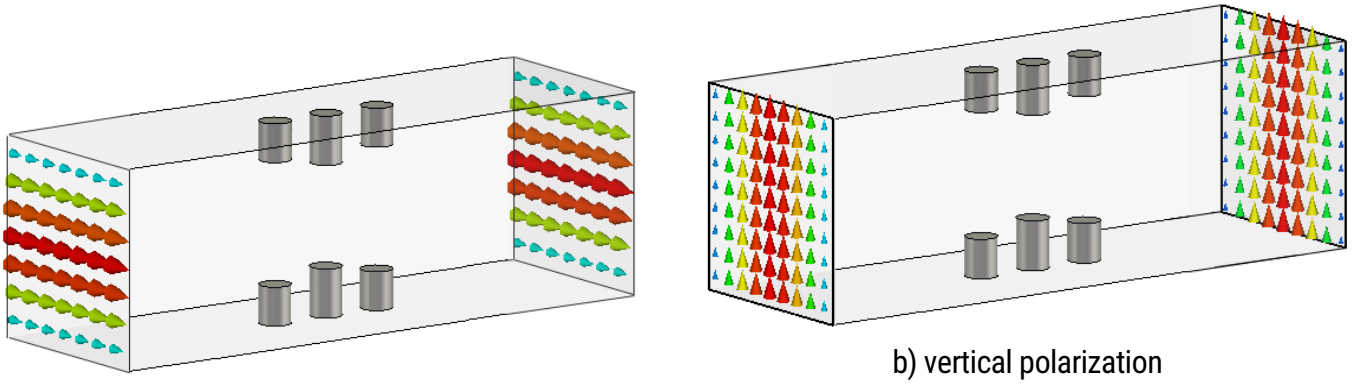
Figure 1 – Polariser design based on a waveguide with three posts

The presence of a cylindrical post allows you to adjust the device's characteristics by changing the post's length.

Figure 2 shows the electric field vectors' spatial location for vertical and horizontal polarisations at the square waveguide polariser's ports.

We represent a polariser with an equivalent circuit using the theory of microwave circuits (Figure 3). Figure 3a shows an equivalent circuit of a polariser model with three capacitive posts. Figure 3b shows an equivalent circuit of a polariser model with three inductive posts. The identical circuit model with inductive seats will have only one regular transmission line [31–32]. The posts are perpendicular to the electric field lines, and the bases are not high relative to the wall size.

Thin inductive posts weakly influence the electric field vector's fundamental electromagnetic mode perpendicular to the post axis. Consequently, the equivalent circuit of a waveguide with inductive posts is as shown in Figure 3b.



a) horizontal polarization

b) vertical polarization

Figure 2 – Electric field vectors at the ports of the square waveguide polariser

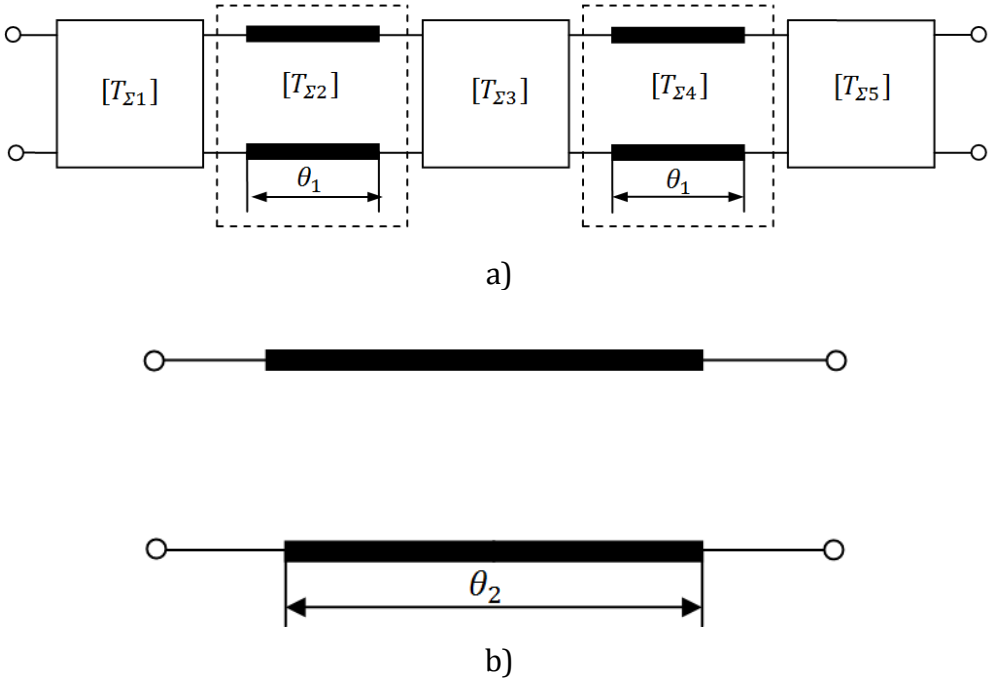


Figure 3 – Equivalent circuit models of the waveguide polariser

a) with three capacitive posts; b) with three inductive posts

The following expression connects the wave scattering and transmission matrices of the two-port device (1):

$$[S_\Sigma]=\begin{bmatrix} S_{\Sigma 11} & S_{\Sigma 12} \\ S_{\Sigma 21} & S_{\Sigma 22} \end{bmatrix}=\frac{1}{T_{\Sigma 11}}\begin{bmatrix} T_{\Sigma 21} & |T| \\ 1 & -T_{\Sigma 12} \end{bmatrix}, \quad (1)$$

where $|T|$ is a determinant of the transmission wave matrix.

We form general wave scattering matrices based on the microwave theory [36], having divided the equivalent circuit of the polariser into smaller courses. In the case of capacitive posts (Figure 3a), we obtain (2):

$$[T_\Sigma]=[T_1]\cdot[T_2]\cdot[T_3]\cdot[T_4]\cdot[T_5]=\begin{bmatrix} T_{\Sigma 11} & T_{\Sigma 12} \\ T_{\Sigma 21} & T_{\Sigma 22} \end{bmatrix}, \quad (2)$$

where

$$[T_1]=[T_5]=\frac{1}{2}\begin{bmatrix} 2+Y_{p1} & -Y_{p1} \\ -Y_{p1} & 2-Y_{p1} \end{bmatrix},$$

$$[T_3]=\frac{1}{2}\begin{bmatrix} 2+Y_{p2} & -Y_{p2} \\ -Y_{p2} & 2-Y_{p2} \end{bmatrix},$$

$$[T_2]=[T_4]=\begin{bmatrix} e^{j\theta_1} & 0 \\ 0 & e^{-j\theta_1} \end{bmatrix},$$

where Y_{p1} and Y_{p2} are the conductivity of the posts, θ_1 is electric line length.

