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Evaluating the Potability of Bonganema, Foya Wulleh, and Kawela Streams Used for Drinking and Agricultural Irrigation in the Kori Chiefdom, Moyamba Districts, Southern Sierra Leone

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ABSTRACT

This research examines the physical, chemical and microbial parameters of Bonganema, Foya Wulleh, and Kawela Streams used for drinking and agricultural irrigation. These three streams (Bonganema, Foya Wulleh, and Kawela Streams) are situated along the Taiama-Njala University highway, in the Kori Chiefdom, Moyamba district, southern province of Sierra Leone. These three streams are used by the locals of the various communities for drinking and agricultural activities. The quality of water is affected by different environmental dynamics such as pH, temperature, opacity or turbidity, amount of nutrients, hardness, alkalinity and the amount of oxygen present in water (Edori, 2020). The physical parameters include: Turbidity, pH, Electrical Conductivity (EC), Temperature, Total Dissolved Solid (TDS); chemical parameters include Sodium (Na), Magnesium (Mg), Calcium (Ca), Iron (Fe), Zinc (Zn) and Copper (Cu) and, the microbial parameters include Faecal coliform, and Non-faecal coliform. Water samples were collected at the respected streams for three months (April, May, and June), at the start of every month (1st of every month). Water samples collected from the three streams were conveyed at the Environmental Management and Quality Control (EMQC) Laboratory, at Njala campus, Njala University, Sierra Leone within 30min of collection time. Result of the physical analysis were found to be within the standard limits set out by World Health Organisation, however, the pH and turbidity of the threes streams; (Bonganema pH 5.73,Turb.7.27; Foya Wulleh pH 5.44, Turb. 12.33; Kawela pH5.81, Turb. 7.11) were found to beoutside the World Health Organisation bracket, the chemical parameter of two of the streams (Bonganema Fe 1.29; Foya Wulleh Fe2.01)recorded high concentration of Iron that far exceed the WHO bracket of Fe in the drinking water, however, the other chemical parameters of all the streams were found to be in conformity with the WHO standards. The microbial parameters of the three streams showed high concentration ofFaecal coliform (Bonganema,13.17; Foya Wulleh, 24.03; Kawela, 10.63) that fell outside the WHO standards, However, there was low concentration of Non-Faecal coliform (Bonganema, 5.97; Foya Wulleh, 5.00; Kawela, 6.97) in all the samples analysed that were within the WHO standards. It can be said that the water sample analysed for the three streams recorded high concentration of pH, Turbidity, Faecal Coliform, and Iron, except Kawela that recorded low concentration of Iron (Fe, 0.03) that is within WHO standards. It can therefore be concluded that water from three streams (Bonganema, Foya Wulleh, and Kawela Streams) are not potable and, therefore not fit for human consumption and agricultural irrigation.

Keywords

Streams, pH, potable, irrigation, parameters and human

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Introduction

Safe drinking water and sanitation are human rights. Without access to these services, a life of dignity, stability and good health is virtually impossible (UN World Water Development Report, 2024). Safe drinking water is defined as water from an improved water source, which include household connections, public standpipes, boreholes, protected dug wells, protected spring and rainwater collections. According to the same organisation access to safe drinking water is define as the availability of 20 litres per person per day (Water challenge from urbanising world, 2018). The water must meet the required (chemical, biological and physical) quality standards at the point of supply to the users. On the continent, however, 418 million people still lack even a basic level of drinking water service, 779 million lack basic sanitation services (including 208 million who still practice open defecation) and 839 million still lack basic hygiene services (WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, 2022). Report published by WHO/UNICEF JMP (2022), shows that 411million people in Africa still lack basic drinking water services, 799 million lack access to basic sanitation services, and 839 million lack access to basic hygiene. Most people die from a lack of safe drinking water, sanitation, and hygiene (WASH) services than water-related disasters, reveals the new UN global water security assessment. Water borne diseases are reported to account for 80% of illnesses in developing world, killing a child every 8 seconds. This is a global public health threat (Hughes and Koplan, 2005).

