

## Microbial Detection and Quantification and its Effects on the Potability of Ofu River Water in Anyigba, Nigeria

by

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### Abstract

*This study aimed at analyzing specie composition and community structure of microbial indicators and its potable water quality implications. The objectives were: to identify the types of microbials in Ofu River and Soils, quantify their community structure and compare with WHO, EU and NSDWQ standards. Total viable bacteria count for water samples was conducted while total coliforms count (TCCs) was analysed using standard Plate Coliform counts Technique using MacConkey Agar. Fecal coliform was determined using Eusin Methylene medium via Pour Plate Technique (PPT). The confirmation of the isolated medium was obtained using Lactose broth at 45.5°C. Both soil and water samples were collected at four (4) different sample points (S1-S4) along the Ofu River channel. Soil samples were emulsified in 45ml of distill water followed by serial dilution until 10<sup>6</sup> was achieved. Results of TVBCs at S1 (Ojofu) was 6.7x10<sup>6</sup>cfu/ml but MacConkey agar revealed 3.0x10<sup>6</sup>cfu/ml concentration. At S2 (Agbenema), results indicate 5.8x10<sup>6</sup>cfu/ml and 2.0x10<sup>6</sup>cfu/ml respectively. At S4(Akponogwu), it was 6.1x10<sup>6</sup>cfu/ml and 3.5x10<sup>6</sup>cfu/ml. For total viable bacteria count (TVBCs) for the riparian soil, S1(Ojofu), it was 8.6x10<sup>6</sup>cfu/kg and 4.1x10<sup>6</sup>cfu/kg. At S2(Agbenema), it was 7.3x10<sup>6</sup>cfu/kg and 5.2x10<sup>6</sup>cfu/kg. S4 revealed a concentration of 9.4x10<sup>6</sup>cfu/kg and 3.8x10<sup>6</sup>cfu/kg. Soil Fecal coliform at S1(Ojofu) 4.0x10<sup>5</sup>cfu/kg and 8.0x10<sup>5</sup>cfu/kg. For water sample at S2 (Agbenema), it was 9.5x10<sup>5</sup>cfu/ml and 11.5x10<sup>5</sup>cfu/ml, S3 (Agala-Ogane)3.5x10<sup>5</sup>cfu/ml and 11.5x10<sup>5</sup>cfu/ml. This study recommends periodic microbiological assessment of Ofu River and its riparian soil so as to be abreast with microbial indicator's concentrations and its potable water implications.*

**Key phrase:** Surface, Quantification, Ofu, Microbial, River, Potable and Water

## 1.0 Introduction

Globally, microbial pollution of river water is a significant threat to humans and the environment. This happens when microorganisms, including bacteria, viruses and protozoa, contaminate water bodies such as rivers, lakes and streams. However, clean and safe water is absolutely needed for healthy and productive life. The quality of water supplied is important in determining the health of individuals and the community. The problem of pollution is profound in developing countries where technology for water treatment is not widespread (Kumar et al., 2021).

Headway streams play important functions in catchment ecosystem processes and are particularly easily influenced by factors such as land use degradation and anthropic (not tended) hydrological alterations (Juan, Ignacio and Tomas, 2022). So long as several factors affect, control and manipulate surface water quality, microbiological pollutants will always be present in them. High incidence of waterborne diseases occurs due to the continuous use of contaminated surface water resources (Majedul, Muhammad and Atikul, 2021). Thus, regular determination of health risks assessment is required by all and sundry to know whether the surface water is suitable, fit and proper for both human consumption and crop irrigation. The deleterious change in the physical structure, chemical properties or appearance due to exposure of coastal water quality from fecal pollution poses a health risk to visitors at recreation beaches (Akechai, Natcha, Surapong and Thammanitchpol, (2021). Fecal indicator bacteria are a proxy for fecal pollution (Akechai et al, 2021).

Microbial surface water contamination can create a disorder in the critical ecosystem services such as recreation and drinking water supply (Allen, 2021). Prediction of water contamination and appraisal or evaluation of sustainability of water resources in the context of water quality are needed but are hard since they require much effort to be achieved (Allen, 2021). Fecal pathogens can be introduced into surface water through open defecation, illegal disposal and inadequate treatment of fecal sludge and wastewater (Daniel, Carolien, Gartjan, Peter and Heather, 2021). Traditional techniques to identify different contaminants (physical, biological or chemical) in water are slow, laborious and can require specialised expertise (Gowher, Muhammad, Mudasir and Mapzoor, 2021).

Water quality of rivers relies on their physical, chemical and biological properties (Suther, et al., 2009). The biological quality is defined by the types of living organisms present in the water, as well as their abundance and diversity (Lear et al., 2011). Therefore, by assessing species composition and community structure of a subset of organisms, biological indicators are very useful in providing an overall index of ecosystem health (Lear et al., 2009). Many groups of organisms have been used in the assessment of aquatic ecosystems, including periphyton, diatoms, benthic invertebrates and fish (Naigaga et al., 2012). Globally, contaminated water is a serious threat to human health and ecosystem integrity (Sabater et al., 2018). The expanding population coupled with the desire and need for improved livelihoods have resulted in anthropogenic activities that have led to the continuous release of pollutants (including sewage) into virtually all environmental matrices (Liyanage and Yamada, 2017). Low level of contamination might remain undetected by using DNA based QPCR assays (Annastiina, Ananda, Anna-Maria and Sari, 2021). Microbiological surface water contamination can disrupt critical ecosystem services such as recreation and drinking water supply systems (Allen, Christopher, Riasi and Lilit, 2021). The assessment of sustainability of water resources are needed but are difficult to achieve with challenges arising from complexity in environmental systems (Allen et al., 2021).