The electric length of a regular transmission line in the case of capacitive posts:

$$\theta_1=\frac{2\pi l}{\lambda_g}, \quad (3)$$

where λ_g is the wavelength in the waveguide.

The wavelength in the waveguide:

$$\lambda_g=\frac{\lambda_0}{\sqrt{1-\left(\frac{\lambda_0}{\lambda_c}\right)^2}}, \quad (4)$$

where λ_0 is the wavelength in the free space; λ_C is the cutoff wavelength.

The expression determines the conductivity of the post [33]:

$$Y_p=\frac{j\pi\lambda_0\lambda_g[1-\cos(kh_p)]^2}{a^2k(\mathrm{a-r})(2+\cos(2kh_p))-\ln(\mathrm{a/r})\sin(2kh_p)}, \quad (5)$$

where a is the length of the wall of a square waveguide; h_p is the height of the post in the waveguide; k is wave number; r is post radius.

Figure 4 presents a capacitive post in a rectangular waveguide.

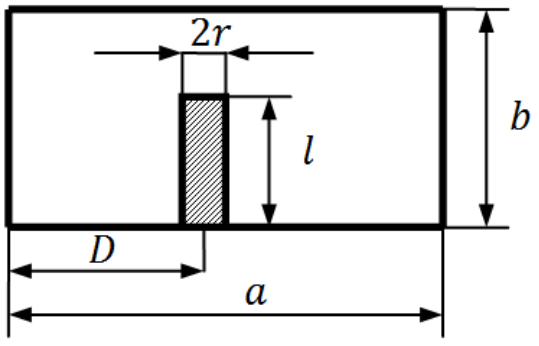


Figure 4 – Capacitive post in a rectangular waveguide

Figure 5 shows the dependence of the module of the conductivity of the posts on the frequency.

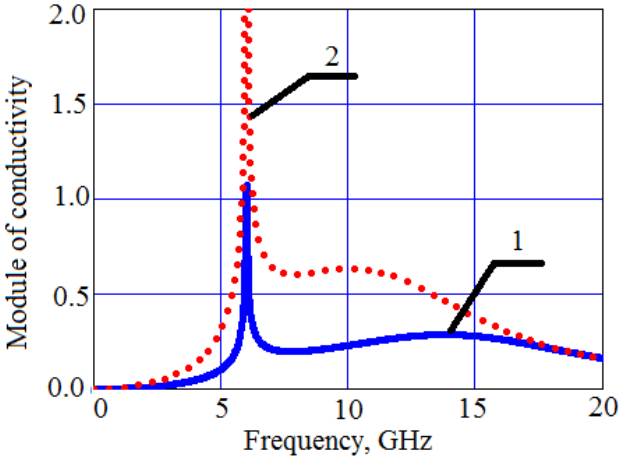


Figure 5 – Dependence of the module of the conductivity on frequency

In Figure 5, we can see that the module of the conductivity of the middle post 2 is greater than the module of the conductivity of the extreme point of curve 1. This indicates that the medium post has a more substantial effect on the electromagnetic characteristics of the polariser.

In the case of inductive posts, the total wave transmission matrix is determined as follows:

$$[T_\Sigma]=\begin{bmatrix} e^{j\theta_2} & 0 \\ 0 & e^{-j\theta_2} \end{bmatrix}=\begin{bmatrix} T_{\Sigma 11} & T_{\Sigma 12} \\ T_{\Sigma 21} & T_{\Sigma 22} \end{bmatrix}, \quad (6)$$

where θ_2 is electric line length.

The electric length of a regular transmission line in the case of the inductive posts is as follows:

$$\theta_2=\frac{2\pi l_2}{\lambda_g},\ l_2=2l+4r. \quad (7)$$

The main characteristics of the polariser are as follows [34, 35]: phase-frequency dependences, matching, and polarisation characteristics. Phase and matching characteristics are the differential phase shift and the voltage stand wave ratio (VSWR). The polarising elements of a polariser are the axial ratio and the cross-polar discrimination (XPD).

The expression determines the differential phase shift:

$$\Delta\varphi = \varphi_{\sum 21.C} - \varphi_{\sum 21.L}, \quad (8)$$

where $\varphi_{\sum 21.C}$ is a phase of the parameter $S_{21\sum C}$ of the total wave scattering matrix for the model with capacitances; $\varphi_{\sum 21.L}$ is a phase of the parameter $S_{21\sum L}$ of the general wave scattering matrix for the model with inductances.

The formula determines VSWR:

$$VSWR = \left[1 + |S_{11}|\right] / \left[1 - |S_{11}|\right]. \quad (9)$$

The axial ratio is determined as follows:

$$r = 10\lg\left(\frac{A^2 + B^2 + \sqrt{A^4 + B^4 + 2A^2B^2\cos(\Delta\varphi)}}{A^2 + B^2 - \sqrt{A^4 + B^4 + 2A^2B^2\cos(\Delta\varphi)}}\right), \quad (10)$$

where $A = 1$, $B = |S_{21}|$.

The formula calculates XPD:

$$XPD = 20\lg\left[(10^{0.05r} + 1) / (10^{0.05r} - 1)\right]. \quad (11)$$

Figure 6 shows the differential phase shift characteristics of the mathematical model, and Figure 7 shows the matching parts of this model.

Figure 6 demonstrates that the maximum deviation of the differential phase shift from 90º is 4.7º. Figure 7 shows that the full value of VSWR is 1.29.

