World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Assessment of physiochemical properties and bacteriological diversity of Otamiri river in Owerri eastern Nigeria

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World Journal of Advanced Research and Reviews, 2023, 18(03), 430–445

Publication history: Received on 24 April 2023; revised on 03 June 2023; accepted on 05 June 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.18.3.0952

Abstract

The physiochemical and bacteria diversity of Otamiri River was analyzed using standard microbiological methods. A total of seventy two (72) water and twenty four (24) sediment samples were collected. The routine plate count revealed that the number of heterotrophic bacteria present ranged from 1.00E+06 Cfu/ml to 9.70E+06 Cfu/ml, fecal coliform count 2.00E+05 Cfu/ml to 9.00E+06 Cfu/ml, *Salmonella/Shigella* count 3.50E+05 Cfu/ml to 1.52E+07 Cfu/ml, *Staphylococcus* count 2.00E+05 Cfu/ml to 1.79E+07 Cfu/ml, coliform count 3.50E+05 Cfu/ml to 4.59E+08 Cfu/ml, *Vibrio* count 1.50E+05 Cfu/ml to 3.52E+07 Cfu/ml. Anaerobic bacteria count ranged from 2.00E+05 Cfu/ml to 2.85E+06 Cfu/ml. The proportion of bacteria isolated from the samples showed that *Alcaligens faecalis* had the highest 68(94.44), 24(100), followed by *Lysinibacillus macrolides* 54(75), 21(87.5) while *Lactobacillus spp* had the least in water sample 6(8.33), *Klebsiella aerogenes* had the least in sediment 6(25). Among the physiochemical parameters analyzed in the river water and sediment samples had values above the recommended standard by WHO. The samples biophysical parameters did not meet the standard recommended by WHO for portable water. Therefore, to prevent potential health risks, those who use river water for domestic purposes must appropriately cleanse it before use. The government of the day should devise ways of disposing solid waste and effluent rather than channel same into the river and enact strict laws that will punish individual, agencies and firms that indulge in such in order to protect natural bodies of water from pollution. Statistical analysis using analysis of variance Posthoc = Tukey Alpha (0.05) indicated that the mean bacteria counts between the sampling stations differ significantly at the 0.05 level.

Key words: Bacteriological; Physiochemical; Water; Pollution; Otamiri.

1. Introduction

All life on earth depends on water for sustenance and survival. According to Arora [1] and Gupta and Gupta [2], water is used for a many purposes such as agricultural (drinking), power generation, navigation, and industrial and recreational activities. It helps maintain the global environmental equilibrium. Water makes up more than 70% of the earth and is a component of hydrologic cycle. According to Montgomery [3], the water on Earth is constantly moving and forms a cycle known as the water cycle. Natural bodies of water, soil moisture, the atmosphere are reservoirs of water cycle[4]. Large bodies of water that flow into other water bodies are constrained into channels by banks and are called rivers and streams. According to Cunningham *et al.,* [5], riverlets merge, forming stream which in turn give rise to rivers. Barnes *et al.* [6], stated that rivers are distinguished by affluent, one sided flow, straightforward, unstable pour, shaky passage, and couch structure. Some of the rivers in Nigeria include the Niger, Benue, Imo, Cross, Aba, Orashi, Aham, Njaba, Otamiri, Onukwu-emeke, Emii, Qua Iboe, and Eke Onumiri. River pollution is changing of its composition or condition as a result of human activity, either directly or indirectly, making the river less useful for any or all of the reasons for which it would be useful in its unpolluted state. According to Symons *et al*, [7] the biophysical attributes of water are what make it suitable for a given purpose. Swimming, food preparation, and home chores all require access

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to clean, fresh water. When river water quality changes due to human activity, whether directly or indirectly, it is said to have become polluted and is no longer suitable for any of the uses it would have been in its unpolluted state. According to Dike *et al.* [8], river pollution may have a number of negative consequences, including the tainting of water sources, restrictions on its usage for recreational activities, the extinction of aquatic life, the development of nuisances, and obstructions to navigation. One of the main rivers that flows through Owerri metropolis and its surroundings is the Otamiri River. This river provides water and aquatic foods for home use, urban agriculture, and other reasons in those areas. The Otamiri River receives unclean, untreated water from home, agricultural, and industrial sources as a result of all the major drainage systems in Owerri Municipality and its surroundings being funneled into the river. Along the river's banks are Nekede mechanic village, a few hospitals and laboratories, as well as car wash and laundry businesses. Run-offs from Owerri metropolitan area and surroundings have unfettered access to the river when it rains. Similar to how sand mining occurs in the river, solid garbage is also disposed of and burned along the riverbank. Large amounts of pollutants that gets into water bodies contaminate it chemically, biochemically and may be present in trash dumps. Uncontrolled trash dumping, fishing, oil and gas production, to name a few industries, pose a threat to the river's quality. Therefore, the need of ongoing surface water quality monitoring cannot be overstated, particularly in light of the fact that growing populations have led to an increase in waste production, which has exposed the water to more pollutants [9]. According to Symon *et al.* [7], water quality refers to a body of water's chemical, physical, and biological qualities as well as how well suited they are to a given use. The importance of ongoing surface water quality monitoring cannot be overstated, particularly in light of the fact that increased population has led to increased waste generation, which has exposed the water to greater levels of pollutants. This study's objective is to evaluate the physiochemical and bacterial diversity of the Otamiri River in Owerri.

2. Methodology

2.1. Study Area

Otamiri is one of the Rivers in Imo State. The River originates from Egbu from where it transverses to other towns (Owerri, Nekede, Ihiagwa, Eziobodo, Olokwu, Umuisi, Mgbirichi, Umuagwo) and flows into Atlantic Ocean. It covers a distance of about 30 kilometers (19 miles) from its source to where it meets other rivers [10]. The River covers a distance of about 10,000 square kilometers (3,900 sq mi). The river receives large tones of solid waste. Liquid waste from domestic, agricultural, industries are channelled into the river. It also serve as the major point of discharge of waste water as major drainage system in Owerri are channelled into the river.

