ORIGINAL ARTICLE

Comparative assessment of physicochemical parameters and bacteriological load of two selected rivers (Ayin and Opeleki) in Igboora, Oyo State, Nigeria

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ABSTRACT

BACKGROUND:
Increase in human populations and technological advancement have been a great thorn in the quality of water we are using for our daily activities due to anthropogenic impacts, particularly in developing countries. This has led to microbial contamination of water, making it unfit for drinking.

OBJECTIVE:
The bacteriological examination and physicochemical parameters of two rivers in Igboora were examined for the water quality parameters. Water samples were collected from two streams at two different locations each.

METHODS:
Physicochemical parameters were carried out using standard method of determination. The bacteriological examination was carried out using the standard procedures.

RESULTS:
The total coliform count were 6.0×10^6 cfu/ml, 7.0×10^5 cfu/ml, 5.0×10^2 cfu/ml, 4.0×10^3 cfu/ml obtained from point A and B (Ayin) and point C and D (Opeleki) respectively. The bacteria isolated were *Escherichia coli, Salmonella* spp*., Shigella* spp. and *Staphylococcus* spp. The coliform counts from all points were above WHO maximum limits of drinking water. The result of physico-chemical parameters were pH (6.8 Mg/L) A, (7.2 Mg/L) B, (7.4 Mg/L) C, (6.6 Mg/L) D, Turbidity (0.712 Ntu) A, (1.654 Ntu) B, (1.468 Ntu) C, (1.811 Ntu) D, Conductivity (230 µs/cm) A, (278 µs/cm) B, (278 µs/cm) C, (288 µs/cm) D, Phosphate (mg/L) (1.70)A, (1.58)B, (1.58)C, (0.71) D, respectively. All values were within WHO/SON permissible limits except the phosphate values that exceeded the standard limits. This indicated pollution of the water body. The bacteriological analysis of the water presently studied indicated the presence of *Escherichia coli, Salmonella spp., Staphylococcus spp.* and *Shigella spp.* which suggests the water is not fit for drinking.

CONCLUSION:
The study revealed that high values of phosphate and the presence of *E. coli* indicated nutrient loads and faecal disposal into the river which is very dangerous to the health of water users.

KEYWORDS:
Bacteriological, Physicochemical Parameters, Phosphate, Rivers, Turbidity, *Shigella* Species, *Salmonella* Species

INTRODUCTION

Water is essential to life, and a satisfactory (adequate, safe and accessible) supply must be available to all[1]. The importance of water to man is aptly summarized in the words of Kofi Annan who said: "Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of people. It is an affront to human dignity''[2]. One of the most abundant and readily available sources of fresh water to man is river. It is the most important freshwater source for man. A river is a natural flowing watercourse, usually freshwater, flowing towards an ocean, sea, lake or another river. In some cases, a river flows into the ground and becomes dry at the end of its course without reaching another body of water. Small rivers can be referred to names as stream, creek, brook, rivulet, and rill. Rivers are very great and significant to humans by the fact that many human cities and civilizations are built around the freshwater supplied by rivers and streams. Most of the major cities of the world are situated on the banks of rivers, as they are, or were, used as a source of water, for obtaining food, for transport, as borders, as a defensive measure, as a source of hydropower to drive machinery, for bathing, flood control, recreation activities, and as a means of irrigating our agricultural farmlands[3].

Rivers are vital and vulnerable freshwater systems that are critical for the sustenance of all lives. However, the declining quality of the water in these systems threatens their sustainability and is therefore a cause for concern. Rivers are waterways of strategic importance across the world, providing main water resources for domestic, industrial and agricultural purposes[4]. The maintenance of healthy aquatic ecosystem is dependent on the physicochemical properties and biological diversity. A regular monitoring of water bodies would not only prevent the outbreak of diseases and occurrence of hazards but would check the water from further deterioration.

Asides, the pollution of rivers by indiscriminate disposal of sewage, untreated industrial waste and plethora of human activities affect their physicochemical characteristics and microbiological qualities[5]. Owing to the large quantity of effluents discharged into receiving rivers, the natural processes of pathogen reduction are inadequate for protection of public health. In addition, industrial wastes that alter the water pH and provide excessive bacterial nutrients often compromise the ability of natural processes to inactivate and destroy pathogens[6].

