Student's Journal of Health Research Africa
Vol. 4 No. 6 (2023): June 2023 Issue
https://doi.org/10.51168/sjhrafrica.v4i6.469
Original article

PATHOGENIC BACTERIA IN LAKE VICTORIA SHORE WATER AT KASENYI LANDING SITE IN ENTEBBE MUNICIPALITY, UGANDA: A CROSS-SECTIONAL PILOT SURVEY ON OCCURRENCE PROFILES AND ASSOCIATED FACTORS.

Fortunate Lujjimbirwa[a,b,*], Martin Odoki[a,c,d]

[a] *Nkumba University (P.O. Box 237; Entebbe, Uganda), Department of applied sciences and Department of natural resources.*
[b] *University of Kisubi (P.O. Box 182; Entebbe, Uganda), Faculty of health sciences, Department of biomedical laboratory sciences.*
[c] *King Caesar University (Plot 32, King Ceasor road Ggaba, Kampala, Uganda), School of medicine, Department of microbiology and immunology.*
[d] *Kampala International University-Western Campus (P.O. Box 71 Bushenyi, Uganda), Faculty of bio-medical sciences, Department of microbiology and immunology.*

Abstract

Background:

Goal six (6) of the 2030 agenda and sustainable development goals highlights the need to "ensure availability and sustainable management of water and sanitation for all." Over the years; Lake Victoria, which supports nearly one-third of the total East African population has been facing pollution-related effects and thus risking water-borne infections from pathogenic bacteria for example; Citrobacter freundii, Klebsiella pneumoniae, Staphylococcus species, Enterococcus species, etc.; with some of the associated factors including wastewater treatment, agricultural activities, soil surface runoffs, bathing, rubbish dumping among others.

Methods:

A two-month cross-sectional pilot survey was done in which thirty-one (n=31) Lake Victoria surface water samples were collected at the Kasenyi landing site and bacteriologically examined through culturing water samples. Additionally; a one-time field observation accompanied by eleven (n=11) short interviews with key respondents was undertaken to identify the factors potentially associated with the bacterial contamination of the Lake Victoria shore surface water. Data were analyzed using Microsoft Excel 2013.

Results:

Citrobacter freundii accounted for the highest occurrence at 58% (46/79) while Klebsiella pneumoniae was the least occurring at 3% (2/79). "Soil surface run-off" emerged as the most occurring factor related to possible bacterial contamination of the shore surface waters (73%; 8/11). One-time field observation revealed the presence of "bathing practices, rubbish dumping, and soil surface runoff."

Conclusion:

Citrobacter freundii was the most occurring bacterial pathogen; soil surface run-off emerged as the most occurring factor; there is a low chance of encountering Klebsiella pneumoniae and a high chance of encountering Citrobacter freundii, Staphylococcus species, and Enterococcus species.

Recommendation:

Establishment of control mechanisms (i.e. physical barriers) for soil run-off into the lake shore.

Keywords:Pathogenic bacteria, Lake Victoria, Citrobacter freundii, Staphylococcus species Enterococcus species, Submitted: 2023-06-10 Accepted: 2023-06-19

1. Introduction:

Goal six (6) of the 2030 agenda and sustainable development goals highlights the need to "ensure availability and sustainable management of water and sanitation for all" (UN and UNEP, 2015). In past years; the world's second-largest lake; "Lake Victoria," which supports nearly one-third of the total East African population through the provision of employment to up to thirty million people have been facing pollution-related effects such as a decline in fish species as a result of shore-based undertakings including; intensified land use, increased human and livestock populations, urban wastewater and industrial discharges, soil erosion, and agricultural run-off (Arsène, 2022). As such; bacterial caused water-borne diseases such as; typhoid, dysentery, and cholera among others may result among the respective shore-based human population following exposure to an unsafe lake water source thus potentially affecting the still existing 2 billion people lacking access to unsafe water (Prüss-Ustün et al. 2014; UNICEF, 2019; and UN, 2022).