Enteric animals are typically responsible for waterborne diseases (Karaboze, et al., 2003). However, the indicator bacteria such as fecal coliforms (FC) and Fecal Streptococci (FS) assessment of fecal pollution and possible water quality deterioration in fresh water sources is widely used (APHA, 1995). However, Youn-Joo et al. (2002) monitored coliform bacteria and *E-coli* in Texas and Oklahoma to determine the microbial pollution in the lake environment. Currently, coliform and *E-coli* are of great importance among bacterial indicators used in water quality definition and health risk assessment (Giannoulis et al., 2005). Microbial pollution in inland water bodies could originate primarily from agriculture and urban land use and although contamination of a water body may occur at any time, the survival of microbial contaminants depends largely on the physical and chemical conditions of the water. Thus, microbial contamination of a water body often appears to be episodic, coinciding with periods that are favourable to microbial growth. In this study therefore, some environmental parameters such as temperature, turbidity, depth and  $P^H$  were monitored (Figures 1 and 2). In addition, the bacteriological analysis involved total viable bacterial count (TVBCs), total coliform (TC) and

estimation of fecal coliform (FC), fecal streptococci and pathogenic bacteria. The physicochemical parameters showed that the temperature values varied from 17- 25°C and the transparency from 40- 220 cm whereas the depth varied from 25m and P<sup>H</sup> valued from 7.24- 8.44. In the same work, the bacteriological analysis showed that TVBCs ranged from 10.8 x 10<sup>7</sup> to 150 X 10<sup>7</sup> cfu/ml and from 8.8 x 10<sup>7</sup> to 152 x 10<sup>7</sup>cfu/ml at 22<sup>o</sup>c and 37°C, respectively. The results of the fecal indicator count reveal that their densities increased from upstream to downstream.

Microbial pollution in inland water bodies could originate primarily from agriculture and urban land use and although contamination of a water body may occur at any time, the survival of microbial contaminants depends largely on the physical and chemical conditions of the water. Monitoring the bacterial quality of stream water is a major public health problem worldwide; because this water can be an important vehicle for the transmission of waterborne diseases: hence the need to evaluate the bacterial quality (Suther, et al., 2009). Monitoring the bacterial quality of drinking water is done through laboratory testing for the coliform groups. Thus, the total coliform refers to the large assemblage of gram-negative, rods shaped bacteria that share several characteristics. These include *E. coli*, Klebsiella, Enterobacter, Streptococcus spp. etc. Before water can be described as potable, it has to comply with certain chemical, physical and microbiological standards (WHO, NSDWQ and EU) which are designed to ensure that the water is potable and safe for drinking and other uses.

The aim of this study is to detect and quantify microbiological indicators of Ofu River in Kogi State, Nigeria. To achieve the aim, the following objectives were formulated; to: quantify and assess contamination level of TVBCs of Ofu River water; evaluate total and fecal coliform in Ofu River water and soil of the watershed; identify health implication of microbial pollution of Ofu River; and suggest mitigatory measures to reduce microbial pollution of Ofu River water. Thus, studies have been conducted to ascertain these parameters in varying water sources: well water (Ezeribe et al., 2012, Aboh et al., 2015, Gambo et al., 2015, Allamin et al., 2013), borehole water (Ibe & Okplenye, 2005; Onwughara et al., 2013; Isa et al., 2013; Ehiowemwenguan et al., 2014), rivers, streams and lakes (Ukpong & Okon, 2013; Sa'eed & Mahmoud, 2014, Okorundu & Anyado-Nwadike, 2015; Joshi et al., 2009; Lawal & Lohdip, 2015). None of the studies above identified, quantified and assessed the microbial indicators of Ofu River, Nigeria. However,, the

current study has identified, quantified and assessed microbiological indicators and their water quality implications in Ofu River, Nigeria.