The assessment of physicochemical parameters is necessary to ascertain the level to which the quality of water can be appreciated by individuals, homes and cooperate bodies. Also, they are readily available tools to determine the level of water acceptability for consumption and irrigation purposes (Solomon and Kehinde, 2017; Banunle *et al.,* 2018). The potential ability of water to transmit microbial pathogens to a great number of people causing subsequent illness is well documented in many countries at all levels of economic development (Dufour *et al.,* 2003). Potable water is a major challenge for developing countries of which Sierra Leone is no exception. The 2021 JMP report for Sierra Leone, shows that only 11% of the country's population uses water sources that are free of contamination and only 14% have access to safely managed sanitation services (WHO/UNICEF, 2021). Similar report published by Water Aid indicated that six out of 10 people in Sierra Leone don't have safe water and eight out of 10 people don't have access to a decent toilet. As a result, over 1,200 children under five die each year from water borne diseases in Sierra Leone.

In Sierra Leone, fresh water is extracted from streams, rivers, hand-dug well, bole hole, hand pump etc. In rural settings of Sierra Leone, the major sources of drinking waters are hand-dug well, hand pump and streams/rivers. Surface water usually occurs on the earth's surface as precipitation, snow, ice, streams, ponds, lakes, rivers, and wetlands (Chigor *et al.,* 2012). Rivers are the momentous natural resource for drinking, domestic, and irrigation purposes, enhancing the economic status and sustainability of the adjacent communities (Kasa *et al.,* 2022). A large percentage of the population in developing countries (majorly African Countries) lack accessibility of potable water supply thus, they are compelled to used untreated water from other sources such as rivers reservoir, spring, streams and groundwater for drinking and other domestics purposes (Welch *et al.,* 2000).

River water quality is greatly influenced by the water supply that comes from the catchment area, and the water supply that comes from the catchment area is influenced by the activities of people who live in the catchment area (Asrini *et al.,* 2017). Along with the increasing population, economic activities become more diverse, so the need for water resources becomes very important because its existence is very volatile (Sutriati, 2011).

In Bonganema, Foya Wulleh, and Kawela communities, the primary source of drinking water includes stream water, hand-pump water and well water. Water from the various streams have long be used for drinking and agricultural irrigations. However, much research (if any) had not be carried out to examine the physicochemical and bacteriological parameters of these three-stream used by the folks of these different communities. Agencies that regulate water qualities worldwide rely on the World Health Organization (WHO) standards and guidelines for drinking water quality (WHO, 1993, 1996, 2001 and 2002). So as to ensure the highest quality of potable water in order to safe guard public health (Anunobi *et al.,* 2006; Isikwue and Chikezie, 2014).

The objective of this research is to examine the physical, chemical and microbial content of these three streams along the Taiama- Njala University highway, used by the folks of these different communities for drinking and agricultural activities, in other to ascertained its suitability for human consumption and agricultural activities.

Materials and Methods

Description of Study Area

Bonganema, Foya Wulleh and Kawela is situated along the Taiama-Njala University highway.

These three communities had a combined estimated population of 912 (self-estimated) people. The primary engagement of the people in these three localities is agricultural activities. The three streams in the three different localities are mainly used for drinking, laundering (down Stream), agricultural irrigation, washing of bike (down Stream), cooking and other domestics activities.

Description of Sampling Area

Water samples were collected from these three streams (localities), along the Taiama- Njala University highway, these communities include Bonganema, Foya Wulleh, and Kawela in the Kori chiefdom, Moyamba district, southern Sierra Leone. These streams are used by the locals of these three communities for drinking, agricultural irrigation and domestics activities.

Sample Collection Techniques

Three clean and Sterilized labeled plastic containers were used to collect water samples from the three streams (Bonganema, Foya Wulleh, and Kawela). A sterilised cup tied with a rope was used to extract water from the streams. Each of the plastic container was rinsed three times with the water sample to be tasted for.

The water sample was centrally poured into the plastic container to avoid water touching the inside mouth surface of the container in other to avoid contamination. The water sample was placed in an iced cool man to maintain normal water temperature and to prevent the demise of the microbial organism in the water sample. The sample was transported to the Environmental Management and Quality Control Laboratory, Njala campus, Njala University, for physicochemical and bacteriological analysis.