Over the years; the occurrence of pathogenic bacteria in lake water sources has always been a public health concern as was justified by Youn-Joo et al. (2002), Edge et al. (2013), Jin et al. (2018), who identified Escherichia coli, Gultepe et al. (2017) who isolated Staphylococcus aureus and Enterococcus species and still is a serious public health problem as studied by Bisimwa et al. (2022) and Rondón-Espinoza et al., (2022), who identified bacterial pathogens such as Salmonella typhi, Escherichia coli, Pseudomonas aeruginosa, Enterococcus species, Vibrio cholerae, Citrobacter freundii, Proteus vulgaris, Shigella dysentriae among others. Such has usually been a result of lake shore-based factors such as; human population increase, increased urbanization, wastewater treatment, agricultural activities, for example, the establishment of crop/farmlands, increased number of livestock, increased surface runoffs as a result of increased precipitation rates, and transportation activities (Islam et al., 2018); bathing along and/or within the water body; laundry activities; dishwashing; wash off from dumped rubbish; and market effluents runoff into a water body (Bisimwa et al., 2022); open defecation, and presence of animal excreta (Bedane et al.; 2022).

To the best of the researcher's knowledge; there has never been a study conducted and published from the Kasenyi landing site to determine the occurrence profiles of the bacterial pathogens in Lake Victoria shore waters and/or the potentially associated factors, thus a foundational aim for this survey.

2. Methods:

2.1. Study design:

A two-month cross-sectional pilot survey was done in February and March 2023 in which thirty-one (n=31) Lake Victoria surface water samples were collected from the shores at Kasenyi landing site was transported on a cold chain to the microbiology laboratory at the University of Kisubi for bacteriological analysis. Additionally; a one-time field observation accompanied by eleven (n=11) short interviews with key respondents was undertaken to identify the factors potentially associated with the bacterial contamination of the Lake Victoria shore surface water.

2.2. Study area:

Kasenyi landing site is located 8km off Abaita Ababiri trading center along the Entebbe-Kampala highway in Entebbe Municipality, Katabi sub-county, Wakiso District in Uganda.

2.3. Unit of analysis and bacteria of interest:

The survey used Lake Victoria's surface shore water samples as the unit of analysis. These were then subjected to bacteriological analysis for the isolation and identification of the bacterial pathogens of interest i.e. Staphylococcus species, Enterococcus species, and Enterobacteria species.

* Corresponding author.
Email address: lujjimbirwafortunate@gmail.com (Fortunate Lujjimbirwa)

2.4. Sample size determination:

The sample size for this particular survey was determined based on the central limit theorem (Arsham, 2005) which considers an amount of, n > 30, to be a sufficiently large sample to represent a large population. Here; "n" represents the sample amount obtained at a particular moment in time.

2.5. Water sampling and bacteriological analysis:

2.5.1. Water sampling in the field:

While roaming on the surface of Lake Victoria; a 200ml capacity wide-mouthed stainless steel metallic water sampling cup was dipped into the Lake water and used to collect the water samples at a randomly selected point. The water would then be transferred from the metallic cup into a 100ml capacity wide-mouthed screw-capped plastic container which would then be chilled on ice in a courier for transportation to the microbiology laboratory.

2.5.2. Bacteriological analysis of water samples:

The following methods were undertaken based on Cheesbrough, (2006);

Lab Day 1

On reception of the water samples; unique identifiers would be assigned to them for purposes of laboratory identification during specimen processing and analysis. Primary inoculation was done by the pour plate method where a portion (approximately 10mls) would be poured to cover the surface of the selective agar medium depending on the target bacterial species and/or genera. The inoculated agar plates would then be cultured through incubation at 37°C overnight (i.e. 14 to 18 hours). The selective media that was used in this study included; Mannitol salt agar (Condalab Chapman medium, Batch number: 206042) for the Staphylococcus species group; Bile esculin azide agar (Conda pronadisa, Batch number: 702142) for the Enterococcus species group; and Mac Conkey bile salts agar (Oxoid limited, Lot number: 2966689) for the Enterobacteriaceae group.