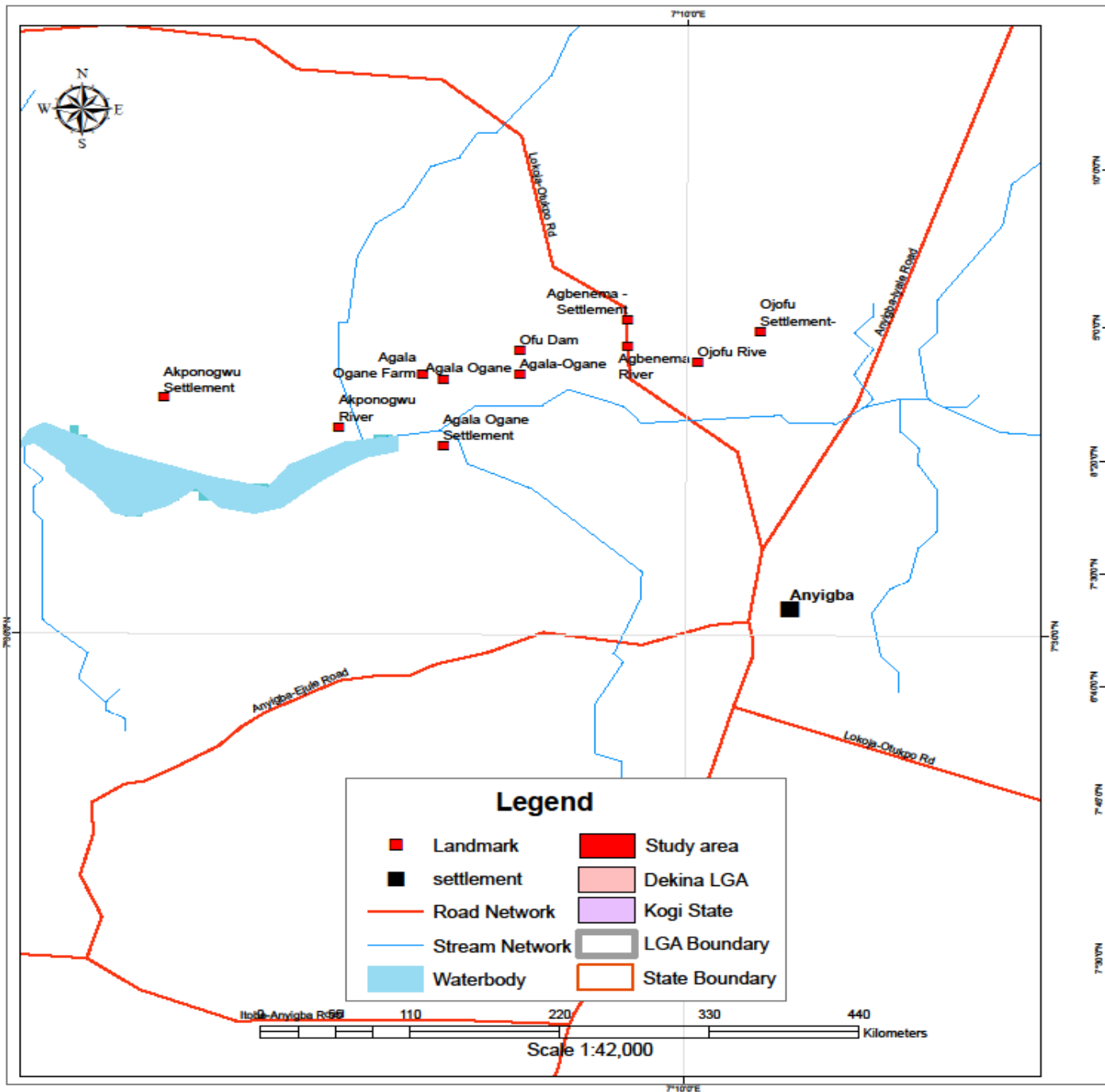


Figure 2: The Study Area

Source: GISLAB Department of Geography and Environmental Studies, PAAU., Anyigba, 2025.

## 2.0 Methods and Instrumentation

The bacteriological analysis comprises Total Viable Bacterial Counts (TVBCs), giving a quantitative estimate of the concentration of microorganisms such as bacteria, yeast or molds spores in a sample. The counts represent the number of colonies forming units (cfu) per gram (or per ml) of the sample. This test is necessary in the water samples because the intended result offers an indication to the general level of contamination within a system and the overall quality of the water. The Total Coliform (TC) gives a general indication of the sanitary condition of the water. Total coliforms include bacteria that are found in the soil and in water that has been influenced by the river and in human or animal waste. Fecal Coliform (FC) are a sub-group of the total coliform bacteria that can be found in the intestines and feces of warm-blooded animals. *E. coli* is an example that typically resides in the intestinal track of warm-blooded animals, and thus the animal fecal matter.

The assessment of microbials were carried out using Total Aerobic Plate Count. All the media used were prepared according to manufacturer's specification as follows:

- (a) Total Viable Bacterial Counts for the water samples at different sampling points;
- (b) Total Coliform Count (TCC) was analysed using the standard plate coliform count technique using MacConkey agar;
- (c) Fecal Coliform (FC) microbiological parameter was determined using Eosin methylene blue medium via Pour Plate Technique (PPT). The confirmation of the isolated was obtained using lactose broth at 45.5°C.

Four samples of water labelled S1-S4 and four samples of soil labelled S1-S4 were collected from each location. The samples from S1-S4 and S1-S4 were analysed as soon as they were submitted to the Microbiology Laboratory, Kogi State University Anyigba, Nigeria for Total Viable Bacterial Counts, Total Coliform Counts and Fecal Coliform Counts. 5g of soil samples were emulsified in

45ml of distilled water. This was followed by serial dilution until a  $10^6$  dilution was obtained. Serial dilution of the water samples was also obtained by diluting 1ml of the sample in 9ml of water and thereafter performing serial dilution until  $10^{-6}$  dilution was obtained. 1ml of  $10^{-5}$  dilution was obtained. 1ml of  $10^{-5}$  and  $10^6$  dilutions of the soil and water samples were inoculated into molten nutrient agar, MacConkey Agar for viable bacterial count and coliform counts Agar for fecal coliform count in petri dishes that were appropriately labelled. Inoculated plates were allowed to set and incubation was at  $35^{\circ}\text{C}$  for 24hrs to 48hrs. Colonies forming units (CFUs) on nutrient agar, MacConkey agar and coliform agar were counted at the end of 48 hours. Questionnaire administration was adopted among staff of health facilities to determine the effects of microbial contamination on the health of the residents of the study area.

**Table 1: Geographical Description of the Sampling Stations**

<i>Sampling codes</i>	<i>Name</i>	<i>Latitude of Sample Site</i>	<i>Longitude of Sample Site</i>	<i>Major Land Use Type</i>	<i>Altitude</i>
S1	Ojofu (Control)	$7^{\circ}31'39.43''\text{E}$	$7^{\circ}10'3.59''\text{N}$	Built-up/Forest	249m
S2	Agbenema (Experimental)	$7^{\circ}9'40''\text{E}$	$7^{\circ}3'46''\text{N}$	Built-up/Agriculture	262m
S3	Agala-Ogane (Experimental)	$7^{\circ}31'35''\text{E}$	$7^{\circ}8'33''\text{N}$	Built-up/Agriculture	299 m
S4	Akponogwu (Experimental)	$7^{\circ}31'15.57''\text{E}$	$7^{\circ}7'6.62''\text{N}$	Built-up, Refuse dump/Agriculture	254m

Source: Field Survey, 2025.