Sample Analysis

Physical Parameters

The analysis for all physical characteristic was conducted according to instructional manual.

pH

A digital pH meter was used to measure the pH of all the water samples. Records were taking in duplicates. The standard limit of the pH of water used in this research is between 6.5 - 8.5 (WHO, 2022).

TDS and EC

Electrical Conductivity (µS/cm) and Total Dissolved Solid (mg/L) was measure using digital conductivity meter, readings were taking in duplicate, and result recorded.

Turbidity

A Photometer, 7100 was used in the examination of turbidity. It is measured in nephelometric turbidity unit (NTU), readings were taking in duplicate and result recorded.

Temperature

The temperature for all the water samples was determined using digital thermometer, reading was taking duplicates and result recoded.

Chemical Characteristics Determination

WAGTECH PHOTOMETER, 7100, was used to examined the chemical nature of all the water samples, after the photometer was calibrated according the operational manual.

Microbial Examination

Non-Faecal coliform and faecal coliform count of the three water samples were analysed at the Njala University Environmental Management and Quality Control Laboratory. The bacteriological quality of the drinking water samples was assessed by using total coliforms, faecal coliforms and Escherichia coli as indicators (American Public Health Association, 1998).

WHO recommended standards for Non-Faecal>10ml, and Faecal coliform are 0 count/100ml. A biological (microbial) parameter is employed for the assessment of drinking water quality using the index/indicator concept.

Results and Discussion

The results of the physical, chemical and microbial characteristics of the three streams were presented in statistical methods (means, variance, and standard deviation). Result of the individual analysis was recorded in Table 1-3.

Physical Characteristics

pH

From Table 1-3, the average mean pH of all the water samples (Bonganema Stream, Foya Stream and Kawela Stream) analysed fell outside the WHO recommendation value. WHO recommended that the pH for drinking water should be within the ranged 6.5-8.5. Drinking water with a pH below 6.5 is considered acidic (WHO, 1998). Increased in pH could be as a result of dissolved carbon dioxide in water. Carbon dioxide in water provoke the concentration of hydrogen ion, which lower the pH of the water. The relationship between Co_2 and pH is that, when carbon dioxide is high, the pH of water automatically becomes acidic. This statement is in line with the research published by Keith (2003), aerobic organisms which degrades organic wastes produces carbon dioxide, which solubilize in water to produce carbonic acid, thus keeping the water in acidic form.

Temperature of Water

From Table 1-3, the average Temperature of all the water sample (Bonganema Stream, Foya Stream and Kawela Stream) analysed fell outside the WHO Standard for temperature of drinking water. WHO does not have any standard value for the temperature of drinking water however, recommended that drinking water should have a temperature of 25.00^0C at a pH of 7.00. Temperature has a direct link with the pH of water, the lower the pH the higher the temperature.

The high temperature of the water sample could be related to anthropogenic heat material, nature of soil, ground level. Temperature played a pivotal role the potability of water, since it influences the physical, chemical and microbial processes in the absorption and microbial growth.

Turbidity

FromTable 1-3, the average turbidity values recorded for the three streams (Bonganema Stream, Foya Stream and Kawela Stream) fell outside the WHO recommended value (<5.0), for turbidity in drinking water. Turbidity played a major role in water quality determination. Material that reduces the turbidity of water include, suspended clay, silt, organic and inorganic, algae and other microscopic particles. Another cause of turbidity increase in water is due to transportation of solid waste and topsoil particles as a result of runoffs (Okeke and Adinna, 2013; Edori and Nna, 2018). Similar research carried out by Solomon and Kehinde (2017), reported similar increased in turbidity values. Another analysis carried by Edeki *et al.,* (2023), reported high values in turbidity that were above the maximal admissible ceiling of 5 NTU for WHO and NSDWQ benchmarks, suggesting an unsatisfactory condition of the water, high turbid waters are often associated with the possibility of microbiological contamination, as high turbidity makes it difficult to disinfect water properly (DWAF, 1999).