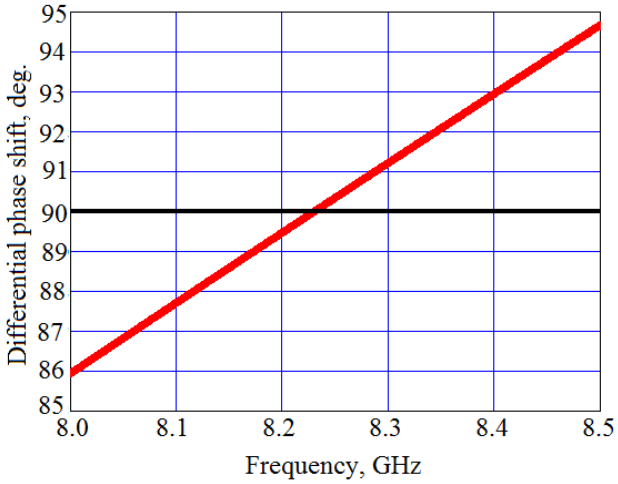


Figure 6 – Dependence of the differential phase shift of the polariser

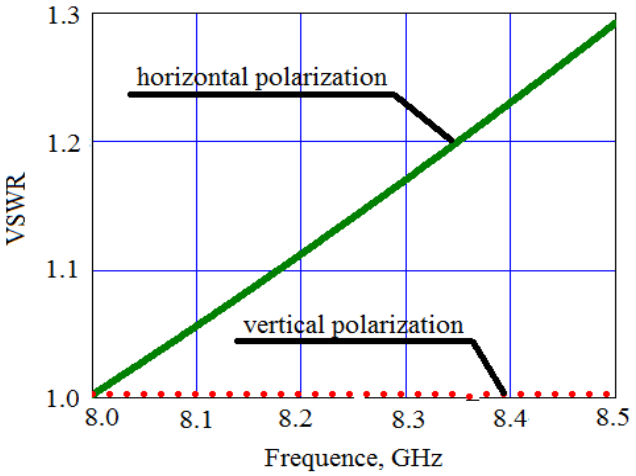
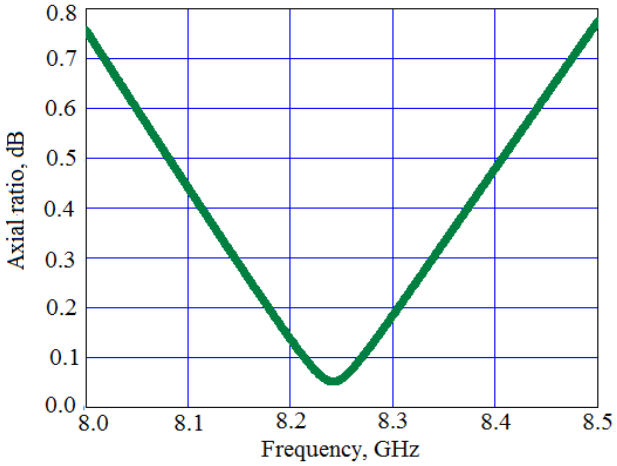
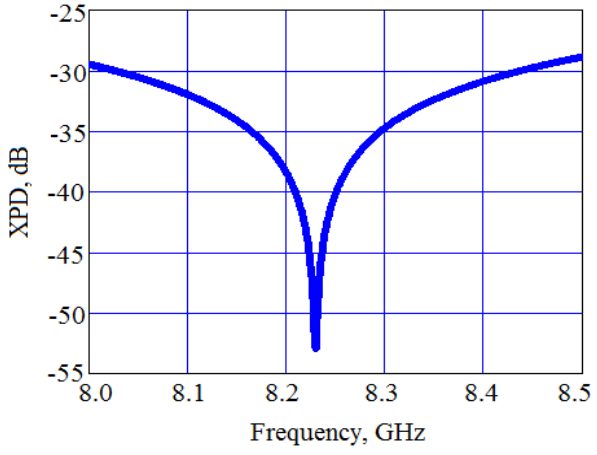


Figure 7 – Matching characteristic of the mathematical model

Figure 8 shows the polarisation characteristics of the mathematical model. Figure 8 represents the axial ratio's dependence on the frequency, and Figure 8b illustrates the support of the XPD on the frequency.



a)



b)

Figure 8 – Polarisation characteristics of the mathematical model

Figure 8a contains the axial ratio's dependence on the frequency, and Figure 8b includes the reliance of the XPD on the frequency. In Figure 8, we see that at a frequency of 8.5 GHz the axial ratio acquires its maximum value of 0.77 dB. Also, at this frequency, the XPD receives a maximum weight of 29 dB.

Thus, within the operating frequency range of 8.0–8.5 GHz, the optimized polariser based on a square waveguide with three posts provides the following characteristics: VSWR for the main modes of horizontal and vertical polarisation is less than 1.29, the differential phase shift is within 90°±4.7º, the axial is less than 0.77 dB, the XPD is higher than 29 dB.

Analysis of the model based on the finite integration technique

Figure 9 and Figure 10 show the phase and matching characteristics of the polariser. Figure 9 contains the differential phase shift's dependence on the frequency, and Figure 10 includes the support of VSWR on the frequency in the operating frequency range from 8.0 GHz to 8.5 GHz.

Figure 9 demonstrates that the maximum deviation of the differential phase shift from 90º is 5.2º. Figure 10 shows that the full value of VSWR is 1.3.

Figure 11 shows the device's polarization characteristics in the operating frequency range from 8.0 GHz to 8.5 GHz. Figure 11 contains the axial ratio's dependence on the frequency, and Figure 11b includes the reliance of the XPD on the frequency. The Figure shows that at a frequency of 8.0 GHz, the axial ratio acquires its maximum value of 0.81 dB. Also, at this frequency, the XPD accepts a maximum weight of 31 dB.