The geographical description of the sample stations, altitude and land use types in the study area are presented in Table 1. Agala Ogane has the highest elevation above mean sea level (299m) closely followed by Agbenema (262m). The least altitude in the selected sample sites is Ojofu (249m) above mean sea level. This implies that the sample stations are diverse in terms of elevation levels. This also means that the elevation of each of the sampling points differ and influences the settlements and land use types differently. This goes a long way to affect flow of runoff in each of

these stations. The table also reveals the land use activities in the study area. The dominating land use type of the study area is agriculture (crop growing/ animal husbandry) and built-up land.

## Presentation of Results and Discussion

Total Viable Bacterial Counts of Ofu River Water

<i>Sample</i>	<i>Nutrient Agar (cfu/ml)</i>	<i>MacConkey (cfu/ml)</i>
<i>S1</i>	$6.7 \times 10^6$	$3.0 \times 10^6$
<i>S2</i>	$5.8 \times 10^6$	$2.0 \times 10^6$
<i>S3</i>	$9.4 \times 10^6$	$3.0 \times 10^7$
<i>S4</i>	$6.1 \times 10^6$	$3.5 \times 10^6$
<b>GUIDELINE</b>		
<i>WHO</i>	$1.0 \times 10^2$	$1.0 \times 10^2$
<i>EU</i>	$1.0 \times 10^2$	$1.0 \times 10^2$
<i>NSDWQ</i>	$1.0 \times 10^2$	$1.0 \times 10^2$

Source: Field Survey, 2025.

As shown in Table 2, the bacteriological analysis of Total Viable Bacteria Counts (TVBCs) of water samples is revealed. At S1 (Ojofu), nutrient agar revealed  $6.7 \times 10^6$  bacteria per milligram of water but with MacConkey agar,  $3.0 \times 10^6$  bacteria were noticed. At station 2 (Agbenema),  $5.8 \times 10^6$  bacteria were discovered through nutrient agar medium, whereas MacConkey revealed  $2.0 \times 10^6$  bacteria counts. The highest bacteria count for the study area was at S3 (Agala-Ogane) with Nutrient agar results of  $9.4 \times 10^6$  bacteria while MacConkey agar revealed  $3.0 \times 10^7$  bacteria. At S4 (Akponogwu), nutrient agar revealed  $6.1 \times 10^6$  bacteria whereas MacConkey medium showed  $3.5 \times 10^6$  bacteria in the sampled water, implying poor sanitary condition of the study area which could affect both humans and the water ecosystem.

This finding is in agreement with the work of Mojedul, Shehid and Islam (2021) in which the researchers conducted a cross sectional sampling to compare microbials in water and Continuous Water Supply (CWS) in Nagpur, India between 2015 and 2017 using 146-gram samples and 90 large dead-end ultrafiltration (DEUF) samples with total volume of 6.925 litres. The results showed a significant increase in the proportion gram positive sample (GPS) for culturable *e-coli*

( $P=0.0007$ ) and DEUF concentrates positive for waterborne pathogens gene target ( $P=0.0098$ ) at household taps.

### Samples of Total Viable Bacterial Counts (TVBCs) of Riparian Soils of Ofu Watershed

Sample	Nutrient Agar (cfu/ml)	MacConkey Agar (cfu/ml)
<i>S1(Ojofu)</i>	$8.6 \times 10^6$	$4.1 \times 10^6$
<i>S2(Agbenema)</i>	$7.3 \times 10^6$	$5.2 \times 10^6$
<i>S3(Agala-Ogane)</i>	$8.3 \times 10^6$	$4.3 \times 10^6$
<i>S4(Akponogwu)</i>	$9.4 \times 10^6$	$3.8 \times 10^6$
<b>Guideline</b>		
<i>WHO</i>	0 cfu/100ml	0 cfu/100ml
<i>EU</i>	0 cfu/100ml	0 cfu/100ml
<i>NSDWQ</i>	0 cfu/100ml	0 cfu/100ml

Source: Field Survey, 2025.

The Total Viable Bacterial Counts for the soil samples are presented in Table 3. The study location with highest Total Viable Coliform Counts (TVCC) using nutrient agar (multipurpose medium) was at S4 (Akponogwu)  $9.4 \times 10^6$  cfu/ml but using MacConkey agar, the highest concentration level was at S2 (Agbenema) with  $5.2 \times 10^6$  cfu/ml. This was followed by S1 (Ojofu) with  $8.6 \times 10^6$  cfu/ml concentration but with MacConkey agar S3 (Agala-Ogane) had  $4.3 \times 10^6$  cfu/ml concentration. The least TVCCs for the sampled soil are S2 (Agbenema)  $7.3 \times 10^6$  cfu/ml and S3 (Agala-Ogane)  $4.3 \times 10^6$  cfu/ml respectively. All the values were higher than WHO, EU and NSDWQ guideline of zero (0 cfu/ml). This indicates that the soil of the river basin is contaminated implying that, since agricultural activities are expanding exponentially with the advent of the mini earth dam, tilling of soil is on the increase enhancing open defecation by both human beings and animals. As such,

these bacteria are exposed and eventually washed through runoff into the river thereby contaminating and polluting the river water.