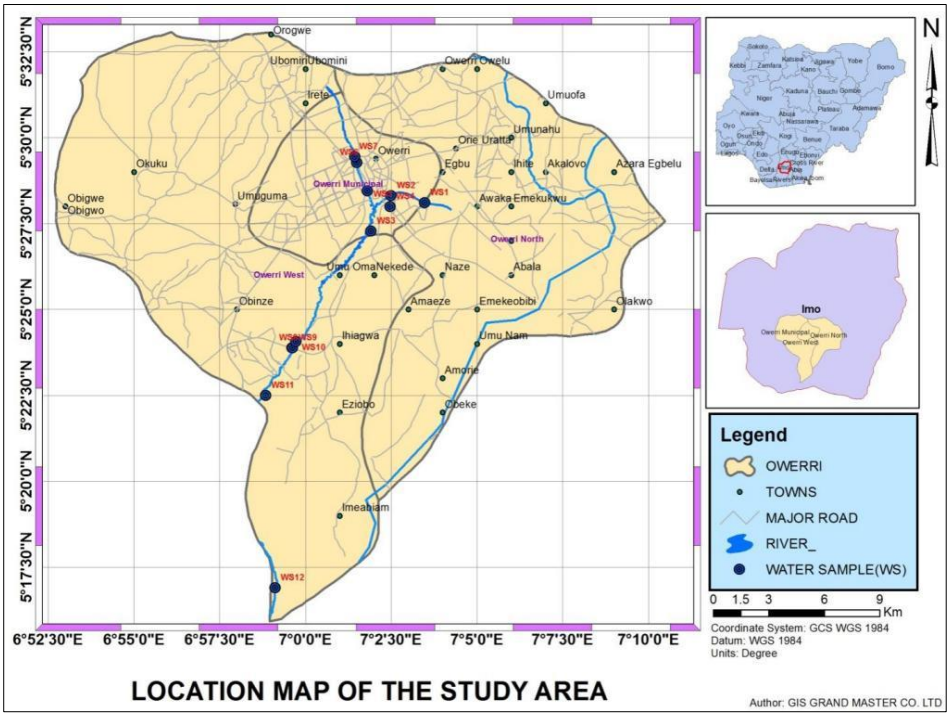

Figure 1 Location map of the study area

2.2. Water Sample Collection

Seventy two (72) water samples were collected from twelve (12) sampling stations viz: Egbu abattoir, Akachi, Aba road, Mechanic Village, Westend, Nekede, Inland Bridge, Umezurike hospital, FUTO, Ihiagwa, Mgbirichi and Umuagwo. The sample points coordinates in each station is shown in table 1. In every sampling station, two samples were taken from three (3) sampling points namely; upstream, midstream, and downstream. At the point of collecting the water sample, 1000 capacity sterile containers were used. The containers were rinsed three (3) to four (4) times with the river water. While mounting on the canoe, samples were collected from the points mentioned above using the sample containers held at the base with one hand with the mouth open, the sample containers were plunge at an elbow depth (about 50cm) beneath the waterline, positioning the container at the direction of water flow. A gap of about three (3 cm) was left in the container. The container was covered and then pulled out and labelled with the sample ID, placed in ice block box and transported to the laboratory.

2.2.1. Collection of Sediments

Eckman grab sampler was used to collect twenty four (24) sediment samples from the river bank in twelve (12) sampling stations viz: Egbu abattoir, Akachi, Aba road, Mechanic Village, Westend, Nekede, Inland Bridge, Umezurike hospital, FUTO, Ihiagwa, Mgbirichi and Umuagwo. The sample points coordinates in each station is shown in table 1. Each sampling site received a total of 3 jabs, each made of a vigorous throw of the equipment into the water sediment. The samples were transported into plastic buckets. The sediment samples were sieved through a sieve with pore size of about 1.00 mm to 250 mm [11]. The samples were carried to the lab for analysis in a cooler that included an ice block.

Table 1 Sampling points coordinates

Location	Sample ID	Latitude	Longitude
Egbu abattoir	WS 1	5.468454	7.0579694
Akachi	WS 2	5.47177	7.041655
Mechanic Village	WS 3	5.454669	7.0319396
Aba Road	WS 4	5.466485	7.0412746
Nekede Westend	WS 5	5.474175	7.030155
Umezurike Hospital	WS 6	5.487788	7.0250167
Inland bridge	WS 7	5.490787	7.024105
Nekede	WS 8	5.398004	6.9934721
Ihiagwa	WS 9	5.39805	6.9937335
Futo	WS 10	5.401005	6.995505
Mgbirichi	WS 11	5.350636	6.967972222
Umuagwo	WS 12	5.281781	6.985272222

2.3. Sample Analysis

2.3.1. Standard Plate Count (Enumeration of Bacteria)

The method described by Okechi and Chukwura [12] were adopted. Briefly using serial dilution, samples were tested using 0.9% w/v normal saline as diluent. From the appropriate dilutions 0.1 aliquots were inoculated into the appropriate Medias (Plates made of Thiosulphate Citrate Bile Salt Sucrose Agar, Mannitol Salt Agar, MacConkey Agar, Eosine Methylene Blue Agar, and *Salmonella Shigella* Agar). Samples were incubated at 37^0C for 24 hours in an incubator except for samples inoculated on EMB plates which were incubated at 45^0C for 24hours. For anaerobes, samples inoculated on nutrient agar plates were incubated using anaerobic with Oxoid gas pak. Colonies which develop after incubation of the examined samples were counted.

2.3.2. Preservation and Cleansing of Pure Cultures

Distinctive colonies that formed were twice sub-cultured onto sterile nutrient agar plates using cultural traits. They were sub-cultured into sterile culture tubes filled with nutritional agar in a slanted posture after being confirmed to be pure isolates. Prior to the biochemical / confirmatory test, the tubes were maintained in the refrigerator at 4^0C.

2.3.3. Biochemical Assay

Confirmatory test were carried out on pure culture of bacteria isolates and the results obtained were referred to Bergeys' manual of determinative bacteriology.

2.4. Molecular Identification of Bacteria Isolates

2.4.1. Using the boiling process, extract DNA

Five milliliters (5mls) of overnight broth cultures (Luria Bertani, (LB) of bacteria isolates in tubes was spun at 14000 rpm for three minutes. After heating the cells at 95^0C for 20 min, it was re-suspended in 500ul of normal saline. They were cooled on ice and afterwards spun for three minutes at 14000 rpm. The supernatant containing the DNA was placed into 1.5ml micro centrifuge tube and stored at -20^0C.

2.4.2. Quantification of DNA

Genomic DNA amount extracted was measured using Nanodrop 1000 spectrophotometer by tapping twice on the Nanodrop icon. The apparatus was blanked with regular saline and initialized with two microliters (2µl) of sterile, distilled water. The higher pedestal was lowered into the extracted DNA on the lower pedestal after adding two microliters (2µl) of the extracted DNA. Measure button was used to calculate the DNA concentration.

2.4.3. rRNA 16S amplification

The isolates 16s rRNA was amplified using the 27F: 5'-AGAGTTTGATCMTGGCTCAG-3 and 1492R: 5'-CGGTTACCTTGTTACGACTT-3 primers on an ABI 9700 Applied Biosystems thermal cycler at a final volume of 40 microliters for 35 cycles. The PCR mixture which consists of X2 Dream taq Master mix from Inqaba, South Africa, taq polymerase, DNTPs, and MgCl were used together with primers at a concentration of 0.5 M, extracting the DNA as template. Temperatures used during the PCR process during initial denaturation, denaturation, annealing, extension and final extension were: 95^0C for 5 minutes, 95^0C for 30 seconds, 52^0C for 30 seconds, 72^0C for 30 seconds for 35 cycles and 72^0C for 5 minutes respectively. The result was seen as a blue light trans illuminator after resolving at 130V for 30 minutes on 1% agarose gel.