Lab Day 2

Following the first overnight incubation of the water samples; plate reading was the next step where the colony characteristics of the bacterial growth that was obtained on the selective media would be investigated. Bacterial colonies of varying characteristics would then be subcultured by streaking from the selective media onto basic media i.e. nutrient agar (Condalab Chapman medium). The subsequent basic agar plate preparation would then be cultured through incubation at 37°C overnight.

Lab Day 3

Following the second overnight incubation; a plate reading was done to identify the colony characteristics of the bacterial growth that had been obtained on a basic medium (nutrient agar). The bacterial colonies would then be stained through the Gram staining technique to microscopically study and classify them under the two main groups i.e. Gram positive and Gram negative groups.

Based on the Gram staining result; an appropriate biochemical test was then performed to facilitate the confirmation of particular bacterial species and/or genera in the Enterobacteriaceae group i.e. Carbohydrate sugar fermentation and hydrogen sulphide gas production: this was carried out with the aid of triple sugar iron agar medium (Oxoid limited, Lot:1155946); Citrate utilization test: this was carried out with the aid of Simmon's citrate agar medium (Becton, Lot: 3105010); Hydrogen sulphide gas production, indole production, and motility test: this was carried out with the aid of SIM medium and Kovac's reagent (Conda pronadisa, Batch: 802012).

2.6. Investigation for factors potentially associated with bacterial contamination of the Lake Victoria shore water:

The factors implicated in the potential contamination of the Lake Victoria surface shore waters were assessed with the aid of a questionnaire checklist. Random individuals residing and/or working along the Lake Victoria shore at the Kasenyi landing site were identified for the

provision of such information through a short one-on-one one-time interview session. Additionally; a one-time field observation session was also carried out to collect data on the factors implicated in the potential contamination of the Lake Victoria surface shore waters.

2.7. Data analysis:

A descriptive and inferential nature of data analysis was undertaken with the aid of Microsoft Excel 2013 computer office application. The qualitative data about the factors associated with bacterial contamination of water was summarized and compiled into tables while the quantitative data from the laboratory bacteriological analysis of water was summarized and compiled into bar graphs. Inferential data analysis was performed using the chi-square and the p-value tests to infer an association between the independent variables and the dependent variables.

3. Results:

3.1. Occurrence of pathogenic bacteria in Lake Victoria shore water:

The overall occurrence of the bacterial isolates in Lake Victoria shore water

A total of seventy-nine bacterial isolates across four categories i.e. Citrobacter freundii, Klebsiella pneumonia, Staphylococcus species, and Enterococcus species were obtained [Figure 1]. Citrobacter freundii accounted for the highest occurrence at 58% (46/79) while Klebsiella pneumoniae was the least occurring at 3% (2/79).

Occurrence of individual bacterial isolates in Lake Victoria shore water

From the thirty-one (n=31) Lakeshore water samples; 71% (22/31) samples contained Citrobacter freundii while only 6% (2/31) samples contained Klebsiella pneumoniae as shown in Figure 2.

Factorsassociated with pathogenic bacteria in Lake Victoria shore water

3.1.1. Factors associated with pathogenic bacteria in Lake Victoria shore water

3.1.2. Demographic characteristics of the key respondents

The survey was carried out among eleven (n=11) random key informants for whom all turned out male [Table 1]; their mean age was thirty-seven years (mean = 36.6± 15.7 years) whereby the youngest was twenty years(minimum = 20 years) and oldest sixty-three years (maximum = 63 years) [Table 2]. Most informants (73%; 8/11) reported to be residents along the shore [Table 3]. Additionally; most (36%; 4/11) were involved in fish trading as their occupation [Table 4].