**Table 4: Fecal Coliform and Total Coliform for Soil and Water Samples**

<b>Soil Samples</b>						
<i>SAMPLE</i> <i>Code/Sample</i> <i>Stations</i>	<i>NUTRIENT</i> <i>AGAR</i> <i>(cfu/ml)</i>	<i>MacConkey</i> <i>Agar</i> <i>(cfu/ml)</i>	<i>Guidelines</i>			
			WHO	EU	NSDWQ	
<i>S1</i>	Ojofu	4.0X10 <sup>5</sup>	8.0X10 <sup>5</sup>	0	0	0
				cfu/100mg/kg	cfu/100mg/kg	cfu/100mg/kg
<i>S2</i>	Agbenema	5.0X10 <sup>4</sup>	2.0X10 <sup>6</sup>	”	”	”
<i>S3</i>	Agala- Ogane	9.0X10 <sup>5</sup>	10.0X10 <sup>5</sup>	”	”	”
<i>S4</i>	Akponogwu	6.0X10 <sup>5</sup>	8.5X10 <sup>5</sup>	”	”	”
<b>Water Samples</b>						
<i>S1</i>	Ojofu	9.5X10 <sup>5</sup>	11.5X10 <sup>5</sup>	0 cfu/250ml	0 cfu/250ml	0 cfu/250ml
<i>S2</i>	Agbenema	5.5X10 <sup>5</sup>	7.5X10 <sup>5</sup>	”	”	0 cfu/10mg/l
<i>S3</i>	Agala- Ogane	3.5X10 <sup>5</sup>	11.5X10 <sup>5</sup>	”	”	”
<i>S4</i>	Akponogwu	3.5X10 <sup>5</sup>	7.5X10 <sup>5</sup>	”	”	”

Source: Field Survey, 2025.

The fecal and total coliform counts of bacteria in different soils and water samples are presented in Table 4. The fecal coliform count in soil was highest at S3 (Agala-Ogane) with a value of

$9.0 \times 10^5$  cfu/ml while the least concentration was S1 (Ojofu) with a value of  $4.0 \times 10^5$  cfu/ml concentration. Agbenema had  $5.0 \times 10^4$  cfu/ml; then that of Akponogwu was  $6.0 \times 10^5$  cfu/ml level of concentration. This indicates that the Ofu River soil environment is contaminated with fecal coliform bacteria with a concentration level that is high compared to WHO, EU and NSDWQ standard of 0 cfu/ml. This finding further shows that there is high possibility of the fecal coliform to be moved into Ofu River water through stormwater flow from the surrounding thereby contaminating Ofu River and reducing its integrity for human consumption due to its pathogenic characteristics.

#### **4.1: Fecal Coliform and Total Coliform Counts in Ofu River Water**

Results also shows the levels of fecal and total coliform bacteria in the samples of Ofu River water (Table 4). The fecal and total coliform counts were highest in water sample of S1 (Ojofu) with concentration level of  $9.5 \times 10^5$  cfu/ml and lowest at S3 and S4 (Agala-Ogane and Akponogwu) with concentration levels of  $3.5 \times 10^5$  cfu/ml respectively. Table 4 also reveals that S2 (Agbenema) had concentration level of fecal coliform of  $5.5 \times 10^5$  cfu/ml. The findings further indicate that the observed values exceed maximum accepted concentration limits in water of zero cfu/100ml established by WHO, EU and NSDWQ guidelines respectively. In fact, many individual factors that contribute to the quality of water are strongly impacted by topographical features. Erosivity index of the surrounding soil around the river could increase coliform counts in the water of Ofu River. The presence of coliform bacteria in the samples of Ofu River water at different sampling stations was as high as ( $9.5 \times 10^6$  cfu/ml), implying that consuming Ofu River water raw could make inhabitants of the river basin vulnerable to waterborne diseases.

As observed in the test for microbiological pollution parameters in Table 4, the levels of coliforms in the samples collected were very high, an observation that was informed by the high level of BOD and the results of the pH tests which all placed the pH results within the safe basic band of between 6.6 - 8.5 (Figures 1&2) indicating that Ofu River water is alkaline. It is above the neutral range required for safe human consumption while the BOD is below the maximum allowable limit of 30mg/l of the World Health Organisation (WHO, 2011) guideline. This situation can be attributed to cumulative fecal contamination from the surrounding built-up environment and surrounding unrestricted grazing areas of the water Ofu River through surface runoff or direct

contamination. Through reconnaissance survey, it was discovered that some stretches of Ofu River channel support shrubs that humans use for convenience and when it rains, due to the terrain, it gets washed into Ofu River. Other possible sources are pollution from herd as herders use Ofu River as watering point. The presence of fecal coliform bacteria indicates that the Ofu River water has been contaminated with fecal materials of man or other animals. At such times, the water source may have been contaminated by pathogens and diseases producing bacteria or viruses which can also exist in fecal materials. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or non-point sources of human and animal wastes. The WHO, EU and NSDWQ require zero presence of *E. coli*/100mg/l for drinking water. On this basis and without treatment, Ofu River Water is not fit for human consumption.

These findings are in line with Mahendra et al (2021), in a study at Upper Kosi River, Central Himalaya, India, which posits that raw water in the Upper Kosi River has a higher concentration of fecal coliform bacteria due to anthropogenic activities around the river watershed. The study further revealed fecal coliform counts of  $8.6 \times 10^6$ cfu/ml,  $3.8 \times 10^5$ cfu/ml and  $9.3 \times 10^7$ cfu/ml at Upper Kosi River respectively. It indicates high fecal pollution when compared to WHO, EU and NSDWQ guidelines of 0 cfu/100mg/l. These results are similar due to structural similarity of the watershed with rapid growth in population without adequate sanitary provisions in most tropical countries of the world due to poverty.