2.4.4. Sequencing

Sequencing was done using 3510 ABI sequencer and the BigDye Terminator kit (Inqaba Biotechnological, Pretoria, South Africa,). This was done at a final volume 10µl using BigDye® terminator v1.1/v3.1, 2.25 l of 5 x BigDye sequencing buffer, 10 mM Primer PCR primer, and 2-10 ng of PCR template per 100 bp. Sequencing conditions were as follows: 32 cycles of 96^0C for 10 s, 55^0C for 5 s, and 60^0C for 4 min**.**

2.5. Physiochemical Analysis of Samples

Sample temperature, pH, TDS, and EC were measured in-situ using field meter probes. Current velocity was calculated using the surface-float technique. A Suntex pH was used to define temperature and pH. Conductivity and TDS were measured using a Suntex conductivity/TDS meter. TSS, turbidity, nitrate, sulphate, phosphate, iron, and copper were measured using a Hana HI 83200 multi-parameter photometer at the proper program number and wavelength. The APHA [13] recommended standard procedures for determining total hardness, dissolved oxygen, and BOD. PyeUnican SP Atomic Absorption Spectrometry was used to determine heavy or trace metals after the samples' had been digested In order to test metal using Atomic Absorption Spectrometry, metal [14]. The degree of pesticide contamination was calculated using the gas chromatography linked to mass spectrometry (GC-MS) method.

3. Results

The data on bacteria counts in this present study showed that heterotrophic bacteria counts ranged from 1.00E+06 Cfu/ml to 9.70E+06 Cfu/ml with upstream water samples from Egbu abattoir and Ihiagwa sampling stations recording highest counts, figure 1.

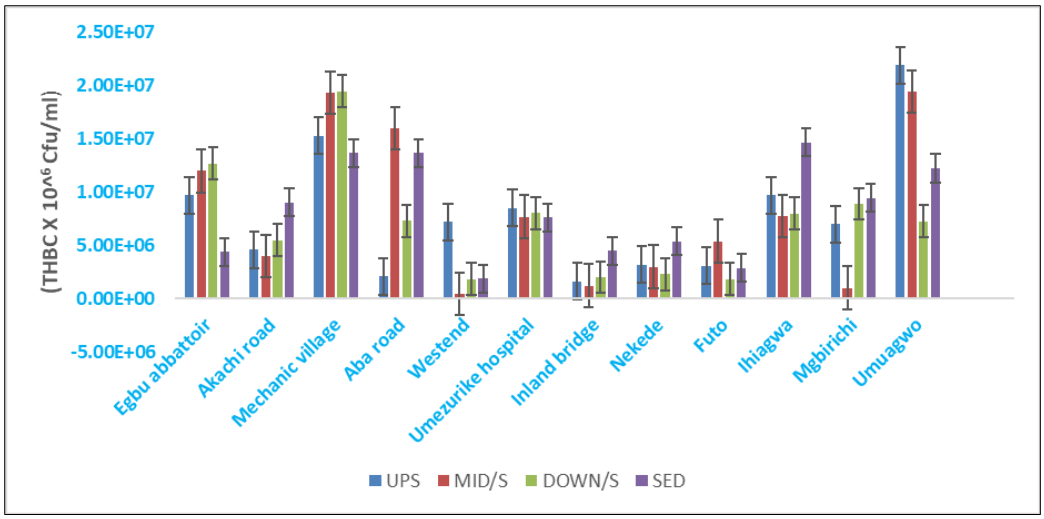

Figure 1 The samples' average heterotrophic bacteria counts (Cfu/ml)

The range of fecal coliform counts was 2.00E+05 Cfu/ml to 9.00E+06 Cfu/ml with upstream water samples from (Aba road and Umuagwo sampling stations) recording the highest counts plus midstream water samples from Umezurike hospital sampling area 9.00E+06 Cfu/ml respectively, figure 2.

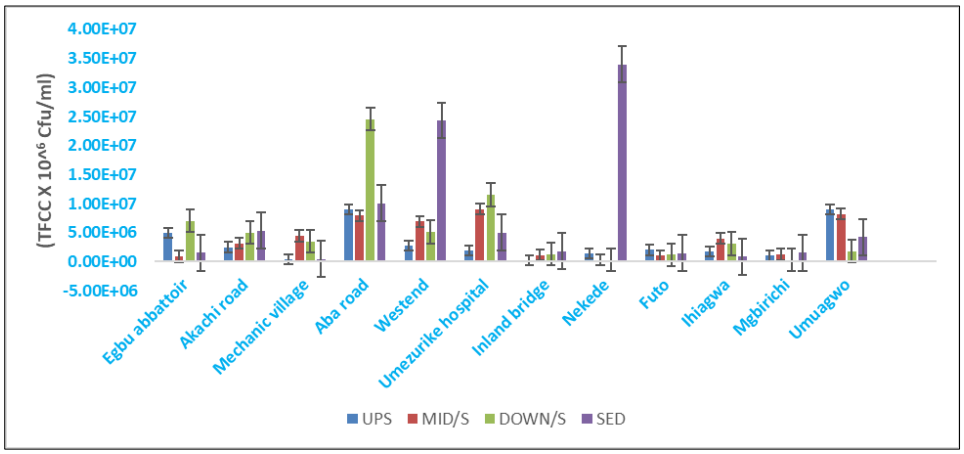

Figure 2 Mean coliform counts Cfu/ml of the samples analyzed

Salmonella / *Shigella* counts as shown in figure 3 ranged from 3.50E+05 Cfu/ml to 1.52E+07 Cfu/ml with midstream and downstream water samples recording the least count while downstream water samples Egbu abattoir had the highest counts.

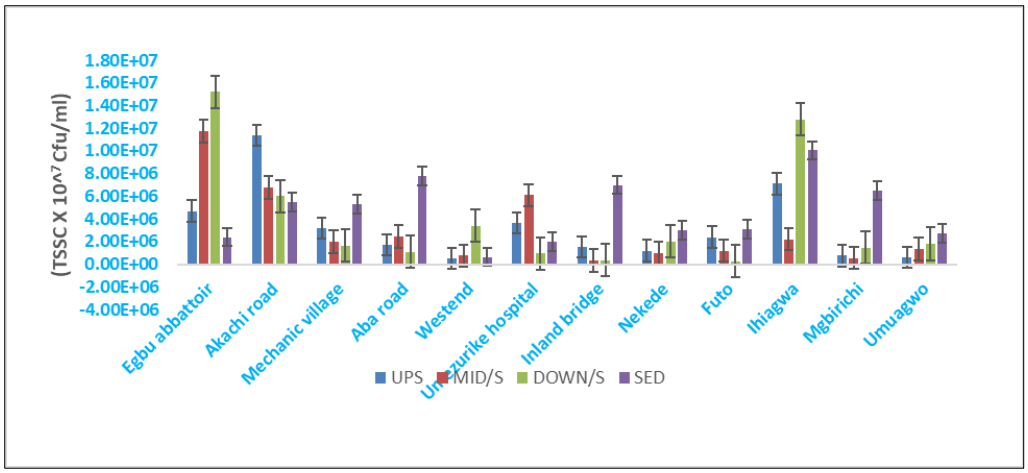

Figure 3 Mean Salmonella / Shigella counts Cfu/ml of the samples analyzed

Downstream water samples from Egbu abattoir had the highest Staphylococcus count 1.79E+07 Cfu/ml while downstream water samples from Nekede station and upstream water samples from Mgbirichi station had the least counts 2.00E+05 Cfu/ml respectively, figure 4.