Electrical Conductivity (EC) and Total Dissolved Solid (TDS)

From Table 1-3, the average EC and TDS for the three streams (Bonganema Stream, Foya Stream and Kawela Stream) fell within the WHO standards for drinking water. The average EC and TDS for all the water sample analysed are with the WHO bracket. WHO recommended limits for EC and TDS are (<450 and <248) respectively. Electrical conductivity of water is directly associated with the concentration of dissolved solids within the water which influences the power of that water to conduct an electrical current (Environmental Protection Agency, 2014).

Chemical Parameters

Sodium (Na)

From Table 1-3, the result of Sodium (Na) concentration in all the water samples analysed fell within the WHO recommended bracket of sodium in drinking water. WHO recommended that the concentration of sodium in drinking water should be 200 mg of sodium per litre.

Sodium is an essential component for the human body as it helps to stabilised blood pressure, control fluid content, and help for normal nerve and muscle stabilisation. Excessive sodium in drinking water is reported to be related to increase in blood pressure, heart disease and stroke.

Magnesium (Mg)

From Table 1-3, the Magnesium (Mg), concentration in all the water samples analysed (Bonganema Stream, Foya Stream and Kawela Stream) fell within the WHO guideline for magnesium in drinking water. Magnesium is vital mineral in maintaining health muscles, bones, nerves and the stabilisation of sugar level in the body. Low magnesium in water could result to low appetite, vomiting, nausea and abnormal heart rhythms.

Calcium (Ca), Zinc (Zn) and Copper (Cu)

From Table 1-3 the result of Calcium (Ca), and Zinc (Zn) and Copper (Cu) in all the water samples analyse fell within the WHO guideline for calcium, zinc and copper in drinking water. WHO recommended that Ca, Zn, and Cu in drinking water should be, <250m/L, <5.0m/L, <1.0mg/L respectively. Low intake of Calcium in the body over a long period of time result in bone fertility, broken bone, loss odd mobility.

Zinc deficiency will cause loss of appetite and, in infant and young children slowed growth. High level of copper in drinking water can result in vomiting, diarrhoea and headaches.

Iron (Fe)

From Table1-3 the result of Iron (Fe) concentration in two of the streams (Bonganema Stream 1.29m/L, and; Foya Stream 2.01m/L,) fell outside the WHO recommendation guideline of iron in drinking water. According to WHO, the concentration of Iron (Fe) in drinking water should be <0.3m/L. However, Iron is an element that is found naturally in surface water (streams, and river) and ground water.

Although it is an essential metal for human health, high Fe concentrations are harmful to humans, affecting several physiological processes. Fe enrichment may be related to the dominant soil type in the region in addition to contamination generated by agricultural activity, and urban and industrial effluents in the vicinity of these water bodies (Bonnail *et al.,* 2017). The presence of high concentrations of iron in water can cause several problems, including incrustation leading to clogging of water treatment setups, acidification of water leading to corrosion of pipes, decline in soil cultivation productivity and undesired taste in drinking water. Similar research carried out by Viana *et al.,* (2021) to determine the concentration of iron in river water recorded values that are above the permissible limits.

Bacteriological Parameter

According to WHO standards (1997), potable water for human consumption must be free of microbial indicators of faecal contamination and the coliform count per 100ml of drinking water must be zero.

Faecal coliform

From table 1-3, the Faecal coliform of all the water sample analysed fell outside the WHO recommended limits of faecal coliform in drinking water. WHO recommended that total coliform bacteria should not be detected in 100 mL of drinking water. The presence of faecal coliform bacteria in stream indicates faecal contamination. Faecal coliform entered streams through runoff, animal faecal matter and water that contact contaminated soil. Faecal coliform are not disease-causing agent, but their potential presence can indicate harmful pathogen from faecal source.

Similar research carried out by total bacterial counts in all the water samples were found to be much higher than the allowable limit for bacteria in drinking water, indicating contamination Abdulkareem *et al.,* (2023).