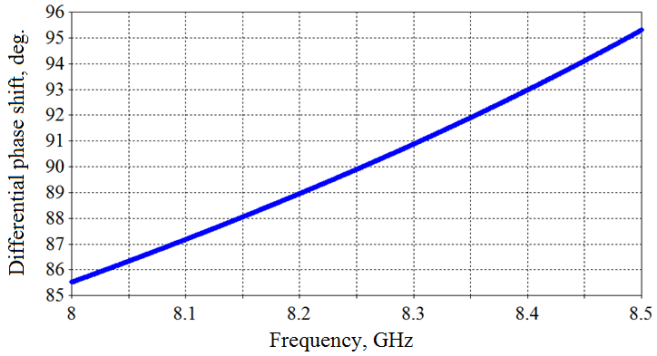


Figure 9 – Dependence of differential phase shift on frequency

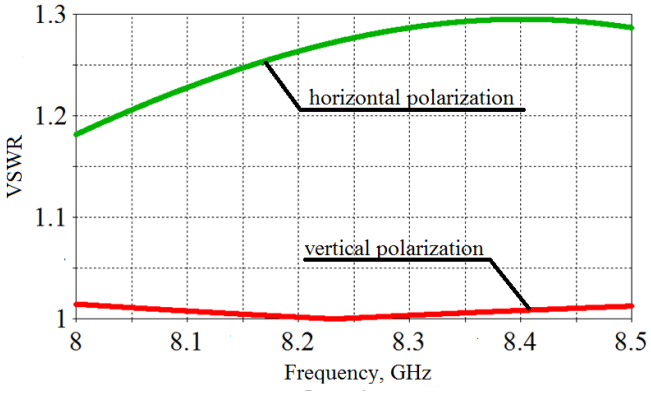
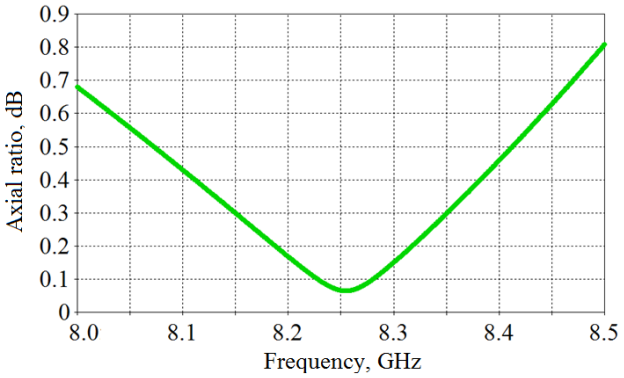
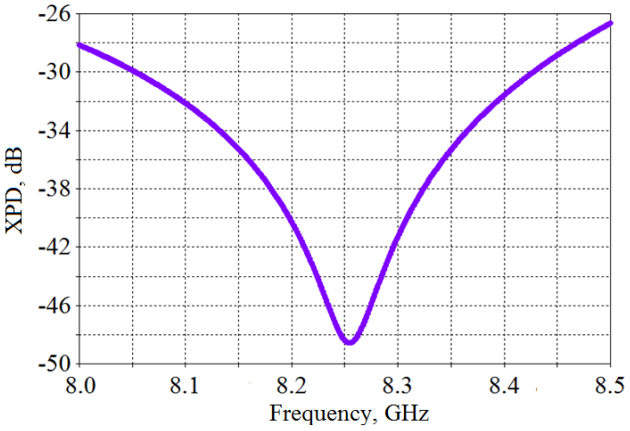


Figure 10 – Dependence of VSWR on frequency

Figure 11a shows that the axial ratio's minimum value is 0.06 dB at a frequency of 8.25 GHz. At the same frequency, the XPD is 48.4 dB. At the minimum frequency of the range, the axial ratio has a value of 0.68 dB, and the XPD is equal to 28 dB.



a)



b)

Figure 11 – Polarisation characteristics of the prototype

Thus, within the operating frequency range of 8.0–8.5 GHz, the optimized polariser based on a square waveguide with three posts provides the following characteristics: VSWR for the main

modes of horizontal and vertical polarisation is less than 1.3, the differential phase shift is within 90°±5.2º, the axial is less than 0.81 dB, the XPD is higher than 26.5 dB.

Comparison of both theoretical models

The optimized polariser sizes are summarised in Table 1.

Table 1 – Sizes of the optimal X-band waveguide iris polarizer obtained by the developed mathematical technique and by the finite integration technique

Size name	Mathematical model	Numerical model
Size of square waveguide walls, mm	a=24,5	a=25,0
Height of the lowest posts, mm	h_1=4,4	h_1=4,8
Height of the medium post, mm	h_2=7,1	h_2=6,9
The gap between the posts, mm	l_1=7,9	l_1=7,6
The thickness of all post, mm	w=3,8	w=4,0

The results were obtained using the developed mathematical technique and the finite integration technique in the operating X-band 8.0 – 8.5 GHz.

Table 2 compares the polariser's characteristics for the mathematical model and the numerical model by finite integration technique.

The small differences in sizes and characteristics given in the tables can explain that the mathematical and numerical models are based on different numerical methods. As we can see, the matching and polarisation characteristics of the mathematical model and numerical model simulated using finite integration technique coincide with relatively high accuracy.

Table 2 – Characteristics of the optimal X-band waveguide iris polarizer obtained by the mathematical model and the numerical model.

Characteristic	Mathematical model	Numerical model
Differential phase shift	90° ± 4,7°	90° ± 5,2°
VSWR	1,29	1,3
Axial ratio	0,77 dB	0,81 dB
XPD	29,0 dB	26,5 dB

CONCLUSIONS

The article suggests the new waveguide polarizer with posts, which improves the information resources economy in satellite information systems. The polariser has a compact design and allows to tune its characteristics by adjusting the positions simply. We proposed a new mathematical model to analyze and optimize the polarizer based on a square waveguide with three posts in the frequency range from 8.0 GHz to 8.5 GHz. The model is based on the general wave scattering matrix of the device. The model allows optimizing its electromagnetic characteristics by changing the design parameters. To compare the results, a numerical model based on the finite integration method was applied to calculate a polarizer's performance. Obtained by both model's products are in good agreement with each other.

The developed square waveguide polarizer with three posts provides the following characteristics. The range of change of the introduced differential phase shift is 90°±5.2°. The developed polariser provides VSWR less than 1.3. The axial ratio is less than 0.81 dB. XPD of the waveguide polarizer is higher than 26.5 dB. Developed square waveguide polarizer with three posts can be widely applied in dual-polarization satellite communication systems to improve their information resources economy.

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Modelling Customer Relationships as Hidden Markov Chains

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Abstract. Models in behavioural relationship marketing suggest that relations between the customer and the company change over time as a result of the continuous encounter. Some theoretical models have been put forward concerning relationship marketing, both from the standpoints of consumer behaviour and empirical modelling. In addition to these, this study proposes the hidden Markov model (HMM) as a potential tool for assessing customer relationships. Specifically, the HMM is submitted via the framework of a Markov chain model to classify customers relationship dynamics of a telecommunication service company by using an experimental data set. We develop and estimate an HMM to relate the unobservable relationship states to the observed buying behaviour of the customers giving an appropriate classification of the customers into the relationship states. By merely accounting for the functional and unobserved heterogeneity with a two-state hidden Markov model and taking estimation into account via an optimal estimation method, the empirical results not only demonstrate the value of the proposed model in assessing the dynamics of a customer relationship over time but also gives the optimal marketing-mixed strategies in different customer state.