3.1.3. Frequency distribution profiles of the factors

A total of eight different factors were assessed among the key informants, from these; eighty-eight responses were obtained for which 34% (30/88) corresponded to a "YES" while 66% (58/88) corresponded to a "NO" [Table 5]. "Soil surface run-off" emerged as the most occurring factor related to possible bacterial contamination of the shore surface waters (73%; 8/11) followed by"rubbish dumping along the shore" (55%; 6/11) while "sewage release into the lake" emerged as the least occurring factor (0%; 0/11) [Table 5].

Further, still; one-time field observation revealed the presence of "bathing practices, rubbish dumping, and soil surface runoff" as factors related to the bacterial contamination of the shore surface waters [Table 5].

3.1.4. Association profiles

Following chi-square (X^2) and p-value analysis as shown in Table 6; a statistically significant association was obtained between all the eight factors for the potential bacterial contamination of the Lake shore water and the occurrence of Klebsiella pneumoniae there-in (i.e. $X^2>7.815$; $p<.05$) while there was no statistically significant association between all the eight factors for the potential bacterial contamination of the Lake shore water and the occurrence of Citrobacter freundii,

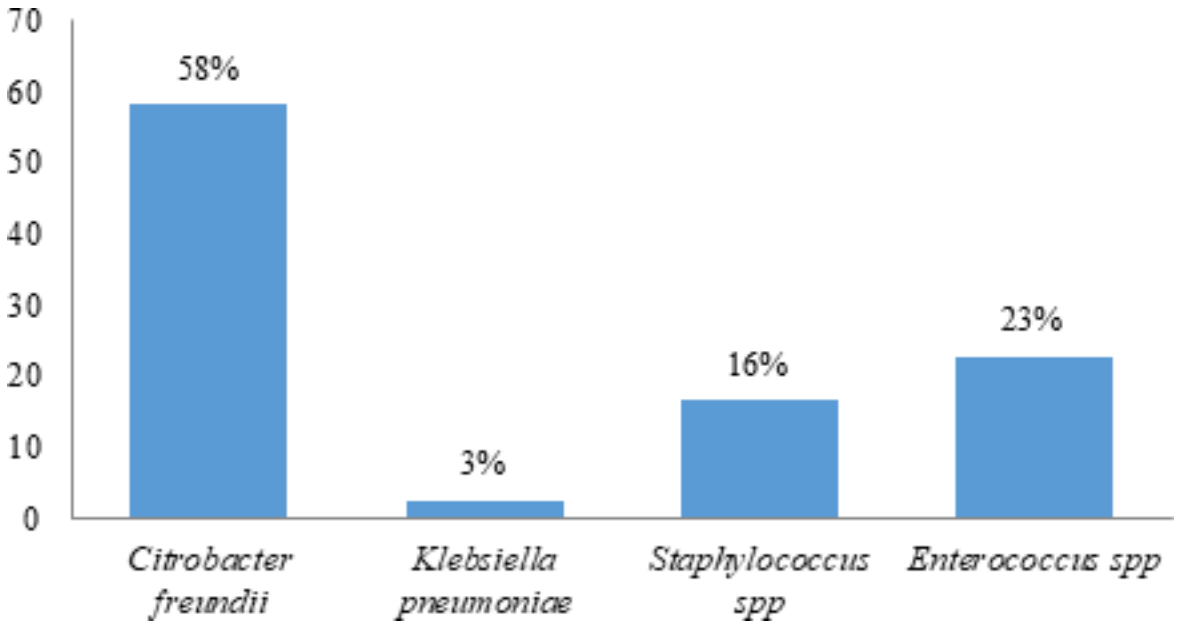

Figure 1: Overall occurrence of bacterial isolates from the Lake Victoria shore water