In the current study, there existed a progressive decrease in pH values from S1- S4 (8.5, 8.3, 6.8 and 6.6) respectively. pH near neutrality of the water samples poses no health risk to consumers who use the water for cooking, drinking, washing and bathing in the selected settlements for this study. The current pH status of Ofu River water may be as a result of diverse anthropogenic activities around the watershed (Figures 1 and 2).

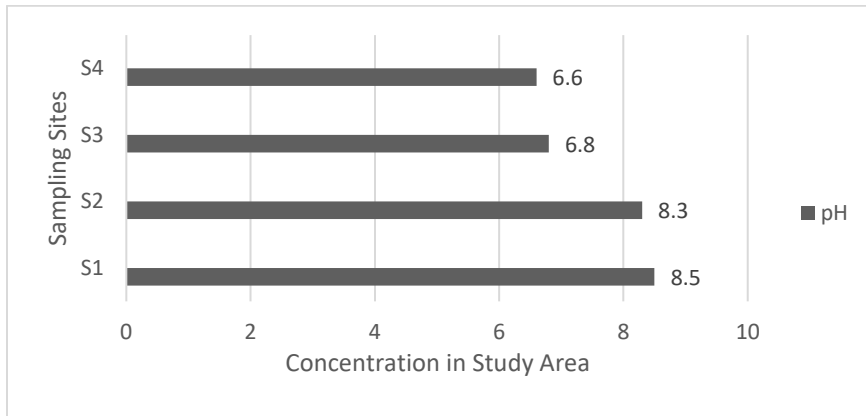


Figure 1: P<sup>H</sup> Concentration

Source: Field Survey, 2025

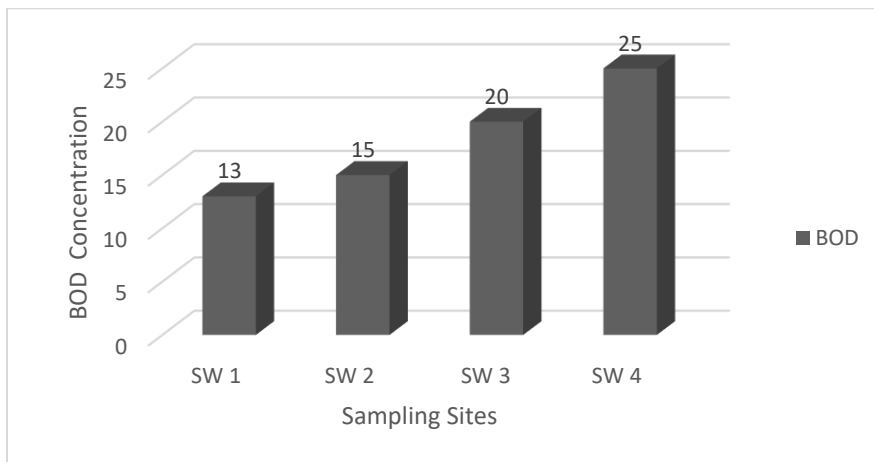
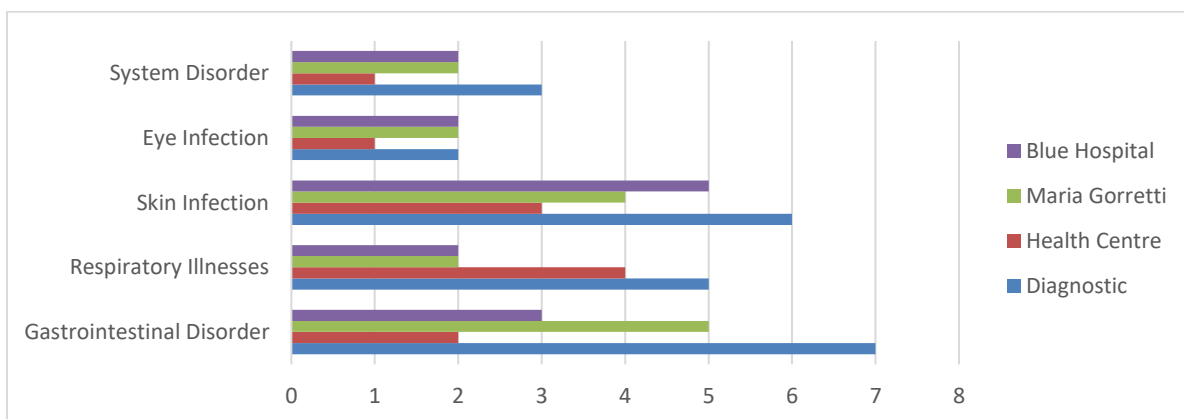


Figure 2: BOD concentration of the study area

Field Survey, 2025



**Figure 3: Health Implications of Microbial Pollution of Water**

**Source:** Field survey, 2025

Findings show results among selected medical staff of health institutions in the study area. At Diagnostic Hospital, 7(11.1%) of the total respondents reported a possibility of gastrointestinal disorder (Figure 3); at Public Health Centre, it was 2(3.1%) and Maria Gorretti Hospital showed 5(7.9%) resulting in 17(26.9%) of the total respondents in the study area. The respondents among selected health facilities opined that those respiratory illnesses are as a result of microbial contamination of surface water, with Diagnostic Hospital having 5(7.9%), PHC 4(6.2%) while Blue House Hospital was 2(3.1%) of the total respondents in the study area. Reports on skin infection as one of the effects of the consumption of microbial contaminated water: at Diagnostic Hospital, it was 6(9.5%) and Blue House Hospital 2(3.1%) resulting in 18(28.5%) of the total respondents, making a total of 28.5% of the total respondents among selected health facilities.