Keywords: customer's relationship management; hidden Markov model; Markov chain; transition probability; estimation.

INTRODUCTION

In interactive marketing, the lifetime value of a customer is very vital and useful, especially given the fact that we are in the age of relationship marketing [27]. An essential attribute of service quality is the direct interaction with customers and having customer-oriented behaviours [29]. Customer relationship management (CRM) is a set of process and enabling systems supporting a business strategy to build long term, profitable relationship with the customers [23]. For [6] CRM is a customer-focused business strategy that creates and adds value to the company and its customers. The author [9] presents the usefulness of CRM for some managerial problems, chiefly the budgeting of marketing expenditures for customer acquisition. CRM is also used to allocate spending across media (mail vs telephone vs television) and programs (gift vs special price); it furthermore informs decisions for retaining existing customers [18]. Author [19] avers that its use helps firms to achieve a strategic competitive advantage. It had developed as an approach based on maintaining positive relationships with customers, increasing customer loyalty and expanding customer lifetime value [2].

Despite the wide adoption of CRM in the business world, the academic community has been lagging in developing models that could help businesses analyze transaction data to assess customer relationships and put forward a support system for marketing decisions.

Lately, marketing modellers started to address this gap by developing models of customer lifetime value [15, 28, 31]. However, far less attention has been given to modelling the dynamics of customer relationships and the effect of relationship marketing actions on customer-brand relationships and the customer's choice behaviour.

In addition to the many available tools to assess customer relationships, one useful tool is the hidden Markov model (HMM). HMMs are widely used in science [22], engineering [29] and many other areas [26] and have been successfully applied in engineering problems such as speech recognition [30]. Advanced models such as higher-order HMM with applications in DNA sequences can be found in [7]. Authors [33]

proposed a methodology based on Partially Observable Markov Decision Processes (POMDPs) with general state and action spaces, under a fractional discounted criterion, a model that combines the Hidden Markov Models with the Markov Decision Process by capturing both dynamics that depend on unobserved states and effects of decisions over time. However, not much work has been done in the field of marketing science.

In an interest in finding patterns in customer relationships and discovering hidden relationship states, this study focuses on the use of the HMM to capture the correct dynamic buying behaviour of customers to services provided by a telecommunication company in Nigeria, proceeding also to find their relationship state over some time. With the relationship states being a finite set which follows the markovian property, transitions between states are determined by the history of interactions between the customers and the brand.

Related Literature

Research in the area of relationship marketing has been emerging in the past decade, both from the consumer behaviour perspective [14] and the empirical modelling perspective [4, 28, 34]. Our focus will be on those relevant to this research.

Authors [17] applied the probabilistic method of Markov chain to the systematic study of brand switching and brand loyalty. After that this application developed slowly. Researchers tried to use it in other dimensions of CRM, such as analyzing and predicting unique customer behaviour [12, 29]. Authors [37] applied a Markov chain model in quality function deployment to analyze customer requirements. Their proposed approach provides a decision-maker to investigate and then satisfy both present and future customers' needs. There probabilistic nature of Markov chain has a crucial impression on decision making [25]. Authors [20] proposed a data mining model that considers e-customer activities through a discrete-time semi-Markov process. Researchers [21] use this modelling technique in a macro marketing decision level, applying the Markov decision process to forecast markets share and determine customer's decision pattern in the diverse circumstances that are common.

Authors [28] constructed and estimated a nonhomogenous HMM to model the transitions among hidden relationship states. They used HMM to overcome the problem of the unobserved state, as well as to describe a set of hidden conditions and changes between them; also, they translated these hidden states into observed customers' behaviours. HMM often encountered researchers with estimating the models' parameters. There are several estimation methods and algorithms, such as expectation-maximization (EM). Authors [36] used this algorithm to estimate HMM's parameters and utilized the Viterbi algorithm to find some path which was describing customers migration pattern in an online retailer. Also, [32] according to Bayesian rules obtained the conditional probability and calculated the Equation that was referred as likelihood function and then designed a classifier based on HMM for discovering which customer is loyal and which is not dedicated. Authors [10, 24] used HMM as a portfolio optimization technique. Their basic idea is to describe the essential movement of the stock price using HMM and to calculate the optimal portfolio using HMM's recursive algorithms. Authors [37] constructed a specific HMM for web browsing, which could prospect whether the users have the intention to purchase in real-time. It can be useful to be ready for customers' needs in the buying process and predicting repetitive customer attitude [5, 16, 29].

Model Development

The hidden Markov model. Although initially introduced and studied as far back as 1957 and early 1970, the recent popularity of statistical methods of HMM is not in question. An HMM is a bivariate discrete-time process $\{X_k, Y_k\}_{k\geq 0}$ where $\{X_k\}_{k\geq 0}$ is a homogeneous Markov chain which is not directly observed but can only be observed through $\{Y_k\}_{k\geq 0}$ that produce the sequence of observation. $\{Y_k\}_{k\geq 0}$ is a sequence of independent random variables such that the conditional distribution of Y_k solely depends on X_k [1]. The underlying Markov chain $\{X_k\}_{k\geq 0}$ is called the state.

An HMM is characterized by the following: N, the number of states in the model. We denote the state set as $S = \{S_1, S_2, \cdots, S_N\}$ and the state at time t as x_t, $x_t \in S$.

The state transition probability distribution $A = \{a_{ij}\}$ where $\begin{matrix} a_{ij} = p(x_t = S_j | x_{t-1} = S_i), \\ a_{ij} \geq 0, , 1 \leq i, j \leq N \end{matrix}$.

The observation probability distribution B. $Y_t \sim g(Y_t|X_t, B)$ $Y_t \sim f(Y_t \mid X_t, B)$ is observation density at time t, $B = \{b_j(k)\}$ gives the conditional probability distribution of each observation symbol within a given hidden state with the definition of

$b_i(k) = p\{Y_t \mid X_t = S_t\}$ denotes the k^{th} observation symbol per state.