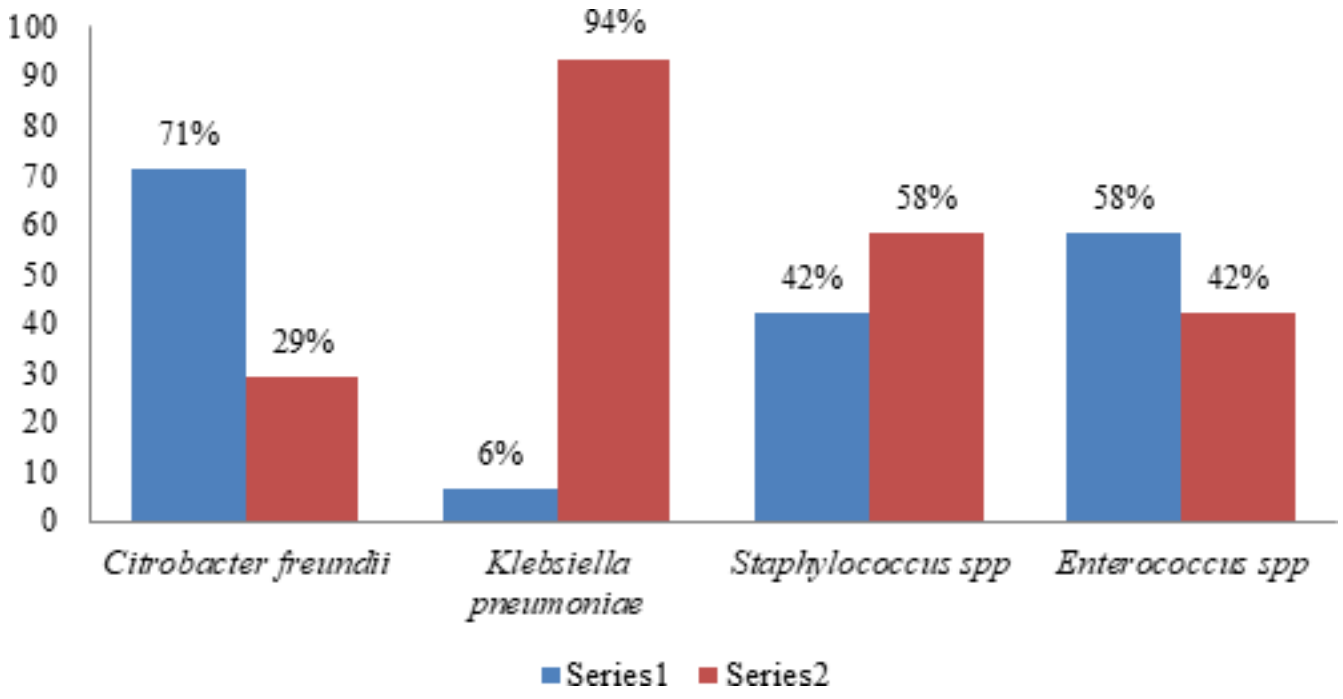

Figure 2: Water sample-based occurrence of individual bacterial isolates Key:series 1 = positive samples; series 2 = negative samples

Table 1: Gender characteristics of the key informants

GENDER	Male	Female	Total
NUMBER	11	0	11

Table 2: Age characteristics of the key informants

ID	AGE
001	50
002	43
003	20
004	24
005	21
006	44
007	48
008	63
009	49
010	21
011	20
Mean	**36.6**
SD	**15.7**
Range	**43**
Minimum	**20**
Maximum	**63**

Key: SD – Standard deviation; ID – participant's identification

Table 3: Shore residence profiles among the key informants

SHORE RESIDENCE		%
Yes	8	72.7
No	3	27.3
Total	**11**	**100**

Key: % - Percentage

Table 4: Occupation profiles of the key informants

OCCUPATION	FREQUENCY	%
Fisheries education officer	1	9.1
Fish trader	4	36.4
Beach attendant	1	9.1
Fish processor	1	9.1
General shore worker	2	18.2
Fish handler	2	18.2
TOTAL	**11**	**100**