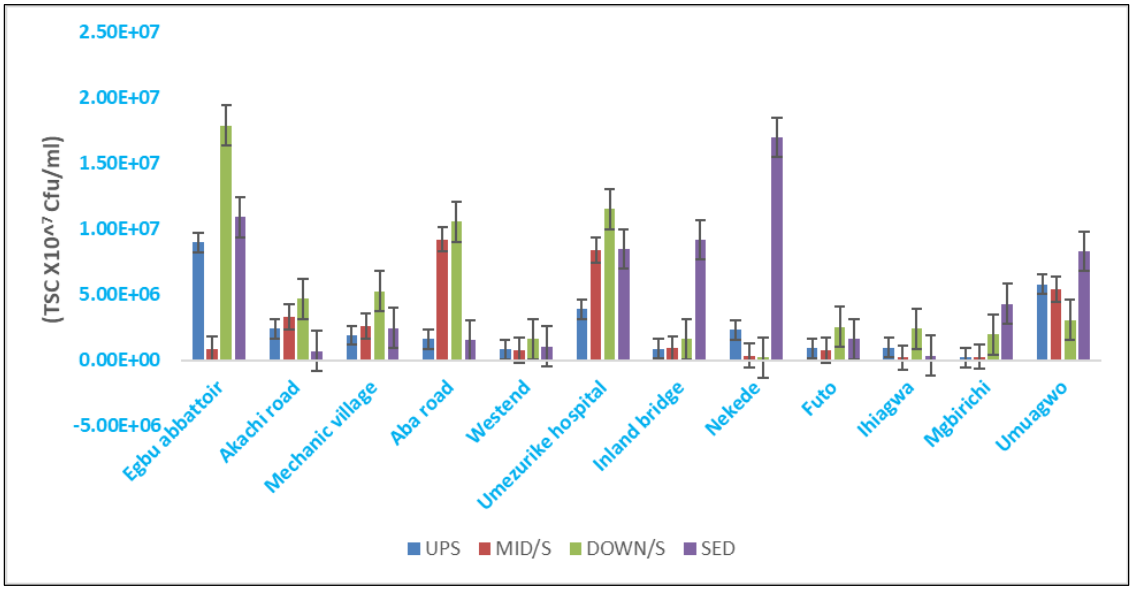

Figure 4 Mean Staphylococcus counts Cfu/ml of the samples analyzed

Coliform counts ranged from 3.50E+05 Cfu/ml to 4.59E+08 Cfu/ml. Sediment and upstream samples from Nekede sampling station recorded the highest and lowest counts, figure 5

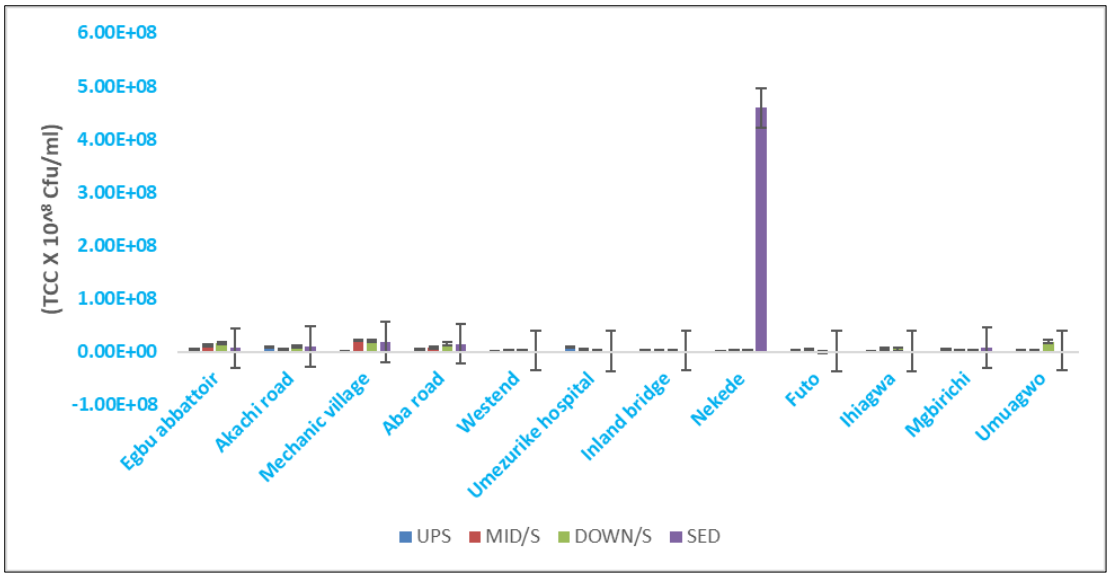

Figure 5 Mean coliform counts Cfu/ml of the samples analyzed

Vibrio count ranged from 1.50E+05 Cfu/ml to 3.52E+07 Cfu/ml. However, upstream water samples from FUTO sampling station had the highest count 3.52E+07 Cfu/ml while midstream water sample from Nekede sampling station had the least count 1.50E+05 Cfu/ml, figure 6.