The initial state distribution $\pi = \{\pi_i\}$, $\pi_i = p(x_i = s_i), 1 \le i \le N$. For convenience, we used the compact notation $\lambda = (A, B, \pi)$ to indicate the complete parameter set of the model. Given the form of the HMMs, the goal is to find the best model for a given time series through optimally adjusting model parameters $\lambda = (A, B, \pi)$ [1].

Hidden Markov Model of Customer Relationships

The HMM presented here is an individual-level model of buying behaviour. We consider a set of customers, each of whom is involved in repeated interactions of the service provided by a telecommunication company. Accordingly, we define a set of hidden relationship states, which differ for the strength of the relationship between the customer and the brand and the conditional likelihood of choice given the relationship state. A first-order random walk model characterizes the stochastic relationship-states model. The transitions between the Markovian states are probabilistically determined and are affected by relationship encounters [28].

The proposed HMM consists of three main components:

(1) the initial state distribution (π),

(2) a sequence of random walk transitions (Q) that is express in a probabilistic manner, the likelihood that the series of customer-brand interactions in the previous period were strong enough to transition the customer to an adjacent state,

(3) a vector of state-dependent choice probabilities given the relationship states (m). The possibility of observing a sequence of choices is defined [28] by:

$$P_i(Y_{i1} = y_{i1}, \cdots, Y_{it} = y_{it}) = \sum_{s_1=1}^{N} \sum_{s_2=1}^{N} \cdots \sum_{s_T}^{N} \left[P(S_{i1} = s_1) \prod_{t=2}^{T} P(S_{it} = s_t | S_{it-1} = s_{t-1}) \prod_{t-1}^{T} P(Y_{it} = y_{it} | S_{it} = s_t) \right] \quad (1)$$

where,

S_{it} is customer i's state at time t in a Markov process with N states, and Y_{it} is customer i's choice at time t.

Following Equation (1) the three components of the HMM are defined as follows:

1) The initial state distribution – the probability that customer i in state s at the time one can be defined as:

$P(S_{i1} = s) = \pi_{is}$.

2) The transitions – the probability that a customer transitions from the state s_{t-1} at the time $t-1$ to state s_t at time t can be defined as: $P(S_{it} = s_t | S_{it-1} = s_{t-1}) = q_{is_{t-1}s_t}$. The transition matrix is defined as,

	State at t					
State at t-1	1	2	3	...	N-1	N
1	q_{11}	q_{12}	0	...	0	0
2	q_{21}	q_{22}	q_{23}	...	0	0
⋮	⋮	⋮	⋮	⋱	⋮	⋮
N	0	0	0	...	q_{NN-1}	q_{NN}

where $q_{itss'} = P(S_{it} = s' | S_{it-1} = s)$ is the conditional probability that individual i moves to state s' at time t given in state s at the time $t-1$ and where $0 \le q_{itss'} \le 1 \ \forall s, s'$ and $\sum_{s'} q_{itss'} = 1$.

Following the random walk transition, all terms that are two states or more away from the diagonal are set to zero. Each one of the matrix elements represents a probability of change to an adjacent state or a likelihood of staying in the current state.

3) The state-dependent choice shows the probability that the customer will choose the product at time t conditioned on her state is defined [28] as:

$$P(Y_{it} = 1 | S_{it} = s_t) = m_{is_t}$$

Most times, the model parameters are obtained by using the EM algorithm, which results in a

nonlinear optimization problem [7, 22, 28]. Still, the EM algorithm does not work for the HMM here, so an optimal estimation method is used for obtaining the transition probabilities among the hidden states which guarantee convergence and global optimum.

Estimation procedure

Here, the work presents the procedure used to estimate the model described above. In choosing the estimation procedure, we focus on properly accounting for observed and unobserved heterogeneity. An optimal estimation procedure, according to [8], is used to estimate the model. The parameter estimation method is an HMM with two hidden states and two observable states.

The number of m hidden states and the stationary distribution of the hidden states is given by:

$$\alpha_t = (\alpha_1, \alpha_2, \cdots, \alpha_m)$$

The number of n observable state and the stationary distribution of the observable states is

(pi1, pi2, . . . , pin).

Given an observed sequence of the observable states, the occurrences of each state in the series are calculated and hence the experimental distribution *q*. If the hidden stats are ignored, the visual states follow the one-step transition probability matrix:

$$\bar{p}_2 = \begin{pmatrix} \alpha_1 & \alpha_2 & \cdots & \alpha_1 \\ \alpha_1 & \alpha_2 & \cdots & \alpha_2 \\ \vdots & \vdots & \vdots & \vdots \\ \alpha_m & \alpha_m & \cdots & \alpha_m \end{pmatrix} \begin{pmatrix} p_{11} & p_{21} & \cdots & p_{m1} \\ p_{12} & p_{22} & \cdots & p_{m2} \\ \vdots & \vdots & \vdots & \vdots \\ p_{1n} & p_{2n} & \cdots & p_{mn} \end{pmatrix} = \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix} p$$

where

$$p = \left(\sum_{k=1}^{m} \alpha_k p_{k1}, \sum_{k=1}^{m} \alpha_k p_{k2}, \cdots, \sum_{k=1}^{m} \alpha_k p_{kn} \right)^T$$

$$\bar{p}_2 p = p \text{ and } \sum_{k=1}^{m} p_k = 1$$

The vector p is the stationary probability distribution of $\bar{P}2$. Therefore, the transition probabilities of the hidden states $\alpha_t = (\alpha_1, \alpha_2, \cdots, \alpha_m)$ are obtained by solving $\min_{\alpha} \|p - q\|_2^2$

subject to $\sum_{k=1}^{m} \alpha_k = 1$ and $\alpha_k \geq 0$

This is a standard constrained least square problem when $\|.\|$ is chosen to be the square of the L2-norm. When $\|.\|$ is determined to be L1-norm or the L*a*? *z*-norm, the resulting optimization problem are transformed into a linear programming problem.

For the model having two hidden states (m = 2),

$$\bar{p}_2 = \begin{pmatrix} \alpha & 1-\alpha \\ \alpha & 1-\alpha \\ \vdots & \vdots \\ \alpha & 1-\alpha \end{pmatrix} \begin{pmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \end{pmatrix} = \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix} p$$

where

$$p = (\alpha\, p_{11} + (1-\alpha) p_{21}, \alpha\, p_{12} + (1-\alpha) p_{22}, \cdots, \alpha\, p_{1n} + (1-\alpha) p_{2n}$$

$$\bar{p}_2 p = p \text{ and } \sum_{k=1}^{n} p_i = 1$$

and therefore p is the steady-state probability distribution.