Key: % - Percentage

Table 5: Potential factors for shore water bacterial contamination

#	POTENTIAL FACTOR FOR SHORE WATER BACTERIAL CONTAMINATION	FREQUENCY YES (%)	NO (%)	OBSERVATIONS
1	Bathing practices along the lakeshore	5 (45.5)	6 (54.5)	Yes
2	Dishwashing along the lakeshore	4 (36.4)	7 (63.6)	No
3	Laundry practices along the lakeshore	5 (45.5)	6 (54.5)	No
4	Rubbish/dumping grounds along the lakeshore	6 (54.5)	5 (45.5)	Yes
5	Animal rearing along the lakeshore	1 (9.1)	10 (90.9)	No
6	Sewage release along the lakeshore	0 (0)	11 (100)	No
7	Soil surface runoff in the rainy season	8 (72.7)	3 (27.3)	Yes
8	Release or dumping of market effluent/waste into or along the lake	1 (9.1)	10 (90.9)	No
	TOTAL OUTCOME	**30**	**58**	
	%Total outcome	**34.1**	**65.9**	

Key: % - Percentage

Staphylococcus species, and Enterococcus species (i.e. $X^2<7.815$; $p>.05$).

Key: p-value = probability value; X^2 = chi-square value; CV = critical value; α = level of statistical significance; df = degrees of freedom

4. Discussion:

4.1. Occurrence of pathogenic bacteria in Lake Victoria shore water at Kasenyi landing site:

In this study; Citrobacter freundii was the most occurring bacterial pathogen at 71% (22/31) while Klebsiella pneumoniae was the least occurring at 6% (2/31).

This has laid a similarity to Banciu et al. (2021), a study in which Citrobacter freundii was determined as a surface water contaminant. This could be a result of soil surface run-off being that soil is a natural habitat for Citrobacter freundii. However; soil surface run-off was not statistically evidenced as attributed to the occurrence of Citrobacter freundii in the Lake surface shore water.

On the other hand; Rondón-Espinoza et al., (2022), Gultepe et al. (2017), and Bisimwa et al. (2022) never identified Citrobacter freundii and/or Klebsiella pneumoniae in their study thus rendering a contradiction here-along. The reason for this difference has been linked to the difference in the bacteriological research scope between the former study and the current.

4.2. Factors associated with pathogenic bacteria in Lake Victoria shore water:

From this study; "Soil surface run-off" emerged as the most occurring factor related to possible bacterial contamination of the shore surface waters (72.7%; 8/11) followed by "rubbish dumping along the shore" (54.5%; 6/11) while "sewage release into the lake" emerged as the least occurring factor (0%; 0/11).

These findings are similar to those of Islam et al. (2018) who identified "increased surface runoffs" as a factor too; Bisimwa et al. (2022) who identified "wash off from rubbish dumped along the water body;" and Bedane et al. (2022) who also identified "run-off of water into the water bodies during the rainy seasons." This could be related to the fact that landing sites are mostly not designed with physical barriers between shore waters and the bare land neighboring the shore as is the case at Kasenyi landing site.

On the other hand; the findings from this study contradict those of Islam et al. (2018) who identified "wastewater treatment close to the water body;" Bisimwa et al. (2022) who identified "market effluents runoff into the water body;" and Bedane et al. (2022) who identified "open accessibility of animals to the lake water shores, occasional

Table 6: Chi-square and p-values for the factors for Lake water contamination and the bacterial occurrence in Lake water.