**Table 5: Mitigation Measures to Reduce Microbial Pollution among Health Facilities**

Facility	Water Quality Monitoring	Sewage Management	Sustainable Agric Practices	Storm water Management	Public health Awareness	Total
Diagnostic Hospital	7(11.1%)	4(6.3%)	3(4.7%)	5(7.9%)	4(6.3%)	23(36.5%)
Public Health Centre	2(3.1%)	3(4.7%)	4(6.3%)	1(1.5%)	1(1.5%)	11(17.4%)
Maria Gorretti Hospital	3(4.7%)	3(4.7%)	3(4.7%)	4(6.3%)	2(3.1%)	15(23.8%)
Blue House Hospital	4(6.3%)	2(3.1%)	5(7.9%)	2(3.2%)	1(1.5%)	14(22.2%)
Total	16(25.3%)	12(19.0%)	15(23.8%)	12(19.0%)	8(12.6%)	63(100%)

**Source:** Field Survey, 2025

According to the staff of the selected health facilities in the study area, several mitigatory measures were put in place to reduce or completely remove the effects of microbial in Ofu River. Among the medical staff of the selected health-care facilities who were respondents, in Diagnostic Hospital, 7(11.1%) reported water quality monitoring while 4(6.3%) observed sewage management but 3(4.7%) opined sustainable agricultural practice as remedies to microbiological water pollution in the study area. In addition, 4(6.3%) also reported enhanced public health awareness, making 23(36.5%) of the total respondents. At Public Health Centre, 2(3.1%) reported water quality monitoring and sustainable agriculture 4(6.3%) while stormwater management was 1(1.5%) respectively, making 11(17.4%) of the total respondents. In the view of the respondents from Maria Gorretti Hospital, 3(4.7%) reported monitoring of water quality, 4(6.3%) reported stormwater management but 2(3.1%) observed public health awareness. Responses from the medical staff from Blue House Hospital reveal that 5(7.9%) reported sustainable agricultural practice while 4(6.3%) opined water quality monitoring and 2(3.2%) observed stormwater management in the study area. The table further shows that majority 16(25.3%) reported water quality management closely followed by 15(23.8%) reporting sustainable agricultural practice while 8(12.6%) believe in public health awareness as mitigatory measure for water pollution in the study area.

### **Summary and conclusion**

This research identified and quantified TVBCs of River Ofu. It also evaluates the total and fecal coliform bacteria counts of both water and soil of the watershed. Using Nutrient and MacConkey Agar (cfu/ml), the total viable bacteria count of Ofu River exceeded WHO, EU and NSDWQ standards. The TVBCs of soils indicated an exceedingly high count. Fecal/total coliform counts of both soil and water samples indicated a concentration exceeding 0 cfu/100mg/kg and 0cfu/250ml.

Both human activities and stormwater flow of the study area could increase coliform count influx of the study area. The significant problems of microbial surface water pollution in Ofu River were largely caused by uncontrolled pollution of both soil and water bodies. The finding underscores the need for frequent monitoring of Ofu River. Stricter regulations on agricultural practices, reduction in open field defecation, development and deployment of new technologies and public awareness campaign should be put in place to safeguard the integrity of the Ofu River water.

Further research is also needed to investigate the long-term effects of pollution on aquatic ecosystems, explore the effectiveness of different remediation strategies in diverse environmental contexts, develop more sensitive detection techniques and assess the risk to human health from specific pathogens.

### Recommendations

It is recommended that innovative low-cost technologies and community-based monitoring systems be put in place to improve river water quality. Again, the development and adoption of efficient irrigation and water recycling technologies be put in place to reduce water wastage. The implementation of Integrated Water Resource Management (IWRM) framework should be adopted. Water managers should be guided on the need for more research that explores mechanisms for strengthening local and national water governance.

### REFERENCES

- Aboh, E.A., Giwa, F.J and Giwa, A. (2015). Microbiological Assessment of Well Water Samaru, Kaduna State, Nigeria. *Ann Afr Med*, 14; 32.
- Allamin, I., Bokoma, M., Joshua, R and Machima, I. (2015). Physicochemical and Bacteriological Analysis of Well Water in Kaduna Metropolis, Kaduna State. *OA Lib*, 2:1.
- Allen Takilitz, Christopher Nietch, Sadegh Riasi, M and Lilit Yeghiazarian (2021). Reliability theory for Microbial Water Quality and Sustainability Assessment. *Journal of Hydrology* 596125711.2021.
- Annastina, R., Tiwari, A., Hokajarvi, A.M., Uusheimo, S., Vepsalainen, A., Tolunem, T. and Pitkanen, T. (2021). The use of Ribosomal RNA as Microbial Source Tracking Target Highlight the Assay Host-Specificity Requirement in Water Quality Assessment. *Frontier in Microbiology*, 12, 673389.
- APHA, (1995). Standard Method for The Examination of Wastewater (20<sup>th</sup> edition). Washington DC: APHA, AWWA