Non Faecal Coliform

From Table 1-3, the none faecal coliform for all the water samples examined fell within the permissible bracket of WHO. According to WHO guidelines for drinking water, there should be <10 coliform and no faecal coliforms or faecal streptococci in 100 ml of any potable water sample (WHO, 2004). Non-fecal coliform bacteria are very common and are found virtually everywhere on soil particles, insects, plants, animals, walls and furniture in homes and on your skin and clothes (American Ground Water Trust).

Table.1 Physicochemical and Microbial Parameters of the Bonganema Stream

Bonganema Stream							
Parameters	Months			Mean	Variance	Standard Deviation	WHO
	April	May	June				
pH	5.69	5.73	5.78	5.73	0.002033	0.0451	6.5-8.5
EC (µs/cm)	118.00	121.00	124.00	121.00	9.00	3.00	<450(µs/cm)
TDS (ppm)	19.00	18.00	17.00	18.00	1.00	1.00	<248ppm
Tempt. (^{0}C)	27.00	28.00	29.00	28.00	1.00	1.00	No Value
Turbidity (NTUs)	3.49	7.24	11.08	7.27	11.69	3.42	<5.0NTU
Na (mg/L)	10.48	9.34	8.21	9.34	0.561	0.749	200m/L
Mg (mg/L)	0.83	1.04	1.24	1.04	0.0286	0.1691	<200m/L
Ca (mg/L)	2.95	6.66	10.46	6.69	10.74	3.28	<250m/L
Fe (mg/L)	1.69	1.30	0.89	1.29	0.1615	0.4019	<0.3m/L
Zn (mg/L)	0.42	0.41	0.40	0.41	0.0000666	0.008164	<5.0m/L
Cu (mg/L)	0.36	0.41	0.47	0.41	0.001733	0.0416	<1.0mg/L
Faecal coliform	16.00	13.00	10.50	13.17	7.29	2.7	0.00
Non-faecal	04.00	6.00	7.90	5.97	2.96	1.72	<10

Table.2 Physicochemical and Microbial Parameters of Foya Wulleh Stream

Foya Wulleh Stream							
Parameters	Months			Mean	Variance	Standard Deviation	WHO
	April	May	June				
pH	5.71	5.44	5.18	5.44	0.042	0.205	6.5-8.5
EC (µs/cm)	181.00	177.00	172.00	176.67	20.45	4.52	<450
TDS (ppm)	18.00	21.00	23.90	22.97	8.8214	2.97	<248
Tempt. (^{0}C)	27.00	27.00	27.00	27.00	0	0	No Value
Turbidity (NTUs)	8.10	12.30	16.60	12.33	395.82	19.895	<5.0
Na (mg/L)	8.62	6.55	4.47	6.55	1.764	1.328	200m/L
Mg (mg/L)	0.16	0.53	0.91	0.53	0.115	0.339	<200
Ca (mg/L)	4.71	7.81	11.01	7.84	7.36	2.71	<250
Fe (mg/L)	1.69	2.01	2.34	2.01	0.1056	0.3250	<0.3
Zn (mg/L)	0.60	0.71	0.83	0.71	0.008933	0.0945	<5.0
Cu(mg/L)	0.45	0.51	0.58	0.51	0.004433	0.06656	<1.0
Faecal coliform	22.00	24.00	26.10	24.03	2.05	1.43	0.00
Non-Faecal	6.00	5.00	4.01	5.00	0.995	0.997	<10