#	POTENTIAL FACTOR FOR SHORE WATER BACTERIAL CONTAMINATION	Citrobacter freundii p-value (X^2) CV=7.815, α=0.05, df=3	Klebsiella pneumoniae p-value (X^2) CV=7.815, α=0.05, df=3	Staphylococcus species p-value (X^2) CV=7.815, α=0.05, df=3	Enterococcus species p-value (X^2) CV=7.815, α=0.05, df=3
1	Bathing practices along the lakeshore	.259 (4.026)	.001 (17.367)	.897 (0.596)	.897 (0.596)
2	Dish washing along the lakeshore	.257 (4.044)	.001 (17.446)	.897 (0.598)	.897 (0.598)
3	Laundry practices along the lakeshore	.259 (4.026)	.001 (17.367)	.897 (0.596)	.897 (0.596)
4	Rubbish/dumping grounds along the lakeshore	.259 (4.026)	.001 (17.367)	.897 (0.596)	.897 (0.596)
5	Animal rearing along the lakeshore	.239 (4.217)	.000 (18.193)	.891 (0.624)	.891 (0.624)
6	Sewage release along the lakeshore	.229 (4.320)	.000 (18.635)	.887 (0.639)	.887 (0.639)
7	Soil surface runoff in the rainy season	.253 (4.082)	.000 (17.607)	.896 (0.604)	.896 (0.604)
8	Release or dumping of market effluent/waste into or along the lake	.239 (4.217)	.000 (18.193)	.891 (0.624)	.891 (0.624)

open defecation by people living and/or working along the lake shores and presence of animal excreta along the lake shores." This could be a result of the absence of any form of industry near the landing site; the presence of a public waste management site; restrictions imposed on rearing animals near the shore; and the presence of public toilets at the landing site as was revealed by the field observation.

4.3. ***Association profiles between the factors and the bacteria occurrence rates:*** From this study; a statistically significant association was obtained between all eight factors for the potential bacterial contamination of the Lakeshore water and the occurrence of Klebsiella pneumoniae while there was no statistically significant association between all the eight factors for the potential bacterial contamination of the Lakeshore water and the occurrence of Citrobacter freundii, Staphylococcus species, and Enterococcus species.

This research has thus established that there is a low chance or probability (i.e. ≤ 1%) for the occurrence of Klebsiella pneumoniae in the Lake Victoria surface shore water at the Kasenyi landing site. At the same time; there is a high likelihood or probability (i.e≥23%) for the occurrence of Citrobacter freundii, Staphylococcus species, and Enterococcus species in the Lake Victoria surface shore water at the Kasenyi landing site.

5. Conclusion:

Citrobacter freundii was the most occurring human bacterial contaminant in the shore surface waters; soil surface run-off emerged as the most

occurring factor related to possible bacterial contamination of the shore surface waters; there is a low chance of encountering Klebsiella pneumoniae and a high chance of encountering Citrobacter freundii, Staphylococcus species, and Enterococcus species in the Lake Victoria surface shore water at Kasenyi landing site.

6. Recommendation:

The researcher recommends the establishment of control mechanisms (i.e. physical barriers) for soil run-off into the lake shore water to minimize water contamination by Citrobacter freundii whose primary source is soil. The researcher also recommends further restriction towards any form of industry establishment near the landing site as this will help keep the lake shore waters safer.

7. Acknowledgements:

Thanks to Mr. Kasozi James, Mr. Ssentongo Vianney, Mr. Mwesigwa Phillip, Mr. Parmu Fred, and Mrs. Nakkungu Jackline who contributed during the sample collection and laboratory work stages; and Mr. Batte who provided transportation means.

8. List of Abbreviations And Acronyms:

etc. - And others
n - Sample size
% - Percentage
UN - United Nations
UNEP - United Nations Environment Protection Agency
UNICEF- United Nations Children's Fund
et al - And others
Km - Kilo meters
ml – Milliliters
$^{\circ}$C - Degrees Celsius
p-value- Probability value
ID - Identification number
SD - Standard Deviation
X^2 - Chi-square
CV - Critical Value
α - Level of statistical significance
df - Degrees of freedom
$\leq$ - Less than or equal to
$\geq$ - Greater than or equal to
i.e. - Such as
UgSh. - Ugandan Shillings

9. Source of Funding:

There was no external funding. All funds invested in this work were privately sourced.