Given the observed distribution q of the observable states, then α is estimated by the following minimization problem [8]:

$$\min_{\alpha} \|p - q\|_2^2$$

subject to $0 \leq \alpha \leq 1$ $0 \leq \alpha \leq 1$ or equivalently

$$\min_{0 \leq \alpha \leq 1} \sum_{i=1}^{n} \{\alpha\, p_{1k} + (1-\alpha) p_{2k} - qk\}^2 \qquad \begin{matrix} min \\ 0 \leq \alpha \leq 1 \end{matrix}$$

$$\tau = \frac{\sum_{j=1}^{n} (q_j - p_{2j})(p_{1j} - p_{2j})}{\sum_{j=1}^{n} (p_{1j} - p_{2j})^2}$$

Let

Then the optimal value of α is given as follows:

$$\alpha = \begin{cases} 0 & if\ \tau \le 0 \\ \tau & 0 < \tau < 1 \\ 1 & if\ \tau \ge 1 \end{cases}$$

noting that

$$\tau = \frac{<(q - p_2),(p_1 - p_2)>}{<(p_1 - p_2),(p_1 - p_2)>} = \frac{\left\|q - p^2\right\|_2 \cos(\theta)}{\left\|p_1 - p^2\right\|_2}$$

Here, $<...,\cdots>$ is the standard inner product on the vector space R_n

$p_1 = (p_{11}, p_{11},\cdots, p_{1n})^T$ and $p_2 = (p_{21}, p_{22},\cdots, p_{2n})^T$

θ is the angle between the vectors $(q - p_2)$ and $(p_1 - p_2)$.

Empirical Results and Discussion

Data Employed. The data records two services offered by a telecommunication company in Lagos State, Nigeria and represented by 'V' (voice) and 'D' (data). From the customer database, information is obtained on the expenditure distribution of 93 randomly chosen customers on these services for four months. The customers are classified into two groups based on responses observed. The data is split into two, which is the 'train data' to build an HMM and the 'test data' to validate the constructed HMM. Given the expenditure distribution of a customer observed from the customer's sequence of purchases, and the average expenditure distributions, the estimation procedure above is used to compute the transition probability α in the hidden states. The parameter estimation procedure is done using the R statistical software.

Through observing the responses of customers, customers are classified into two groups, among which 60 customers being loyal (Group 1) and the other 33 customers not-loyal (Group 2). For the train data, two-third of the customers are randomly selected from Group 1 and Group 2. This implies that for the train data, 40 customers are randomly selected (these customers are labelled in the first 40 customers in Table 1) from Group 1, and 22 customers are selected from Group 2. The remaining 20 customers from Group 1 and 11 customers from Group 2 are used for validating the constructed HMM. An HMM of two observable states (V and D) and two hidden forms (Group 1 and Group 2) is built. From the information of the customers in Group 1 and Group 2, the probability distributions of customers' purchases and the emission probability distributions for both groups are computed in Tables 1 and 2.

Table 1 – Probability distribution of observations (Two-third of the data used to build the HMM)

	Customer	V	D		Customer	V	D
1	3	0.96	0.04	21	52	1.00	0.00
2	8	0.99	0.01	22	55	1.00	0.00
3	12	0.81	0.19	23	56	0.85	0.15
4	19	0.92	0.08	24	58	0.96	0.04
5	20	1.00	0.00	25	59	1.00	0.00
6	23	0.94	0.06	26	61	0.93	0.07
7	24	1.00	0.00	27	65	0.95	0.05
8	25	0.88	0.12	28	66	0.88	0.12
9	26	1.00	0.00	29	67	0.94	0.06
10	29	0.98	0.02	30	68	0.98	0.02
11	32	0.98	0.02	31	69	1.00	0.00
12	33	0.99	0.01	32	71	1.00	0.00
13	34	0.91	0,09	33	79	1.00	0.00
14	36	0.98	0.02	34	86	0.86	0.14
15	37	0.91	0.09	35	87	0.98	0.02
16	38	0.96	0.04	36	90	1.00	0.00
17	39	0.95	0.05	37	92	0.99	0.01
18	42	0.90	0.10	38	93	1.00	0.00
19	49	0.80	0.20	39	95	0.84	0.16
20	51	0.97	0.03	40	96	1.00	0.00
41	1	0.17	0.83	52	60	0.63	0.37
42	2	0.28	0.72	53	73	0.51	0.49
43	6	0.43	0.57	54	74	0.04	0.96
44	7	0.72	0.28	55	81	0.74	0.26
45	11	0.76	0.24	56	82	0.08	0.92
46	17	0.78	0.22	57	83	0.08	0.92
47	30	0.76	0.24	58	88	0.39	0.61
48	46	0.65	0.35	59	94	0.57	0.43
49	48	0.44	0.56	60	97	0.29	0.71
50	50	0.59	0.41	61	99	0.53	0.47
51	54	0.7	0.3	62	100	0.56	0.44

Table 2 – Emission probabilities

Group	V	D
1	0.95	0.06
2	0.49	0.51

To find the corresponding optimal state given the observation sequence, the transition probability

α in the hidden states is computed with the function 'optimize' after defining a process α which is

$$\min_{0\le\alpha\le1}\sum_{i=1}^{n}\{\alpha\, p_{1k}+(1-\alpha)p_{2k}-q_k\}^2$$

where p is the stationary distribution,

$p = 0.94975\alpha + 0.48636(1-\alpha)\ 0.05025\alpha + 0.51363(1-\alpha)$

and q is the probability distribution of the observation sequence of each customer.

