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Bacteriological and Physicochemical Analysis of Surface Water; Implications on Public Health

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ABSTRACT

Surface water is any source of water above the surface of the earth, surface water sources are lakes, rivers, streams, and even oceans. This surface water is the major source of water for drinking, agricultural and domestic use in the rural communities in Nigeria. The aim of this study was to determine the bacteriological and physicochemical parameters of the selected surface water in Ifaki Ekiti, Ekiti State, Nigeria. To achieve this aim, water samples were taken from Omi-Oniyo and Omi-Igbo streams in Ifaki-Ekiti and examined using microbial culture and physicochemical analysis method. The mean total coliform counts of the water samples at various times of collection were $1.83x10^4$cfu/ml and $1.43x10^4$cfu/ml, respectively, above the WHO limit for drinking water. The mean total bacterial counts were $3.7x10^4$cfu/ml and $4.03x10^4$cfu/ml, respectively. The isolated organisms are *Escherichia, Enterobacter, Pseudomonas, Bacillus, Staphylococcus,* and *Enterococcus* aerogens. Some of the physicochemical characteristics of the water samples are pH range of (6.30-6.80), and temperature (25-26) ^{0}C. Some of the isolates displayed multiple resistance to widely used antibiotics, thereby making the surface water a threat to public health. Therefore, water treatment and purification is recommended for these streams to prevent outbreak of waterborne diseases in the community.

Keywords: Surface Water; Microorganisms; Public Health; Physicochemical Parameters

Introduction

Water is a universal solvent, a critical component of life, as it constitutes about 71% of the earth's surface. In its purest form, water is clear, transparent, almost colorless, odorless, and tasteless, and devoid of germs and suspended particles. It has the chemical formula H_2O, with boiling and freezing points of 100°C and 0°C respectively. Water exists in nature as a liquid, a gas (water vapor), and a solid (ice) [1]. In rural areas of Nigeria, wells are common source of water for consumption and other household activities, additionally, streams and rivers in rural communities also serve as sources of water for domestic and agricultural use [2]. However, access to safe and clean water in Nigeria remains a challenge, particularly in rural areas where water sources are often contaminated with bacteria, pollutants, and suspended solids. This poses a threat to human health and the environment, emphasizing the need for proper water treatment and management strategies. Streams in Nigeria are highly susceptible to contamination with pathogens due to insufficient protection and their proximity to human activities, including washing, dumping trash, mining, and industrial processes.

This poses a threat to freshwater resources, which are becoming increasingly vulnerable to degradation on a daily basis [3]. Nigeria is one of the countries in the world with dangerous water supplies due to the disorganized activities of government entities, as noted by Adeyinka et al. [4]. Waterborne infections are easily transmitted due to the poor quality and inadequate treatment of drinking water in Nigeria. Bacterial and physicochemical contamination of water is most prevalent in Nigeria's rural areas where little or no attention is devoted to sources of potable water. The most common pollutants of surface water in Nigeria include microbes, metals, plastics, chemicals, excrement, urine, and debris. Among these pollutants, coliforms are the most common organisms found in contaminated water [3,4]. Increased levels of physicochemical characteristics and microbiological contamination can result in inevitable human and economic losses. Therefore, it is necessary to check the quality of water adequately to prevent an increase in element concentration and microbiological contamination.

Materials and Methods

Study Area

Ekiti State is a small state in southwestern Nigeria, bordering Kwara, Kogi, Ondo, and Ogun states to the north, northeast, south, and west, respectively. It covers a land area of 6,353 square kilometers, with geographical coordinates of 7°04'N 5°15'E. With an estimated population of 2,210,095, Ekiti State is the 30th most populous state in Nigeria and comprises sixteen local government areas.

The study sites, Omi-Oniyo and Omi-Igbo streams, are situated in Ido-Osi local government area of Ekiti State with a coordinate of 7.7800° N, 5.2423° E.

Samples Collection

A total number of eight (8) water samples were collected from eight (8) sites from two streams, and four samples were collected from Omi-oniyo in Iwore Street, Akushusun Quarters Ifaki Ekiti and labeled A1, A2, B1, and B2. Another four samples were obtained from Omi-Igbo stream, Along Methodist Cathedral Iloogbe Street, Ifaki Ekiti, and labeled C1, C2, D1, and D2. A random sampling technique was adopted. The samples were sealed and stored at a temperature of 4^0C to maintain the microbial load of the samples collected before performing microbiological analysis.