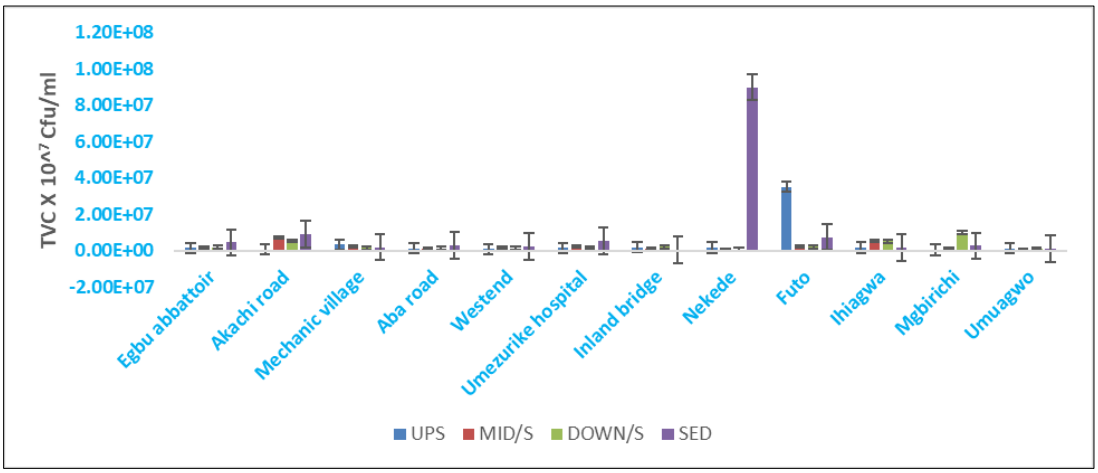

Figure 6 Mean Vibrio count Cfu/ml of the samples analyzed

Anaerobic bacteria counts as shown in figure 6 revealed that mean anaerobic count ranged from 2.00E+05 Cfu/ml to 2.85E+06 Cfu/ml. Upstream water samples from Ihiagwa sampling station had the least count 2.00E+05 Cfu/ml while sediment samples from Egbu abattoir had the highest 2.85E+06 Cfu/ml.

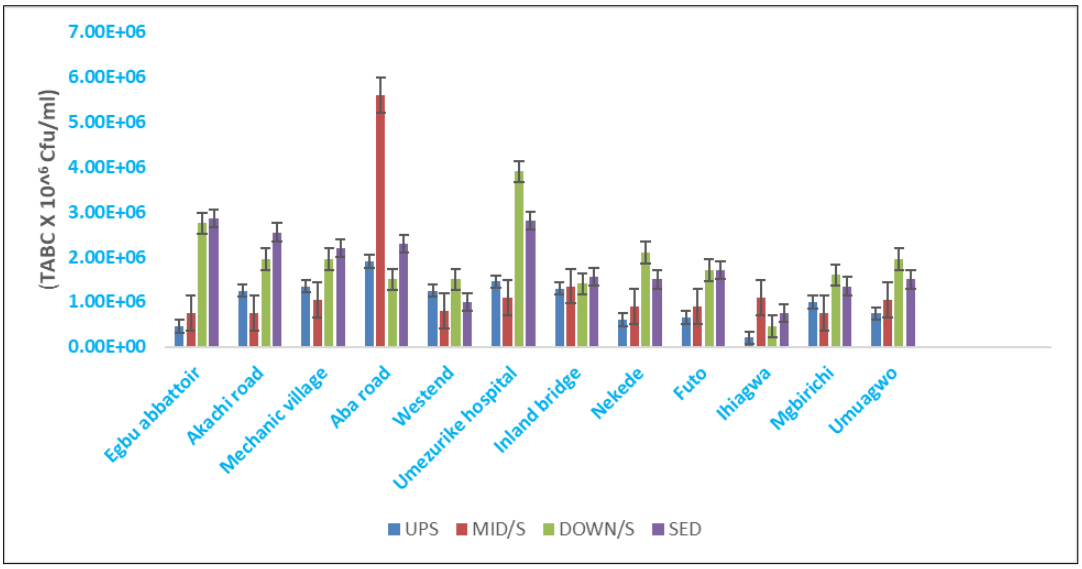

Figure 7 Mean anaerobic bacteria count Cfu/ml of the samples analyzed

The result of the biochemical test and molecular identification of the bacteria isolates revealed that the following bacteria were identified viz: *Klebsiella aerogenes, Klebsiella pneumonia, Eschericia coli. Enterobacter aeruginosa, Enterococcus faecalis, Alcaligens faecalis, Staphylococcus aureus, Vibrio cholera, Bacillus subtilis, Salmonella spp, Shigella Spp., Citrobacter spp, Pseudomonas spp, Bacillus anthracis, Serratia marcescens, Proteus spp, Clostridium spp, Lysinibacillus macrolides, Streptococcus spp, Micrococcus roseus, Lactobacillus spp*. Tables 2 and 3 show the frequency of occurrence of these bacterial isolates from the sampling locations in each sampling station. From the water tests, *Alcaligens faecalis* and *Lysinibacillus macrolides* had the highest percentage of occurrence while *Lactobacillus spp* and *Proteus spp* had the least, table 2. Percentage occurrence of bacteria isolates from the sediments samples revealed that *Alcaligens faecalis and Lysinibacillus macrolides* had the highest percentage of occurrence while *Vibrio cholera* had the highest percentage of occurrence while Vibrio cholera had the least, table 3.

Table 2 Percentage occurrence of water samples from the sampling station

Isolates	**Egbu abattoir N=6 n=%**	**Akachi bridge N=6 n=%**	**Mechanic village N=6 n=%**	**Aba road N=6 n=%**	**Westend N=6 n=%**	**Umezuruike hospital N=6 n=%**	**Inland bridge N=6 n=%**	**Nekede N=6 n=%**	**FUTO N=6 n=%**	**Ihiagwa N=6 n=%**	**Mgbirichi N=6 n=%**	**Umuagwo N=6 n=%**	**Overall % of occurrence N=72 n=%**
Klebsiella aerogenes	4 (66.66)	3 (50)	2(33.33)	1.(16.66	3(50)	5(83.33)	3(50)	3(50)	1.(16.66	4(66.66)	4(66.66)	4(66.66)	37(51.38)
Klebsiella pneumonia	0 (0)	0 (0)	0(0)	0(0)	0(0)	0(0)	3(50)	3(50)	3(50)	3(50)	0(0)	3(50)	15(20.83)
Eschericia coli	5 (83.33)	5 (83.33)	4(66.66)	5(83.33)	6(100)	5(83.33)	4(66.66)	6(100)	5(83.33)	4(66.66)	5(83.33)	5(83.33)	59(81.94)
Enterobacter aeruginosa	2 (33.33)	1 (16.66)	1(16.66)	4(66.66)	4(66.66)	2(33.33)	2(33.33)	2(33.33)	2(33.33)	2(33.33)	2(33.33)	2(33.33)	24(33.33)
Enterococcus faecalis	2 (33.33)	0 (0)	0(0)	0(0)	1(16.66)	2(33.33)	3(50)	4(66.66)	2(33.33)	3(50)	3(50)	3(50)	21(29.16)
Alcaligens faecalis	6 (100)	6 (100)	6(100)	5(83.33)	5(83.33)	5(83.33)	5(83.33)	6(100)	6(100)	6(100)	6(100)	6(100)	68(94.44)
Staphylococcus aureus	0 (0)	0 (0)	0(0)	0(0)	0(0)	3(50)	5(83.33)	0(0)	5(83.33)	4(66.66)	4(66.66)	4(66.66)	25(34.72)
Vibro cholerae	3 (50)	3 (50)	1(16.66)	3(50)	2(33.33)	4(66.66)	4(66.66)	4(66.66)	4(66.66)	3(50)	3(50)	3(50)	37(51.38)
Bacillus subtilis	0 (0)	0 0)	0(0)	0(0)	4(66.66)	0(0)	0(0)	1(16.66)	0(0)	1(16.66)	1(16.66)	1(16.66)	8(11.11)
Salmonella spp	5 (83.33)	4 (66.66)	2(33.33)	3(50)	4(66.66)	3(50)	3(50)	3(50)	3(50)	3(50)	3(50)	3(50)	39(54.16)
Shigella spp	5 (83.33)	5 (83.33)	2(33.33)	4(66.66)	0(0)	5(83.33)	3(50)	4(66.66)	5(83.33)	5(83.33)	5(83.33)	5(83.33)	48(66.66)
Citrobacter spp	2 (33.33)	3 (50)	2(33.33)	3(50)	3(50)	1(16.66)	4(66.66)	2(33.33)	2(33.33)	2(33.33)	2(33.33)	2(33.33)	28(38.88)
Pseudomonas spp	1 (16.66)	0 (0)	0(0)	2(33.33)	0(0)	2(33.33)	1(16.66)	1(16.66)	1(16.66)	1(16.66)	1(16.66)	1(16.66)	11(15.27)
Bacillus spp	0 (0)	0 (0)	0(0)	0(0)	3(50)	2(33.33)	4(66.66)	0(0)	1(16.66)	5(83.33)	5(83.33)	5(83.33)	25(34.72)
Serratia marcescenes	2 (33.33)	3 (50)	2(33.33)	1(16.66)	0(0)	2(33.33)	1(16.66)	2(33.33)	2(33.33)	2(33.33)	2(33.33)	2(33.33)	21(29.16)
Proteus spp	0 (0)	0 (0)	0(0)	0(0)	5(83.33)	0(0)	0(0)	0(0)	0(0)	1(16.66)	0(0)	0(0)	6(8.33)
Clostridium spp	4 (66.66)	0 (0)	0(0)	4(66.66)	3(50)	3(50)	4(66.66)	4(66.66)	2(33.33)	4(66.66)	4(66.66)	4(66.66)	40(55.55)
Lysinibacillus macrolides	5 (83.33)	5 (83.33)	5(83.33)	6(100)	0(0)	5(83.33)	5(83.33)	5(83.33)	3(50)	5(83.33)	5(83.33)	5(83.33)	54(75)