Table.3 Physicochemical and Microbial Parameters of Kawela Stream

Kawela Stream							
Parameters	Months			Mean	Variance	Standard Deviation	WHO
	April	May	June				
pH	6.27	5.81	5.35	5.81	0.16	0.4	6.5-8.5
EC (μs/cm)	327.3	330.00	332.8	330.00	7.2225	2.6875	<450
TDS (ppm)	36.00	39.00	42.00	39.00	9	3	<248
Tempt. (^{0}C)	27.00	28.00	29.00	28.00	1	1	No Value
Turbidity (NTUs)	4.34	7.09	9.89	7.11	5.07	2.25	<5.0
Na (mg/L)	9.66	10.06	10.46	10.06	0.16	0.4	200m/L
Mg (mg/L)	9.42	9.58	9.75	9.58	0.0167	0.1292	<200
Ca (mg/L)	10.87	12.03	13.20	12.03	35.609	5.967	<250
Fe (mg/L)	0.00	0.04	0.06	0.03	0.000889	0.0298	<0.3
Zn (mg/L)	35.00	33.00	30.00	32.67	6.29	2.51	<5.0
Cu(mg/L)	0.40	0.48	0.57	0.48	0.0067	0.082	<1.0
Faecal coliform	4.00	12.00	15.90	10.63	0.0067	0.082	0.00
Non-Faecal	12.00	8.00	3.90	6.97	10.03	3.17	<10