Sterilization

All the glassware were sterilized in a hot air oven at 160^0C for 2 hours while the culture media used were autoclaved at 121^0C for 15 minutes.

Pour Plate Method

A ten-fold serial dilution method was adopted, 1ml of samples from dilutions 10^{-3} and 10^{-4} was inoculated into Nutrient agar, MacConkey agar, Eosin Methylene Blue agar, and Salmonella Shigella agar. Nutrient agar slants were prepared in bijou bottles, pure culture of the organisms were picked aseptically, inoculated into the slants, and stored at 40 degree Celsius for further identification.

Characterization and Identification of Isolated Organisms

All isolated organisms were characterized and identified by appropriate tests.

Antimicrobial Susceptibility Test

This was done using the disk diffusion method on Mueller-Hilton agar according to CLSI [5]. Eight ABTEK disc antibiotics which comprised ceftazidime, cefuroxime, gentamicin, oflaxacin, cefixime, augmentin, nitrofuratoin and ciprofloxacin was used to test for the antibiotic susceptibility. The inoculum was incubated at 35 degrees celsius for 18 hours, the diameter of the zone of clearance was measured and interpreted based on CLSI guidelines [5].

Physicochemical Analysis of Water

The pH, temperature and conductivity were measured with a pH meter, thermometer and CDM83 conductivity meter respectively. Total alkalinity, total hardness and calcium hardness were determined by acidometry and EDTA respectively [6]. A visual method of the human sense of vision was used for the physical appearance of the samples.

Results

The result of the total bacterial and total coliform counts of samples obtained from Omi-Oniyo and Omi-Igbo streams in Ifaki-Ekiti are shown in (Table 1). The mean total bacterial count and mean total coliform counts of Omi-Oniyo stream are $3.7x10^4$ CFU/ml and $1.83x10^4$CFU/ml respectively while the mean total bacterial count and mean total coliform count of Omi-Igbo stream are $4.03x10^4$ CFU/ml, and $1.43x10^4$ CFU/ml respectively. The total bacterial count and total coliform count of Omi-Oniyo ranged from $2.7x10^4$ to $5.2x10^4$ CFU/ml and $1.4x10^4$ to $1.6x10^4$ CFU/ml respectively while that of Omi-Igbo ranged from $2.7x10^4$ to $5.5x10^4$ CFU/ml and $1.2x10^4$ to $1.6x10^4$ CFU/ml respectively.

Table 1: Total Bacterial density (CFU/ml) of the water samples from Omi-Igbo and Omi-Oniyo streams, Ifaki Ekiti, Ekiti State.

SAMPLES	Total Bacterial Count (cfu/ml)	Total Coliform Count (cfu/ml)
A1	$4.5x10^4$	$1.6x10^4$
A2	$5.2x10^4$	$1.8x10^4$
B1	$2.7x10^4$	$2.5x10^4$
B2	$3.7x10^4$	$1.4x10^4$
Mean value	$4.03x10^4$	$1.83x10^4$
Range	$2.7x10^4$ - $5.2x10^4$	$1.4x10^4$ - $1.6x10^4$
C1	$5.5x10^4$	$1.2x10^4$
C2	$4.4x10^4$	$1.6x10^4$

D1	$3.5x10^4$	$1.6x10^4$
D2	$2.7x10^4$	$1.3x10^4$
Mean value	$4.03x10^4$	$1.43x10^4$
Range	$2.7x10^4$ - $5.5x10^4$	$1.2x10^4$ - $1.6x10^4$

Note: KEY: A1, A2, and B1, B2= Samples obtained from Omi-Oniyo stream Ifaki Ekiti.

C1, C2 and D1, D2= Samples obtained from Omi-Igbo stream Ifaki Ekiti.