Streptococcus spp	1 (16.66)	0 (0)	1.0(16.66)	3(50)	1.(16.66)	3(50)	0(0)	1.(16.66)	1.(16.66)	1.(16.66)	1.(16.66)	1.(16.66)	14(19.44)
Micrococcus roseus	1.(16.66)	1 (16.66)	1.(16.66)	1.(16.66)	0(0)	3(50)	3(50)	1.(16.66)	1.(16.66)	1.(16.66)	1.(16.66)	1.(16.66)	15(20.83)
Lactobacillus spp	0 (0)	0 (0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(33.33)	0(0)	4(66.66)	6(8.33)

Legend: N= total number of samples in each sampling station, n= percentage occurrence of bacteria isolates

Table 3 Percentage occurrence of sediment samples from the sampling station

Isolates	**Egbu abattoir N=2 n=%**	**Akachi bridge N=2 n=%**	**Mechanic village N=2 n=%**	**Aba road N=2 n=%**	**Westend N=2 n=%**	**Umezuruike hospital N=2 n=%**	**Inland bridge N=2 n=%**	**Nekede N=2 n=%**	**FUTO N=2 n=%**	**Ihiagwa N=2 n=%**	**Mgbirichi N=2 n=%**	**Umuagwo N=2 n=%**	**Overall % of occurrenc N=24 n=%e**
Klebsiella aerogenes	0(0)	0(0)	2(100)	0(0)	0(0)	0(0)	2(100)	0(0)	0(0)	0(0)	0(0)	2(100)	6(25)
Klebsiella pneumonia	1(50)	1(50)	0(0)	1(50)	1(50)	2(100)	2(100)	2(100)	1(50)	2(100)	2(100)	2(100)	16(66.66)
Alcaligens faecalis	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	24(100)
Enterobacter aeruginosa	0(0)	0(0)	1(50)	0(0)	0(0)	0(0)	2(100)	0(0)	0(0)	0(0)	2(100)	2(100)	7(29.16)
Enterococcus faecalis	2(100)	2(100)	0(0)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	2(100)	1(50)	0(0)	13(54.16)
Lysinibacillus macrolides	2(100)	0(0)	2(100)	2(100)	2(100)	1(50)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	21(87.5)
Eschericia coli	2(100)	1(50)	0(0)	1(50)	1(50)	2(100)	0(0)	1(50)	2(100)	2(100)	2(100)	2(100)	16(66.66)
Vibro cholerae	0(0)	0(0)	1(50)	0(0)	0(0)	2(100)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	3(12.5)
Lactobacillus spp	1(50)	1(50)	0(0)	1(50)	1(50)	0(0)	0(0)	2(100)	0(0)	1(50)	1(50)	1(50)	9(37.5)
Salmonella spp	1(50)	1(50)	2(100)	0(0)	2(100)	2(100)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	13(54.16)
Shigella spp	1(50)	2(100)	2(100)	2(100)	1(50)	2(100)	0(0)	0(0)	2(100)	1(50)	1(50)	1(50)	15(62.5)
Citrobacter spp	0(0)	0(0)	2(100)	1(50)	2(100)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	12(50)
Pseudomonas spp	2(100)	2(100)	0(0)	1(50)	1(50)	2(100)	1(50)	2(1000	2(100)	2(100)	2(100)	2(100)	18(75)

Bacillus spp	1(50)	1(50)	0(0)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	11(45.83)
Serratia marcescenes	0(0)	0(0)	2(100)	1(50)	1(50)	0(0)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	10(41.66)
Proteus spp	1(50)	1(50)	0(0)	1(50)	2(100)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	12(50)
Clostridium spp	2(100)	2(100)	0(0)	1(50)	1(50)	2(100)	2(100)	2(100)	1(50)	2(100)	2(100)	2(100)	19(79.16)
Bacillus spp	1(50)	1(50)	2(100)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	13(54.16)
Streptococcus spp	1(50)	1(50)	0(0)	1(50)	0(0)	1(50)	0(0)	1(50)	1(50)	1(50)	1(50)	1(50)	9(37.5)
Micrococcus roseus	0(0)	0(0)	1(50)	1(50)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	18(75)
Staphylococcus aureus	2(100)	2(100)	0(0)	2(100)	0(0)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	2(100)	20(83.33)

Legend: N= total number of samples in each sampling station, n= percentage occurrence of bacteria isolate

Tables 4 Displayed the findings of the physiochemical parameters of river water samples that were examined. The findings were interpreted and contrasted with drinking water criteria set by the World Health Organization (WHO, 2017).