10. Conflicts Of Interest:

There are no conflicts of interest associated with this work.

11. Publisher details:

Publisher: Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256775434261
Location: Wisdom Centre, P.O.BOX. 148, Uganda, East Africa.

12. References:

1. Arsène A. H. Mukubwa. (2022). The Lake Victoria Basin Integrated Water Resources Management Programme (LVB IWRMP) Marks International Day for Biological Diversity 2022.

2. Arthur Mubwebwe Bisimwa, Bramuel Kisuya, Zoé Malumba Kazadi, Bamba Bukengu Muhaya, Alidor Busanga Kankonda. (2022). Monitoring faecal contamination and relationship of physicochemical variables with faecal indicator bacteria numbers in Bukavu surface waters, tributaries of Lake Kivu in Democratic Republic of Congo. Hygiene and Environmental Health Advances 3, 100012.
3. Bedane, T.D., Agga, G.E. & Gutema, F.D. (2022). Hygienic assessment of fish handling practices along production and supply chain and its public health implications in Central Oromia, Ethiopia. Sci Rep 12, 13910.
4. Edge, T. A., Khan, I. U., Bouchard, R., Guo, J., Hill, S., Locas, A., Moore, L., Neumann, N., Nowak, E., Payment, P., Yang, R., Yerubandi, R., & Watson, S. (2013). Occurrence of waterborne pathogens and Escherichia coli at offshore drinking water intakes in lake Ontario. Applied and environmental microbiology, 79(19), 5799–5813.
5. H. Arsham. (2005). System Simulation: The Shortest Route to Applications, Version 9. from
6. Jin, D., Kong, X., Cui, B. et al. (2018). Bacterial communities and potential waterborne pathogens within the typical urban surface waters. Sci Rep 8, 13368.
7. M.M. Majedul Islam, Muhammad Shahid Iqbal, Rik Leemans, Nynke Hofstra. (2018). Modelling the impact of future socio-economic and climate change scenarios on river microbial water quality. International Journal of Hygiene and Environmental Health 221, 283–292.
8. Monica Cheesbrough. (2006). District Laboratory Practice in Tropical Countries, part 2. Cambridge University Press; ISBN-13 978-0-521-67631-1.
9. Nejdet Gultepe, Saleh BA Alkhunni, Mousa SM Gaballah. (2017). Pathogenic bacteria for human and fish isolated from fish farm in Kastamonu, Turkey. Journal of Aquaculture & Marine Biology 6(3).
10. Prüss-Ustün A, Bartram J, Clasen T, Colford JM, Jr, Cumming O, Curtis V, et al. (2014). Burden of disease from inadequate water, sanitation and hygiene in low-and middle-income settings: a retrospective analysis of data from 145 countries. Trop Med Int Heal.;19:894–905. doi:10.1111/tmi.12329.
11. Rondón-Espinoza, J.; Gavidia, C.M.; González, R.; Ramos, D. (2022). Water Quality and Microbiological Contamination across the Fish Marketing Chain: A Case Study in the Peruvian Amazon (Lagoon Yarinacocha). Water 2022, 14, 1465.
12. United Nations Children's Fund, UNICEF. (2019). UNICEF Uganda annual report 2019.
13. United Nations, UN and United Nations Environment Protection Agency, UNEP. (2015). The sustainable development agenda 2030.
14. United Nations, UN. (2022). Sustainable development goals report 2022.
15. Youn-Joo An, Donald H Kampbell, G Peter Breidenbach. (2002). Escherichia coli and total coliforms in water and sediments at lake marinas. Environmental Pollution, Volume 120, Issue 3, Pages 771-778, ISSN 0269-7491,

Author biography

Fortunate Lujjimbirwa Laboratory technologist and manager at the University of Kisubi, Faculty of Health Sciences, Department of Biomedical laboratory sciences.

Martin Odoki Lecturer at King Caesor University; School of Health Sciences, Department of Microbiology and Immunology.