(Table 2) shows the percentage distribution of the isolates. The frequency of occurrence of the isolates is as follows: *Escherichia coli* had the highest frequency of occurrence of 50%, while *Staphylococcus aureus* had the lowest frequency of 6.25%. *Enterobacter aerogens* (15.6%), *Pseudomonas aeruginosa* (12.5%), *Bacillus sp* (6.25%), and *Enterococcus feacalis* (9.38%). (Table 3) shows the Percentage antibiotic resistance of each isolate from Omi-Igbo and Omi-Oniyo streams to each antibiotic. WHO=World Health Organization standard, BOD=Biochemical Oxygen Demand, Samples A and B=Samples obtained from Omi-Oniyo at different intervals, Sample C and D=Samples obtained from Omi-Igbo at different intervals. (Table 4) shows the multiple antibiotic resistance pattern of the isolates.

Table 2: Percentage distribution of the isolates from Omi-Igbo and Omi-Oniyo Streams, Ifaki Ekiti, Ekiti State.

Isolates	Number of Isolates	Frequency (%)
Escherichia coli	16	50.0
Enterobacter aerogens	5	15.6
Pseudomonas aeruginosa	4	12.5
Enterococcus feacalis	3	9.38
Bacillus sp	2	6.25
Staphylococcus aureus	2	6.25
Total	32	100

Table 3: Percentage antibiotic resistance of isolates from Omi-Igbo and Omi-Oniyo streams.

S/N	ISOLATES	CPR(5µg)	CAZ(30µg)	CRX(30µg)	GEN(10µg)	CXM(5µg)	OFL(5µg)	AUG(30µg)	NIT(300µg)
1	*Escherichai coli* (n = 16)	0%	6.25%	37.5%	12.5%	37.5%	0%	25%	18.75%
2	*Enterobacter aerogens* (n = 4)	0%	25%	50%	25%	0%	0%	75%	0%
3	*Pseudomonas aeruginosa* (n=2)	0%	0%	100%	50%	50%	0%	100%	100%
4	*Enterococcus feacalis* (n=2)	0%	0%	50%	0%	0%	0%	50%	0%
5	*Bacillus sp* (n=5)	0%	60%	60%	0%	60%	20%	60%	20%
6	*Staphylococcus aureus* (n=3)	0%	33.3%	66.7%	0%	100%	0%	66.7%	100%

Table 4: Physico-chemical results of water samples from Omi-oniyo and Omi-Igbo stream Ekiti-State.

PARAMETER			SAMPLES		
	A	B	C	D	WHO [12]
Temperature (^{0}C)	25	25	25	26	30
Odour	Odourless	Odourless	Odourless	Odourless	-
Colour	Colorless	Colorless	Colorless	Colorless	-
Turbidity (NTU)	0.02	0.02	0.03	0.04	5-25
Conductivity (µS/cm)	$9.8x10^2$	$9.7 x10^2$	$10.2 x10^2$	$10.2 x10^2$	$<10^3$
pH	6.70	6.30	6.78	6.80	6.5-8.5
Total dissolved solids (mg/L)	111.50	110.40	108.20	113.00	1500
Total solid (mg/L)	133.50	132.60	131.70	136.70	600
Total suspended solids (mg/L)	22.00	22.20	23.50	23.70	>10

Total alkalinity (mg/L)	24.00	23.00	26.00	27.00	100
Acidity as $CaCO_3$ (mg/L)	2.20	2.30	2.50	2.40	-
Total hardness (mg/L)	123.00	124.00	121.00	23.00	500
Chloride (mg/L)	20.50	21.00	19.00	20.00	250
Sulphate (mg/L)	11.30	11.50	10.25	12.30	250
Phosphate (mg/L)	4.50	4.30	5.20	5.20	<5
Nitrite (mg/L)	6.21	6.23	5.20	5.20	<50
Dissolved Oxygen (mg/L)	8.20	8.20	7.50	8.00	<5
BOD (mg/L)	3.50	3.20	3.30	3.50	-

Note:

1) WHO=World Health Organization standard
2) BOD=Biochemical Oxygen Demand,
3) Samples A and B=Samples obtained from Omi-Oniyo at different intervals,
4) Sample C and D=Samples obtained from Omi-Igbo at different intervals.

Table 5: Mineral analysis of water samples from Omi-oniyo and Omi-Igbo Streams Ekiti-State.