Table 4 Physiochemical parameters (mg/l) of the river water samples analyzed

Parameters	**Egbu abattior**	**Akachi bridge**	**Mechanic village**	**Aba road**	**Westend**	**Umezuruike hospital**	**Inland bridge**	**Nekede**	**FUTO**	**Ihiagwa**	**Mgbirichi**	**Umuagwo**	**WHO standards (2017)**
Temperature(°c)	27	27	26	24	24	25	25	24	24	26	25	23	28-29
Ph	5.3	5.6	5.5	6.4	5.41	5.72	6.11	5.65	6.05	5.39	5.22	5.4	6.5-8.5
Alkalinity	40	50	54	46	48	51	55.9	45.7	55.5	42	39	46	NONE
Chloride	7.646	8.354	8.921	5.911	7.08	7.821	6.872	8.884	7.055	7.611	6.9	8.003	5
BOD(mg/L)	3.9	3.05	2.2	2.45	3.3	3.09	3.4	3.25	2.9	3.2	2.9	3.5	5
DO(mg/L)	7.2	5.1	4.9	5.8	6.7	7.07	7.3	7.11	6.5	6.5	6.8	6.5	10
Total hardness	96	88	104	65	50	69	53.2	45	71	81	76	60.6	500
E/conductivity(µS/cm)	115.8	117.25	99	154	138	110	98	118.6	112	125	99	100	100
Acidity	27.68	28.9	28.05	28	32.04	32.45	29	33	31	27	29	31.2	0
Turbidity(NTU)	10.55	10.8	12.2	12.8	22	18.5	21.6	20	10.8	11.8	12.5	10.8	5
TSS	205	211	112	115	211	341	245	115	121	1.29	234	111	NONE

PO_4	0.286	0.31	0.411	0.261	0.331	0.29	0.196	0.223	0.303	0.331	0.119	0.263	3.5
Ca	50.6	42	63.9	39.5	31	49	33	30	40	50.9	46	40.5	NONE
Mg	35,4	36	43.1	20.5	19	20	20.2	15	31	29.1	31	20.1	NONE
SO_4	1.9	1.98	2.1	1.89	2.2	2.21	2.1	1.98	1.99	1.9	1.19	1.79	NONE
NH_4	0,008	0.009	0.109	0.18	0.003	0.001	0.004	0.1	0.105	0.1	0.12	0.004	0.2
Fe	0.14	1	1.9	0.98	0.99	0.67	1.89	1.98	1.8	1.7	1.99	1.09	N0NE
Ni	0.121	0.132	0.141	0.086	0.089	0.11	0.111	0.079	0.068	0.045	0.062	0.066	3
Zn	0.106	0.114	0.122	0.079	0.068	0.086	0.059	0.066	0.049	0.054	0.076	0.049	0.002
Cu	0.121	0.139	0.211	0139.	0.12	0.211	0.13	0.109	0.067	0.112	0.103	0.069	2
Cd	0.062	0.078	0.096	0.064	0.051	0.039	0.036	0.044	0.052	0.056	0.053	0.049	0.003
Pb	0.148	0.169	0.211	0.089	0.106	0.13	0.082	0.021	0.063	0.059	0.03	0.116	0.01
Hg	0	0.005	0.01	0	0.005	0.01	0.007	0.005	0	0	0	0.001	0.001

The results of the physiochemical parameters of the sediment samples from each sampling station are displayed in the table below. The outcomes were compared to the 2017 WHO standard.

Table 5 Physiochemical parameters (mg/l) of the sediment samples analyzed

Parameters	**Egbu abattior**	**Akachi bridge**	**Mechanic village**	**Aba road**	**Westend**	**Umezuruike hospital**	**Inland bridge**	**Nekede**	**FUTO**	**Ihiagwa**	**Mgbirichi**	**Umuagwo**	**WHO standards (2017)**
pH	5.4	5.8	5.5	5.87	6	6	6.6	6	6	5.5	5.2	5.4	6.5-8.5
PO_4	17	18.4	18.2	18.6	17.8	17.9	18	18.5	18.2	17.8	18.3	18.6	3.5
Fe	18	18.5	19.818	18.8	19.5	17.5	17.8	19	18	18	17.71	17	NONE
Ni	0.139	0.155	0.17	0.123	0.12	0,133	0.132	0.123	0.099	0.069	0.071	0.084	3
Zn	0.144	0.16	0.146	0.116	0.139	0.142	0.094	0.082	0.065	0.08	0.088	0.089	0.02
Cu	0.139	0.141	0.211	0.138	0.12	0.211	0.13	0.114	0.088	0.144	0.119	0.062	2
Cd	0.082	0.116	0.118	0.119	0.089	0.128	0.094	0.082	0.071	0.093	0.12	0.073	0.003
Pb	0.162	0.176	0.261	0.129	0.16	0.165	0.114	0.114	0.080	0.084	0.06	0.152	0.01
Hg	0.85	1.5	1.89	0.905	1.67	1.44	1.62	1.33	0.89	1.2	0.98	0.6	0.001