Table 3 – Train data - Transition probability α in the hidden states

	Customer	V	D	α		Customer	V	D	α
1	3	0.96	0.04	1.00	21	52	1.00	0.00	1.00
2	8	0.99	0.01	1.00	22	55	1.00	0.00	1.00
3	12	0.81	0.19	0.70	23	56	0.85	0.15	0.78
4	19	0.92	0.08	0.94	24	58	0.96	0.04	1.00
5	20	1.00	0.00	1.00	25	59	1.00	0.00	1.00
6	23	0.94	0.06	0.99	26	61	0.93	0.07	0.96
7	24	1.00	0.00	1.00	27	65	0.95	0.05	1.00
8	25	0.88	0.12	0.85	28	66	0.88	0.12	0.85
9	26	1.00	0.00	1.00	29	67	0.94	0.06	0.98
10	29	0.98	0.02	1.00	30	68	0.98	0.02	1.00
11	32	0.98	0.02	1.00	31	69	1.00	0.00	1.00
12	33	0.99	0.01	1.00	32	71	1.00	0.00	1.00
13	34	0.91	0,09	0.91	33	79	1.00	0.00	1.00
14	36	0.98	0.02	1.00	34	86	0.86	0.14	0.81
15	37	0.91	0.09	0.91	35	87	0.98	0.02	1.00
16	38	0.96	0.04	1.00	36	90	1.00	0.00	1.00
17	39	0.95	0.05	1.00	37	92	0.99	0.01	1.00
18	42	0.90	0.10	0.89	38	93	1.00	0.00	1.00
19	49	0.80	0.20	0.68	39	95	0.84	0.16	0.76
20	51	0.97	0.03	1.00	40	96	1.00	0.00	1.00
41	1	0.17	0.83	0.00	52	60	0.63	0.37	0.31
42	2	0.28	0.72	0.00	53	73	0.51	0.49	0.05
43	6	0.43	0.57	0.00	54	74	0.04	0.96	0.00
44	7	0.72	0.28	0.50	55	81	0.74	0.26	0.55
45	11	0.76	0.24	0.59	56	82	0.08	0.92	0.00
46	17	0.78	0.22	0.63	57	83	0.08	0.92	0.00
47	30	0.76	0.24	0.59	58	88	0.39	0.61	0.00
48	46	0.65	0.35	0.35	59	94	0.57	0.43	0.18
49	48	0.44	0.56	0.00	60	97	0.29	0.71	0.00
50	50	0.59	0.41	0.22	61	99	0.53	0.47	0.09
51	54	0.7	0.3	0.46	62	100	0.56	0.44	0.16

This value of α was used to classify a customer: if α is close to 1, the customer is likely to be a loyal customer, and if α is close to 0 then the customer is expected to be a not-loyal customer. Based on the values of α for all the 62 customers listed in table III, the values of α of the first 40 customers falls under Group 1 as it lies in the interval [0.68, 1.00]. In contrast, the importance of α between [0.00, 0.63], of the remaining customers, falls under Group 2. Thus, the two groups of customers are separated by setting the cutoff value β to be 0.67.

Furthermore, the decision rule is that a customer is classified to Group 1 if $\alpha \ge \beta$, otherwise the customer is classified to Group 2.

Table 4 shows the HMM and the decision rule applied to the "test data" among which contains 20 customers belonging to Group 1 and 11 belonging to Group 2.

Table 4 – The remaining one-third of the data for the validation of the HMM

	Customer	V	D	α		Customer	V	D	α
1	9	1.00	0.00	1.00	11	44	0.97	0.03	1.00
2	10	1.00	0.00	1.00	12	45	0.94	0.06	0.98
3	13	0.85	0.15	0.78	13	53	0.92	0.08	0.94
4	16	0.90	0.10	0.89	14	57	0.96	0.04	1.00
5	22	1.00	0.00	1.00	15	63	0.92	0.08	0.94
6	27	0.97	0.03	1.00	16	64	0.97	0.03	1.00
7	28	0.95	0.05	1.00	17	72	0.83	0.17	0.74
8	31	1.00	0.00	1.00	18	77	0.86	0.14	0.81
9	35	0.80	0.20	0.68	19	84	0.85	0.15	0.78
10	41	0.98	0.02	1.00	20	98	0.98	0.02	1.00
21	4	0.64	0.36	0.33	27	47	0.51	0.49	0.05
22	5	0.35	0.65	0.00	28	62	0.47	0.53	0.00
23	18	0.78	0.22	0.63	29	70	0.58	0.42	0.20
24	21	00.57	0.43	0.18	30	76	0.58	0.42	0.20
25	40	0.63	0.37	0.31	31	78	0.77	0.23	0.61
26	43	0.77	0.23	0.61					

Table 5 – The transition probability

States	1	2
1	0.94	0.06
2	0.24	0.76

Table 6 – Stationary distribution

States	1	2
1	0.80	0.20
2	0.80	0.20

Tables 5, 6 are the transition probabilities and the long-term behaviour of the hidden Markov chain. The pattern of the one-step transitions of the customers based on their purchases with cutoff 0.67 separating the two related groups shows a higher percentage of loyal customers and a frequent movement from loyal customers to loyal customers.

Empirical Findings

Based on the analysis, the emission probability of the observations showed a 95% probability of a loyal customer making a purchase in service 'V' and a 49% probability of an unloyal customer purchasing service 'V' (see Table II). In measuring the loyalty of the customers to this service, the transition probability showed a 94% probability of a loyal customer remaining loyal and a 6% probability of a loyal customer becoming unloyal. It also showed a 76% probability of an unloyal customer remaining unloyal and 24% of an unloyal customer becoming loyal (see Table 5). This led to a higher possibility of an unloyal customer becoming reliable than a loyal customer becoming unloyal. Loyal and unloyal customers were separated using cutoff value 0.67 which implied that a customer is loyal if $\alpha \geq 0.67$ and is unloyal if $\alpha \leq 0.67$. A likely future state for a loyal or unloyal customer is predicted with an 80% possibility of a loyal customer remaining loyal and a 20% possibility of an unloyal customer remaining unloyal (see Table 6).

CONCLUSION

This study is based on modelling customer relationships as hidden Markov chains. The importance of good customer relationships to any company cannot be over-emphasized. Every business requires customers, but it is not enough to have customers, companies must be able to manage their customers and build good relationships with them. In this study, a Hidden Markov model (HMM) is utilized to study customer's relationship dynamics of a telecommunication service company using data on purchases made by these customers. The HMM developed in this research helped to relate the relationship-states Markov chain process to the observed buying behaviour by identifying customers purchases for two services provided and then obtained the hidden relationship states of customers through the observed

sequence of investments made over some time. The customers were further classified as loyal or not based on these relationship states. By accounting for the functional and unobserved relationship with a two-state hidden Markov model and taking estimation into account via an optimal estimation method for the transition probabilities, the empirical results show that the model not only takes care of the dynamic effect of interactions between the customer and the brand on the customer's relationship state but also helps to establish a proficient structure for customer relationship management.

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