Contamination of water is a serious environmental problem as it adversely affects human health and biodiversity in the aquatic ecosystem. Akubuenyi[7] stated that the presence of these bacteria's is an indication that the water sources are not potable for human consumption. The occurrence of pathogens in water resources is a sign that such waters may result in the transmission of waterborne diseases. Egbe[8] also reported that the occurrence of coliform in the potable water sources could be due to the presence of human and animal excreta in such water. The excreta could provide appropriate nutrients require for growth and proliferation. Generally, *E. coli* and *Enterobacter aerogenes* in polluted water indicates presence of recent faecal matters[9]. Isikwue and Chikezie[10] stated that feacal coliform in water is influenced by the presence of wastewater and septic system effluent, animal waste, sediment load, temperature and nutrients levels. Therefore, this research was designed to examine bacterial load that might associated with the contaminant in the rivers and its physicochemical qualities to probably proffer methods of treating the river water before use.

METHODS

Description of Sampling Site:
The study was carried out in two rivers Ayin and Opeleki in Igboora, Oyo State, Nigeria. At Ayin river, farming activities were ongoing, such as banana, coconut, orange, pineapple, cocoa and vegetable plantation like Ilasa (*Abelmoschus esculentus*), Lime (*Citrus aurantiifolia*), Cashew (*Anacardium occidentale*), Tangiri *(Laganaria breviflorus)* were cultivated by the residents close to the river, fishing activities were also taking place in the river. Ayin river is about 25 Km long from Igboora to the mouth of Oyan river.
Opeleki River contained plant like Cassava (*Manihot esculentus*), Palm tree (*Arecaceae*), Banana (*Musa spp.*), Mango (*Mangifera indica*), Pawpaw (*Carica papaya*) and activities like palm wine production and fishing activities were taking place by residents close to

the river. Opeleki river is about 30 Km long from Eruwa which meets at the river Ogun in Abeokuta, Ogun State. The two rivers were about 50 km distant to each other.

Sample collection:
Water samples were collected from two points in each river at 50 metres apart. The samples collected was preserved and taken to the laboratory for further analysis. Water samples for microbiological analysis were collected in a sterile amber coloured glass bottle. Sample containers were tightened carefully to ensure homogenized samples for laboratory analysis. The water samples were transported on ice to the laboratory to prevent possible alteration of parameters and also ensure microorganisms were immediately transported to the laboratory for analysis.

Preparation of Agar:
Nutrient agar, MacConkey agar and Eosin Methylene Blue (EMB) were prepared according to the manufacturers specification which state that about 28g of nutrient agar powder. 50g of MacConkey agar powder and 36g of Eosin Methylene Blue were weighed and dissolved separately in 1 litre or 100ml of distilled water. These were autoclaved at 121°C for 15 minutes respectively. After inoculation, the agar media were poured into a plate where the samples were introduced for culturing and isolation of microorganisms, following the procedure of Adebayo and Okonkwo[11].

Inoculation on Media in the Plate:
The Pour plate was used following the procedure of Izuchukwu *et al.*[12]. Ten - fold serial dilution of the water samples was prepared aseptically in physiological saline of 10^{-1} to 10^{-6} and 0.1ml of the dilution was placed on the nutrient agar plates at 37°C for 24 hours.

Total Heterotrophic Bacteria Count:
The microorganisms were inoculated. Plate containing 30 – 300 colonies was selected and counted. The number of colony forming per ml (cfu/ml) was calculated by multiplying the number of colonies by the dilution factor. Also, subculturing was carried out so as to obtain a pure culture and was viewed under the microscope for identification. Bacterial isolates were characterized on the basis of their colonial morphology and gram staining reaction as described by Cheesebrough[12].

Determination of Total Faecal Coliform:
Membrane filtration method was used to determine the total and faecal coliform according to International Organization for Standard. Serial dilutions of 10^{-1} to 10^{-6} were prepared. MacConkey Agar was used for the total coliform while Eosin Methylene blue EMB) was use for the faecal coliform count. The membrane was removed from a sterile package and was placed into the funnel assemblage. The poring lip of the sample container was fame and the sample was pour into the funnel. The vacuum was turn on so as to allow the sample to draw completely through the filter. The forceps was flamed and use to remove the membrane from the funnel. The membrane filter was place into the prepared petri-dish and was incubated at 35°C for the total coliforms and 44°C for the faecal coliform for 18 – 24 hours. The number of colonies was counted after incubation as described by Cheesebrough[12].