Parameter	Sample A	Sample B	Sample C	Sample D	WHO [12]
Na (mg/l)	3.00	2.50	4.20	3.00	200
K (mg/l)	11.50	12.00	12.50	4.00	20
Ca (mg/l)	5.50	5.60	5.80	5.70	75-200
Mg (mg/l)	24.00	24.50	23.50	24.50	30-150
Zn (mg/l)	0.01	0.01	0.02	0.02	5-15
Fe (mg/l)	0.03	0.02	0.01	0.01	0.1-1
Cu (mg/l)	0.01	0.01	0.01	0.01	0.05-1.5
Pb (mg/l)	ND	ND	ND	ND	0.01
Cd (mg/l)	0.30	0.20	0.25	0.20	0.03
Cr (mg/l)	1.10	1.20	0.05	1.00	0.05

Note: Key: ND: Not detected.

Bacillus sp showed no multiple resistance pattern, *Pseudomonas aeruginosa* showed resistance towards Cefuroxine, Gentamicin, and Augmentin, *Enterococcus feacalis* showed resistance towards Cefuroxine, Cefixime, Augmentin, Ceftazidime, and Nitrofuratoin, *Staphylococcus aureus* showed resistance towards Cefuroxine, Cefixime, Augmentin, Ceftazidime and Nitrofuratoin, *Enterobacter aerogens* showed resistance towards all the antibiotics except Ciprofloxacin and Gentamicin while *Escherichia coli* showed resistance towards Cefuroxime, Gentamicin, and Cefixime. (Table 5) shows the physicochemical parameters of the samples. The water samples have a temperature range of 25.00 to 26.00^{0}C, pH range of 6.30 to 6.80, TDS range of 110.40 to 113.00mg/L, and total hardness of 121.00 to 124.00. Minerals such as Sodium had a range of 2.50 to 4.20, Potassium from 11.50 to 14.00, and Calcium from 5.50 to 5.80 while lead was not detected.

Discussion

The Omi-Igbo and Omi-Oniyo streams are uncontrolled and unmanaged bodies of surface water with a high pollution rate. While water is essential for life, it can also harbor bacteria that cause infections in humans. In Nigeria, the intake of contaminated water is a significant contributor to sickness, with about 90 million people lacking access to safe drinking water. Every year, 130,000 under-five-year-old citizens die from curable waterborne infections, as reported by Yusuf [4]. The natural quality of water has deteriorated due to ongoing human exploitation, population growth, and urbanization. The promiscuous exchange and movement of genes and genetic vectors in water can lead to the development of resistance against bacteria from various sources, including humans, animals, and ecosystems [7].

In this study, 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. Total coliform counts in all water samples also exceeded the permissible level of zero total coliform count per 100ml of water, as specified by the EPA in 2003 [8]. *Escherichia coli* was the only member of the coliform group that was isolated. These findings highlight the urgent need for proper management and control of the Omi-Igbo and Omi-Oniyo streams to prevent further contamination of water sources and safeguard public health.

The high coliform count in the water samples, above the allowable limit of 0 per 100 ml, indicates the presence of fecal matter, which could be from humans or animals. Banwo [9] reported that the availability of thickets around water sources facilitated the familiarity of cattle with water sources, leading to their excretion into water bodies. *Staphylococcus aureus*, a common water contaminant, was found in all the water samples, indicating the presence of enterotoxins that make the water unsuitable for consumption similar to the report of Faria et al. [10].

This study observed that most of the isolated bacteria were resistant to more than three antibiotics, posing a potential danger to the

health of the community residents. The physicochemical study of the water samples revealed that they did not meet WHO standards. The pH range of 6.5 to 6.8 in the water samples met the WHO requirements. The high concentration of free carbon (IV) oxide reported by Edema et al [11]. could be the reason for the low pH value found in sample B. The measured turbidity deviated from WHO guidelines [12], although Asano [13] argued that suspended solids have protective effects. According to Banwo [9] the temperature increased from 28.00°C to 30.00°C on relatively hot days, which is thought to have had an impact on the temperature range. All of the water samples had results that did not meet the WHO criteria for total dissolved solids, total solids, total alkalinity, total hardness, chloride, sulfate, and dissolved oxygen. While nitrite concentration met the WHO norm, samples A and B (Omi-Oniyo stream) had phosphate concentrations that were also in accordance with the WHO standard, but samples C and D (Omi-Igbo stream) deviated from the standard. All the identified elements in the samples were also out of the range allowed by the World Health Organization.