4. Discussion

This present study has revealed the physiochemical and bacteria diversity in Otamiri River. From the study total bacteria counts recorded from the sampling stations were high. This can be as a result of human activity at these sample points, the introduction of waste and waste water into the river, or both. Waste water from major towns in Owerri is channelled through large drainages into the rivers. These factors pollute the water body hence with massive increase in the bacteria bio-load. Egbu abattoir sampling station recorded the highest total heterotrophic count. This concurs with that of Victor *et al.,* [15] in which Egbu abattoir produced the highest heterotrophic bacteria count in their study. The high indicator and fecal indicator bacteria counts recorded in this present study, *Escherichia coli, Klebsiella, Enterobacter* is as a result of disposal of untreated sewage and waste water into the river. However there were high counts of indicator bacteria as reported in this study across all sampling stations. The counts obtained were in agreements with other researchers who reported high indicator bacteria counts. Rheinheimer, [16] and Victor *et al.,* [15] reported high indicator bacteria counts in their study. High bacterial load counts were also found to be a good indicator of the degree of water pollution since they show high presence of organic matter [17, 18]. With respect to sediments the high values for bacteria bio-load is as a result of the conditions as stated above for river water. The bacteria isolated from Otamiri river water and sediments includes *Klebsiella aerogenes, Klebsiella pneumonia, Eschericia coli, Enterobacter aeruginosa, Enterococcus faecalis, Alcaligens faecalis, Staphylococcus aureus, Vibrio cholera, Bacillus subtilis, Salmonella spp, Shigella Spp., Citrobacter spp, Pseudomonas spp, Bacillus anthracis, Serratia marcescens, Proteus spp, Clostridium spp, Lysinibacillus macrolides, Streptococcus spp, Micrococcus roseus, Lactobacillus spp*. Amongst these bacteria, *Alcaligens faecalis* and *Lysinibacillus macrolides* had the highest percentage occurrence in river water and sediments in Otamiri. The bacteria isolated are pathogenic in nature. Hospital-acquired illnesses caused by *Serratia marcescens* include infections of the urinary and respiratory tracts, wounds, and bacteriaemia linked with catheters. According to Ahiarakwem [19], indicator bacteria in water have been linked to cholera, hepatitis, dysentery, typhoid, and other diseases. When indicator bacteria are present, it means that fecal contents have contaminated the water. In particular, fecal *Streptococci* such as *Enterococcus Spp* and *Clostridium* spores demonstrate contamination with fecal material [20]. Since the communities that live along the banks of the Imo River regularly use the water body for domestic, agricultural, and aquaculture purposes, there is a chance that these organisms could be transferred to people and that diseases associated with them could subsequently spread [21,22]. The presence of hospitals and other medical facilities, abattoir, sand dredging, channels of waste water, anthropogenic activities of man may be a factor in the river's and its sediment's high concentrations of certain human diseases. The physiochemical parameters as shown in tables 4 and 5, showed that pH ranges for river water is 5.22 - 6.4 while for sediment is 5.2 - 6.6. The pH ranges is slightly acidic. According to Ekhaise and Anyasi [23], the river's pH may have been altered by substances like aluminum or iron chloride, which dissolve in excess water to generate solutions (Lewis acids), that played a part to the pH observed. This is consistent with the results of a research on the Otamiri River and sediment by Okechi *et al.,* [12], which found a slightly acidic pH. The temperature ranged from 24^0C - 27^0C. The rate of disinfectant decay by-product generation is just one of the many effects of temperature, which is regarded as a crucial characteristic. Increases lead copper solubility, nitrification, microbial activity, algal development, taste odor events, and disinfectant degradation through product production. Additionally, precipitation of calcium carbonate ($CaCO_3$) also rises [24]. Oxygen that has been dissolved in water (DO) is a reflection of the physical and biological processes taking place there. The optimal dissolved oxygen standard is 10 mg/l. All Otamiri River water samples' DO values, ranging from 4.9 mg/l to 7.3 mg/l, are below recommended level. Because the majority of aquatic species rely on it for respiration, dissolved oxygen is a crucial component of water. Results obtained from this work demonstrate that the River has reduced DO along some of its length, which may have an impact on aquatic respiration. The range of the biochemical oxygen demand is 2.2 mg/l to 3.5 mg/l. The BOD is an approximate indicator of the volume of organic matter that can be degraded biochemically in a sample [25]. Chloride concentration range from 5.911 mg/l to 8.921 mg/l, exceeding the WHO 2017 limit of 5 mg/l. Water that contains a lot of chloride is unpleasant to drink and unsuited for watering livestock. The permeability and porosity of the soil are crucial factors in the development of the chloride concentration. Total hardness range from 45mg/l to 98mg/l, which is below WHO's maximum acceptable limit. This demonstrates that the concentration of alkaline earth metals is low, the river with calcium and magnesium ions. All of the sampling stations had turbidity levels that are higher than those allowed by the WHO. Due to suspended matter in the water body, including clay, silt, finely divided organic inorganic debris, soluble coloured organic compounds, planktons, and other microscopic organisms, turbidity level is quite high. Conductivity level is above the permissible limits 100 mg/l except for stations Mgbirichi with 99mg/l, Inland Bridge 98mg/l and Mechanic Village 99mg/l. Electrical conductivity is ability of water to conduct current. It is brought on by the presence of electrolytes, which include salts, acids, and bases that can produce cations and anions. Chlorides, sulfates, and magnesium are the main ions in water that cause EC. All of the sampling stations have turbidity levels that are greater than the WHO-permissible standard (5 mg/l). Runoff and anthropogenic activities are to blame for the high amount of turbidity found in this study. The high levels of total suspended solid (TSS) found in the samples caused the most variability to the physical, chemical, and biological parameters under investigation. Inorganic elements found in the Otamiri River range in concentration from 0.119 to 0.196 mg/l for phosphate, 30 to

63.9 mg/l for calcium, and 15 to 43.1 mg/l for magnesium. The presence of excessive phosphate levels in river water is a sign that pollution, which is mostly to blame for eutrophic conditions, is present [26]. Other researchers have noted low amounts of phosphorus in this study [27,28]. Some workers reported the amount of dissolved calcium, magnesium ions affecting the hardness of water. Both calcium and magnesium concentrations are below the minimum permitted range of 200.00 mg/l-1 for each [29]. The range of sulfate is 1.19 mg/l to 2.2 mg/l. Due to human-caused anthropogenic activities and the use of oxygen by aquatic life for respiration, there may be an increase in sulphate levels. Weathering of parent rocks and anthropogenic activities impact water bodies. Several studies have shown heavy metals contents of Otamiri River [30, 31]. Some of these researches have shown accumulation of heavy metals in Otamiri River due to industrial, agricultural or domestic activities. Iron (Fe) and mercury (Hg) are over the WHO-permitted levels for sedimentary heavy metals, whereas iron (Fe), zinc (Zn), cadmium (Cd), and lead (Pb) are above the limits for river water. Indiscriminate disposal of these solid wastes at the river's edge, runoff from Owerri urban area and surroundings, and the unrestricted disposal of untreated waste and effluent into the river are all possible causes of the high levels of heavy metals. Additionally, as poor pH has been found to accelerate the dispersal of heavy metals from polluted sediment. The river's slightly acidic pH also contributed to the great amount of these metals [32]. In comparison to river water, Otamiri sediment had a higher concentration of heavy metals. This might be explained by the sediment's build-up of heavy metals.

5. Conclusion

The biophysical characteristics of the River and its silt from several sample points have been disclosed by the current investigation. The findings indicated the existence of harmful bacteria, in particular the indicator bacteria, in river water and sediment, raises the likelihood of fecal contamination of the River. The water was also inappropriate for human consumption since the physiochemical and bacterial parameters assayed for recorded greater than WHO-recommended quality requirements for portable water. Therefore, those who live in Owerri municipality and depend on river water, especially for domestic purposes, should try to thoroughly purify the water before using it. Examples of such treatments include chlorination, boiling, ozonization etc. These demonstrate how the Otamiri River's water quality and sediment quality have declined over time. As a result, the microbiological features of the river must be continuously monitored. Communities around rivers need to make sure that untreated garbage is not dumped carelessly on land where it might wash into the river, and inappropriate human activities in river environments need to be regulated and thoroughly checked. By offering alternate pathways, the current government should make sure that businesses do not channel their drainage system into rivers or discharge untreated waste-water there. Therefore, those who live in Owerri municipality who depend on river water, especially for domestic purposes, should make an effort to thoroughly purify the water before using it. Examples of such treatments include chlorination, boiling, ozonization etc. The state ministry of water resources should ensure that natural bodies of water in the state are well protected from pollution via several laws with strict sanctions and punishment for the offenders.

Compliance with ethical standards

Acknowledgements

We acknowledge the staff of Emmabel Pnnacle Laboratories, Owerri, Imo State, Nigeria for their technical assistance in the course of this work.

Disclosure of conflict of interest

There was no conflict of interest.

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