RESULTS

The pH values gotten for Ayin River was 6.8mg/L and 7.2mg/L in the two sampled location A and B and that of location B is more than location A. opeleki river reported 7.4mg/L and 6.6mg/L in the location C and D respectively and that of location C is higher compared to the location D. All pH values were acidic to neutral and were within the acceptable limits of WHO and SON standards. Turbidity has low values across station ranges Ayin (0.712 Ntu and 1.654 Ntu) and Opeleki River (1.811 Ntu and 1.468 Ntu). The values were lower than WHO and SON standard limits. The conductivity values ranges from 230-288 (µs/cm), the values from Ayin river was 230µs/cm and 278µs/cm and that of location B is greater than location A. Opeleki river reported 278µs/cm and 288µs/cm and that of location D was greater than location C. All values recorded for the three parameters were within the standard limits. In the same vein, the phosphate values (mg/L) recorded in this study revealed a high values more than the required limits for drinking water across Ayin River (1.70 mg/L and 1.58 mg/L) and Opeleki river (1.58 mg/L and 0.7 mg/L), (Table 1).

Table 1. Physicochemical Parameters of Ayin and Opeleki Rivers in Igboora

Parameters	Ayin River		Opeleki River		WHO	SON
	A	**B**	**C**	**D**		
pH (mg/L)	6.8	7.2	7.4	6.6	6.5 – 8.5	6.5 – 8.5
Turbidity (Ntu)	0.712	1.654	1.468	1.811	5.0	5.0
Conductivity(µs/cm)	230	278	278	288	1000-2500	1000
Phosphate (mg/l)	1.70	1.58	1.58	0.71	0.05	0.05

A – Sample A (Ayin River) B – Sample B (Ayin River), C – Sample C (Opeleki River), D – Sample D (Opeleki River), WHO – World Health Organization (2020); SON – Standard Organization of Nigeria (2020)

From table 2, it revealed the total coliform counts recorded in Ayin and Opeleki river with the mean total coliform count of A(6.0×10^6), B (7.0×10^5), C (5.0×10^2) and D (4.0×10^3) respectively. The highest cfu/ml occurred in river (Ayin) stations compared to that of Opeleki.

Table 2. Mean Total Coliform Counts (cfu/ml) of the Water Samples Collected from Ayin and Opeleki Rivers

Parameters	River Samples (cfu/ml)	WHO Standard
Sample A	6.0×10^6	0/100ml
Sample B	7.0×10^5	0/100ml
Sample C	50×10^4	0 / 100ml
Sample D	4.0×10^3	0 / 100ml

A – Sample A (Ayin River), B – Sample B (Ayin River), C–Sample C (Opeleki River), D – Sample D (Opeleki River), WHO – World Health Organization

Table 3. Result of Biochemical Characteristics of the Bacteria Isolates

CODE	Gram Identity	I	CI	MR	CARBOHYDRATE				G	CA	O	Confirmation of Identity
					S	**L**	**Dex**	**Mal**				
A	-ve	+	-	+	-	-	+	-	+	-	-	*E. coli*
B	-ve	-	+	+	-	-	+	+	+	+	-	*Salmonella spp.*
C	+ve	-	+	+	+	+	+	-	-	+	-	*Staphylococcus spp.*
D	-ve	-	+	+	-	-	-	+	+	+	+	*Shigella spp.*

MR – Methyl Red; I – Indole; CI – Citrate; CA – Catalase; O – Oxidase; Gram – Gram's Staining Test; S – Sucrose; L–Lactose; Dex – Dextrose; Mal – Maltose; G – Gas production; A – Sample A (Ayin River), B – Sample B (Ayin River), C – Sample C (Opeleki River), D – Sample D (Opeleki River); -ve – Negative +ve – Positive

Table 3 above shows the result of biochemical characteristics of the bacteria isolates from the water samples collected from two different sampling points of Ayin and Opeleki Rivers. The isolated organisms include; *Escherichia coli, Salmonella spp. Shigella spp.* and *Staphylococcus spp. Escherichia coli* are isolated from point A and *Salmonella spp.* are isolated from point B while *Staphylococcus spp.* and *Shigella spp.* are isolated from Point C and D. *E. coli* react negatively to gram staining test, citrate test, sucrose test, lactose test while it reacted positively to other biochemical parameters such as, indole test, sucrose test, lactose test and oxidase test while it reacts positively to others. *Staphylococcus spp.* reacted negatively to indole test,

maltose test, gas production and oxidase test but reacts positively to other test. *Shigella spp.* reacts positively to citrate test, methyl red test, maltose test, gas production test, catalase test and oxidase test but reacts negatively to other tests.