Conclusion and Recommendations

This study showed that improper human activities are the main cause of water contamination in the study area. These activities include poor sanitation, illegal waste disposal, sewage leakage, organic waste disposal, inappropriate washing of clothes and vehicles, and improper sewage disposal. Erosion has also been identified to contribute to the contamination of surface waters. It is essential to note that these streams harbor various pathogenic microorganisms with different antibiotic resistances, which pose a severe health risk to the community's residents. Antibiotic-resistant genes may be present in these organisms and spread to other potentially dangerous bacteria in the ecosystem.

To prevent waterborne diseases, it is necessary to carry out regular studies of these streams to ensure that the coliform level is within the permitted limit, and the level of metals and mineral composition is likewise within the acceptable range before human use. It is also crucial to raise community members' awareness of the state of their source of water and the potential implications of using it for domestic purposes. Additionally, the community's residents need to be educated on the importance of ceasing all improper human activity near and in the vicinity of the streams. To provide safe water for human use and reduce the risk of the occurrence of waterborne diseases, the state government of Ekiti is strongly advised to work with the federal government, pertinent health organizations like the World Health Organization (WHO), ministries of water resources, and environment. By putting in place a drainage system, government organizations can also prevent the discharge of wastewater onto surrounding soils, soil erosion, and runoff from the community. It is crucial to treat water sources for domestic use, and community members need to be instructed on how to treat their water to prevent problems from waterborne diseases in the area.

Conflict of Interest

The authors declare no conflict of interest.

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References

1. Gleick P H (1993) Water in crisis: A Guide to the World's Freshwater Resources. Oxford University Press. Water reserves on the earth. Archived from the original on ed, p. 13.
2. Oluyege J O, Koko A E, Aregbesola O A (2011) Bacteriological and physicochemical quality assessment of household drinking water in Ado-Ekiti, Nigeria. Water Science and Technology: Water supply 11(1): 79-84.
3. Mahananda H B, Mahananda M R, Mohanty B P (2005) Studies on the Physico-chemical and Biological Parameters of a Fresh Water Pond Ecosystem as an Indicator of Water Pollution. Ecology Environment and Construction 11(3-4): 537-541.
4. Adeyinka Sikiru Yusuff, Wasiu John, Akintayo Christopher Oloruntola (2014) Review on prevalence of waterborne diseases in Nigeria. J. of Advancement in Medical and Life Sciences 1(2): 2348-294X.
5. Sarah I Umeh, Chika Paulinus Enwuru (2005) CLSI Performance standards for antimicrobial susceptibility testing; fifteenth informational supplement, Clinical and Laboratory Standard Institute Wayne, Pa M100-S15 4(4).
6. Gildas K Gbassi, Thodhekes N S J Yao, Patrick G Atheba, Mariette D Yehe, Germain A Brou, et al. (2005) AOAC Official Methods of Analysis. (18th Edn.,), Association of Official Analytical Chemists International, Gaithersburg, MD, USA, Official Method 7(2).
7. Bamikole OJ, Olajide TH, Adedeji BA, Ademola SA, Fayehun AF, et al. (2023) Drug Use Practices and Self-treatment for Suspected Malaria in Ibadan, Nigeria. Am J Trop Med Hyg 108(6): 1122-1126.
8. (2005) EPA Protecting Water Quality from Agricultural Runoff. Fact Sheet No. EPA-841-F-05-001.
9. Banwo K (2006) Nutrient Load and Pollution Study of Some Selected Stations along Ogunpa River in Ibadan, Nigeria. M.Sc. Dissertation. University of Ibadan, Ibadan, Nigeria, pp. 107.
10. Faria C, Vaz Moreira I, Serapicos E, Nunes O C, Manaia C M (2009) Antibiotic resistance in coagulase negative Staphylococci isolated from wastewater and drinking water. Science Total Environment 407(12): 3876-3882.
11. Edema M O, Omemu A M, Fapetu O M (2001) Microbiological and physicochemical analysis of different sources of drinking water. Nigerian Journal of Microbiology 15: 57-61.
12. (2017) WHO Guidelines for Drinking-Water Quality. (4th Edn.)., Incorporating first addendum. World Health Organization, Geneva, Switzerland.
13. Asano T, Franklin Burton, Harold Leverenz, Metcalf, Eddy, et al. (2007) Water reuse; Issues, technologies, and applications. New York; McGraw-Hill, pp. 1570.

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