Figure.1 Map of Study Area

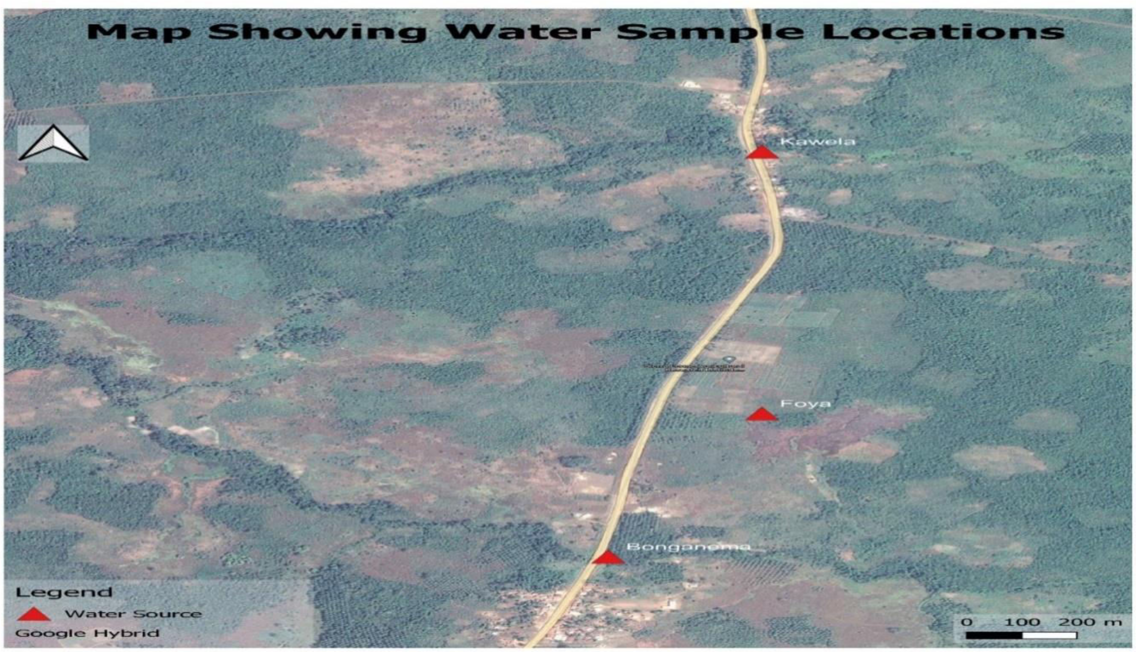


Figure.2 pH and Turbidity of all the water samples analysed

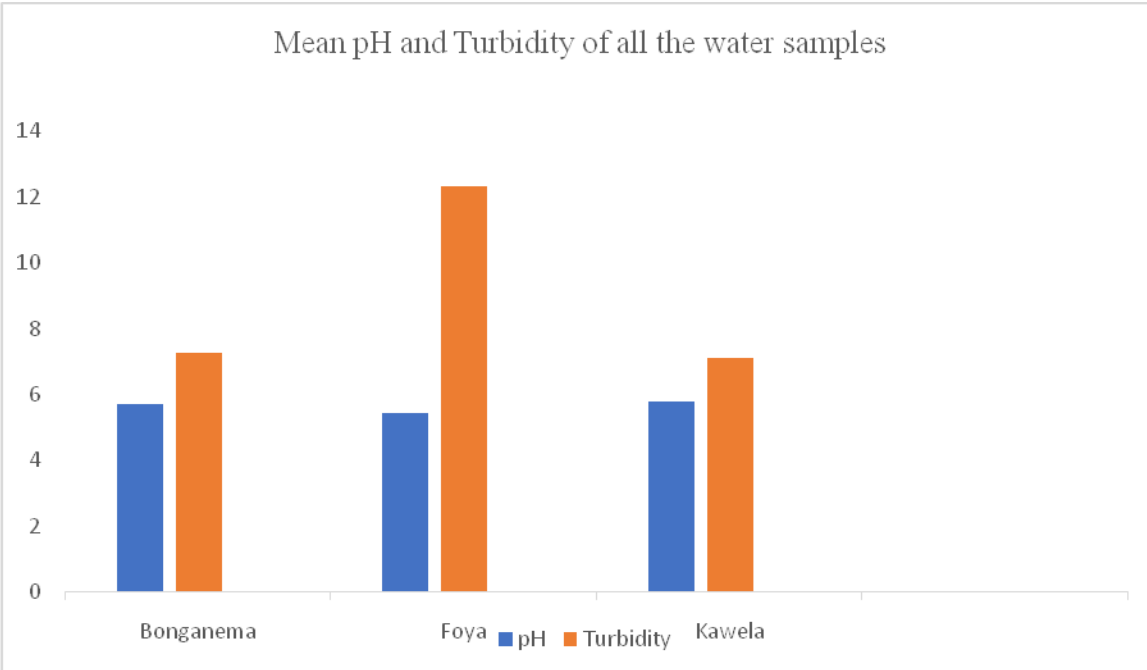


Figure.3 Level of Iron (Fe) content in the three Streams

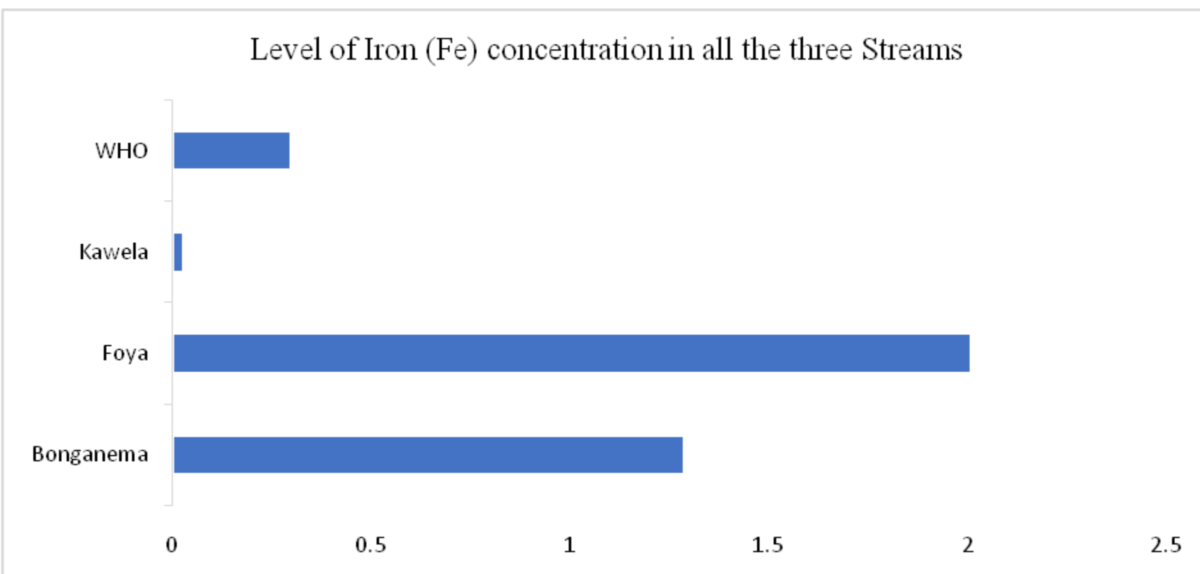
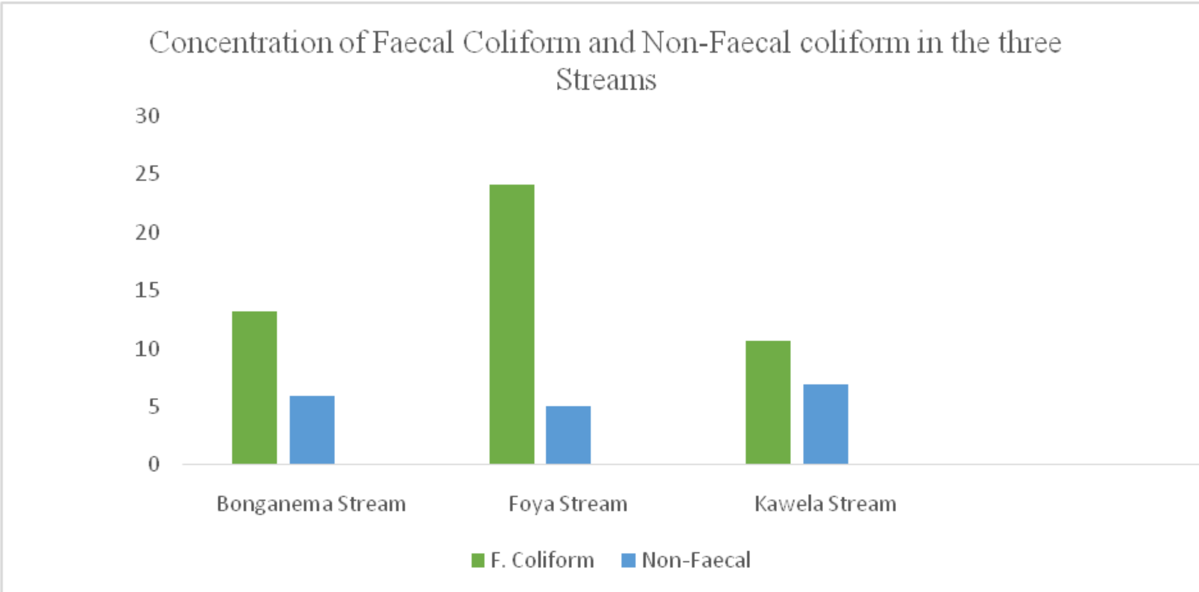


Figure.4 Faecal Coliform and Non-Faecal coliform content in the three Streams



The motive of this investigation is to examine the suitability for consumption of the Bonganema, Foya and Kawela Streams that are used for drinking and agricultural activities. The three streams are situated along Taiama- Njala University highway in the Kori chiefdom, Moyamba district, southern Sierra Leone.

Water played a pivotal role in nourishing and maintenance of the human body and temperature; therefore, it is imperative to examine it potability before it is consumed by all.

Agencies that regulate water qualities worldwide rely on the World Health Organization (WHO) standards and guidelines for drinking water quality (WHO, 1993, 1996, 2001 and 2002). So as to ensure the highest quality of potable water in order to safe guard public health (Anunobi *et al.,* 2006; Isikwue and Chikezie, 2014).

From the result of the samples analysed, the physical parameters of all the water samples fell within the WHO recommended standards for drinking water, except the pH and Turbidity that fell outside the WHO guidelines of drinking water, all the chemical parameters are in consistence with WHO guidelines except Iron, that shown high concentration in two of the streams (Bonganema and Foya) that far exceed the WHO recommended guideline for drinking water. All the three Streams shown high concentration of faecal coliform, that exceeded WHO recommended limits, however, result of non-faecal coliform for all the streams fell within the World Health Organisation guidelines for drinking water. It can however, be concluded that all the water samples examined are not potable and therefore unfit for drinking.

Author Contributions

Mohamed Pujeh Junior: Investigation, formal analysis, writing—original draft. Juma Sheriff: Validation, methodology, writing—reviewing. Yahaya Kudush Kawa:—Formal analysis, writing—review and editing. Sallu Pujeh: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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