DISCUSSION

The key findings of this study is the high nutrient load (phosphate) values that exceeded the standard limits which implies pollution of the water body as a result of anthropogenic activities of the residents closed to the river, such as cloth washing, faecal deposition, flood, runoff from agricultural field etc. The present study revealed the status of the water samples of those rivers as being affected by human activities which in turn leads to pollution. The investigation also showed some organisms of health importance such as *E-coli* and others which are capable of causing water associated diseases. Water samples collection were limited due to distance of the rivers, cost of transportation and laboratory analysis and lack of accessible roads to the rivers.

Quality of water for drinking is determined by its physical, chemical and biological properties which include host of natural and human factors. The natural factors are geological, hydrological and climatological while human factors include activities such as discharge of domestic, industrial, urban and other waste waters [13].

Water pH values were within WHO and SON permissible limits in all sampling sites. The high pH could be attributed to increase floods and human activities. The findings from this study agree with those reported by Mulanda *et al.*[14] who also found pH levels in all sites within WHO permissible limits. Human activities such as accidental spills, sewer overflows and discharge of chemicals by communities and industries can possibly have significant effect on pH levels[15]. In all sampling sites, water turbidity values were below WHO and SON permissible limits (0 – 5 NTU) and could be attributed to low runoff. The findings from this study agree with those of Ontmbi *et al.*[16] and Wekulo [17]. Conductivity values that were below the WHO and SON permissible levels across stations could be associated to less organic input. Conductivity is

dependent on water temperature and salinity. In all sampling sites, the result obtained for phosphates that revealed high values could be attributed to varied discharge of agricultural runoff, human sewage and livestock activities in the region[18].

Four pathogenic bacteria were isolated from River Ayin and Opeleki rivers. *Escherichia coli*, *Staphylococcus spp.*, *Salmonella spp.* and *Shigella spp.* from rivers sampled. This is an indication of some contamination in the two rivers. The present report is in line with the Findings of Bamigbola [19] and May *et al.*[20] who conducted similar studies in river water. The least total coliform count in point D could be due to low organic input into the river and this disagrees with the result of May *et al.*[21] and Khalid *et al.*[22] who conducted similar studies on Tigris river and reported high total coliform count (1795 – 63000 cfu/ml) above the WHO permissible limit. Similar findings have been reported by Hassanein *et al.*[24] and Karikari and Ansa-Asare[23].

The availability of these bacteria in the two river can be associated with the activities in the river such as waste deposits, agricultural activities, wine production, fishing, etc. The bacteria isolated mainly belonged to the family *Enterobacteriacea* that is known to be pathogenic (Karikari and Ansa-Asare[24]. *Salmonella spp.* and *E. coli* are considered as food and waterborne pathogens and *E. coli* is a good indicator of faecal contamination of water[25].

The high number of total coliforms obtained from the water samples (A and B) could indicates high level of faecal contamination of the river which may pose health risk for the inhabitant of the community. This agrees with WHO[25] who stated that high coliform counts are an indication of high faecal contamination.

CONCLUSION

The study examined the physicochemical parameters and microbial load of water samples from Opeleki and Ayin rivers in Igboora, the result of physical and chemical parameters for this study indicated moderate pollution of the water bodies as the high values of phosphate indicated nutrient input. The bacteria isolated from the water bodies such as *Staphylococcus spp., E. coli., Shigella spp.* and *Salmonella spp.* are

pathogenic organisms, particularly *E-coli* that indicated faecal contamination can leads to waterborne disease for the users of this water. Therefore, this water bodies assessed are unfit for drinking unless treated. The potable water should be free of contaminant so as to live in healthy condition. Therefore, this study suggests that the individual residing in a close range with these water bodies should be enlightened on proper disposal of refuse and waste treatment.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest as far as this manuscript is concerned.

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