- Daniel A. Akuali, Carolien Kroezer, Gertjan Medema, PeterBureck and Heather Mumby (2021). Modelling Rotavirus Concentration in Rivers: Assessing Ugandan Present and Future Microbial Water Quality. *Water Research*, 204 (4); 123-135.
- Ehiowemwengum, G., Iloma, A. and Adetuwo, J. (2014). Physicochemical and Bacteriological Quality of Sampled water in Eyaen Community of Edo State. Nigeria. *IJBAS*, 3: 60-66.
- Ezeribe, A., Oshieke, K and Jauro, A. (2012). Physicochemical properties of well water samples from some villages in Nigeria with cases of Stained and Mottled teeth. *Sc j.* 7: 1-3.
- Gambo, J., James, Y and Yakubu, M., (2015). Physicochemical and bacteriological analysis of well water at crescent road, Poly Quarters Kaduna. *Int J Eng Sci*, 4 (11): 11-17.
- Giannoulis, N., Maipa, V., Konstantinou, I., Albanis, T. and Dimoliatis, I. (2005). Microbiological Risk Assessment of Agios Georgios Source Supply in North West Greece Based on Faecal Coliform Determination and Sanitary Inspection Survey. *Chemosphere*, 58:1269-1276.
- Gowher A. Wani, Muhammad Asgar Khan, Midasir A. Dar and Mapzoor A. Sahar (2021). Next Generation High Throughput Experiencing to Assess Microbisl Communities: An Application based on Water Quality. *Journal of Environmental Contamination and Toxicology 1-7*; 197-213.
- Ibe, S. and Okplenye, J. (2005). Bacteriological Analysis of Borehole Water in Uli, Nigeria. *Afri J. Appl. Zool. Environ. Biol* 7: 116-119.
- Isa, M.A., Allamin, I.A., Ismail, H.Y. and Shettima, A., (2013). Physicochemical and Bacteriological Analysis of Drinking Water from Wash Borehole in Maiduguri Metropolis, Borno State, Nigeria. *Afri. J. Food Sci*, 7: 9-13.
- Islam M.D., Abubakar, M., Reza, M.D. and Islam D.R.M.T (2021). Hydrological Distribution of Physicochemical Parameters and Heavy Metals in Surface Water and their Ecotoxicological Implications. The Bay of Bengal Coast of Bangladesh. *Environmental Science and Pollution Research 1-15*.
- Juan Martin Paredes del Puerto, Ignacio Daniel Garcia and Tomas Maiztequi Ariel (2022). Impact of land Use and Hydrological Altreations of Water Quality and Fish Assemblage Structure in Headway Pampean Streams, Argentina. *Aquatic Sciences* 84 (1), 1-15.
- Karaboze, U., Ucar, F., Eltem, R., Ozdmir, G and Ates, M. (2003). Determination of Existence and Count of Pathogenic Microorganisms in Izmir Bay. *JES* 26: 1-18.

- Kumar, R., Singh, S. and Patel, V. (2021). Assessment of Drinking Water Quality and Public Health Implications. *Environmental Health Perspectives*, 129(7), 075001.
- Lawal, R and Lohdip, Y., (2015). Physicochemical and Microbial Analysis of Water from Mimyak River in Kanke LGA of Plateau State, Nigeria. *Afri J Nat SCI*, 1119-1104.
- Leah, G., Erman, S.M., Buckley, H.L., Bradley, S.C, (2011). Connecting Through Space and Time. Catchment-Scale Distribution of Bacteria in Soil, Stream water and Sediment. *Environmental Microbiology* 6 (2): 253-268.
- Liyanage, C.P. and Yamada, K. (2017). Impact of Population Growth on the Water Quality of the Natural Water Bodies. *Sustainability*, 9 (8): 1405.
- Mahendra S, Rawat J.S and Parihar D.S. (2021). Analysis of Water Quality Status of the Upper Kosi River of Central Himalayas, India. *International Journal of Science and Research (IJSR)* 10(11): 1262-1266.
- Majedul Islam, M.M., Muhammad Shauhid Iqal and Atikul Islam, M.D. (2021). A review on present and future microbial Surface Water Quality Worldwide. *Environmental Nanotechnology Monitoring and Management Vol. 16 (5); 1023-1031. [http://doi.org/10:1016/j.enmm.2021.100523](http://doi.org/10.1016/j.enmm.2021.100523)*.
- Naigaga, I., Celsus, S., Joseph, E., Philip, K.M., Sylvester, O., Julius, M., Benigna, G.N., Charles, D.K., George, S., Kevin, M. and Michael, O. (2016). Occurrence and Genetic Characterization of *Acanthamoeba* spp. From Environmental and Domestic Water Sources in Queen Elizabeth Protected Area, Uganda. *Parasites and Vectors* 9: 127.
- Nigerian Standard for Drinking Water Quality (NSDWQ, (2007). Standards Organisation of Nigeria.
- Okorondu, S. and Anyadoh-Nwadike, S. (2015). Bacteriological and Physicochemical Analysis of Oguta Lake Water, Imo State, Nigeria. 3: 5-1.
- Onwuaghara, N.I., Ajiwe, V.E., Nnabuenyi, H.O. and Chima C.H. (2013). Bacteriological Assessment of Selected Borehole Water Samples in Umahia North LGA., Abia State, Nigeria. *Journal of Environmental Treatment Techniques* 1 (2): 117-121.
- Sa'eed, M. and Mahmoud, A. (2014). Determination of some physicochemical Parameters and some heavy Metals in Boreholes from Fagge LGA. Of Kano Metropolis, Kano State, Nigeria. *World J Anal Chem.* 2: 42-46.

- Sabater, P.A., Focht, W., Lubell, M., Tracchtenberg, Z., Vedlitz, A. and Maltlock, M. (Eds.). (2005). *Swimming Upstream: collaborative Approach to Watershed Management*. Cambridge: MIT Press.
- Suther, S., Chhimpa, V and Singh, S. (2009). Bacterial Contamination in Drinking Water: a case study in Rural Area of Northern Rajasthan, India. *Environ. Monit. Assess*, 159: 43-50.
- Ukpong, E. and Okon, B. (2013). Comparative Analysis of Public and Private Borehole Water Supply Sources in Uruan LGA., Akwa-Ibom State. *IJAST*, 3.
- Youn-Joo, A., Campbell, D.H. and Bredienbach, J.P. (2002). Escherichia Coli and Total Coliforms in Water and Sediment at Lake Marinas. *Journal of Environmental Pollution* 120 (3): 771-778.