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Evaluation of Physicochemical Parameters and Microalgae Composition of Otamiri River Water and Sediment in Imo State, Nigeria

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ABSTRACT

Using accepted methods, the physicochemical characteristics and microalgae composition of the water and sediment of Otamiri river were assessed. The results showed that the electrical conductivity (EC), turbidity, and biological oxygen demand (BOD) levels were higher than those allowed by the World Health Organisation (WHO). As expected, the dissolved oxygen (DO) level of 8.33mgL^{-1} was below the WHO standard of 10mgL^{-1}. Out of all the heavy metals discovered in the river water, iron had the highest quantity (0.542mgL^{-1}). Similarly, concentrations of arsenic, mercury, and lead were found to exceed the WHO drinking water quality criteria. Nevertheless, there was no nickel, copper, or cadmium in the river water. The lowest and greatest quantities of arsenic (0.004 mg kg^{-1}) and iron (1.789 mg kg^{-1}) were found in the sediment, respectively. Benzethonium chloride was the most prevalent cationic surfactant in both the river water (3.9634mgL^{-1}) and the sediment (1.5631mgkg^{-1}). Diethyl heptadecyl imidazolinium chloride and benzalkonium chloride exhibited the lowest concentrations in water and sediment, measuring 0.5408mgL^{-1} and 0.9758mgkg^{-1}, respectively. The amounts of cationic surfactants detected in the river water were all higher than the permissible limit of 0.5mgL^{-1} established by the Environmental Protection Agency (EPA) in 1979. The most concentrated anionic surfactant in sediment (5.6551mgkg^{-1}) and water (2.0938mgL^{-1}) was discovered to be sodium decylsulfate. Sodium tetradecylsulfate had the lowest amount in the water (0.0521mgL^{-1}), however sodium octadecylsulfate was absent from the sediment. Both sodium decylsulfate and sodium octadecylsulfate levels were higher than those advised by the EPA. The concentrations of certain physicochemical parameters in soil samples and river water point to possible human-caused pollution of the aquatic environment. Aquatic creature disturbance, alterations in water chemistry, and bioaccumulation in the food chain are just a few of the ecological effects that these contaminants may have. The microalgae isolates were identified as *Micractinium pusillum*, *Chlorella sorokiniana*, and *Dictyosphaeriun ehrenbagianum* by BLASTn's partial 18S rRNA gene sequence similarity analysis.

Key words: Physicochemical parameters, heavy metals, surfactants, microalgae, Otamiri river water and sediment.

Introduction

Water is an obvious necessity for life that can have negative effects directly or indirectly. A wide variety of animals and plants found in aquatic environments can be utilized for industrial, agricultural, and pharmacological purposes. Every environmental, industrial, and physiological function requires water. In biological things, water has many uses as a solvent, temperature buffer, metabolite, living environment, and lubricant. In addition to providing food and shelter for aquatic life, the aquatic environment is crucial for environmental processes such water purification, nutrient recycling, and the provision of habitat for wildlife (Inyinbor et al., 2018). Conversely, water becomes contaminated when natural or human-caused irregularities and unguided activities alter the physical, chemical, and biological characteristics of the water, impairing certain of its quality metrics (Okechi & Chukwura, 2020). Freshwater environments, including the river, are more contaminated than other settings due to effluents from industry and urban expansion, as well as discharge from industrial operations (Fernandesa et al., 2007).

Most aquatic environments can withstand a certain amount of pollution, but extreme pollution alters the local flora and fauna (Yahya et al., 2018). Otamiri River environmental contaminants include surfactants and heavy metals (Okechi & Chukwura, 2020). Humans and aquatic creatures are both harmed by toxic and physiologically detrimental effects of environmental pollutants (Allan et al., 2013).

The primary source of fresh surface water in the state of Imo is the Otamiri River. The river rises in Egbu and flows through Owerri and other Imo state communities until meeting the Atlantic Ocean at Ozuzu, Nigeria's Rivers state. The river's name comes from Ota Miri, a god who is the owner of all the streams bearing his name (Fagorite et al., 2019). Among other things, it supplies aquatic food and water for drinking, swimming, cleaning, domestic chores, and urban agriculture. However, untreated wastewater discharge, fertiliser application, leachate from trash dumps, chemical fishing, swimming, mining, corrosion of sheets, cables, and pipes, washing machine discharge, oil and grease run-off from the increasing number of gas stations and auto mechanic shops, and waste from hospitals and institutions are some of the reasons it is susceptible to pollution (Eze et al., 2021; Okechi & Chukwura,

2020). These operations change the chemistry of the river's water, degrade its physical quality, and may affect microalgae, which are important for the aquatic ecosystem's primary productivity. This can lead to a loss of biodiversity, the bioaccumulation of pollutants, and biomagnification of pollutants in the food chain.

The physicochemical and bacteriological analysis of the water from the Otamiri river has been the subject of numerous publications (Okoli et al., 2010; Amadi et al., 2010; Fegorite et al., 2019; Okechi & Chukwura, 2020; Eze et al., 2021). However, alterations in both natural and man-made activities can cause an environment's physico-chemical properties to shift throughout time. Moreover, information regarding the physiochemical characteristics and microalgal composition of the river is scarce. Therefore, the purpose of this study is to evaluate the physicochemical characteristics and microalgae composition of the water and sediment of the Otamiri river.

Materials and Methods

Geographical Location of the Study Area

The geographical location of the study site is shown in figure 1.

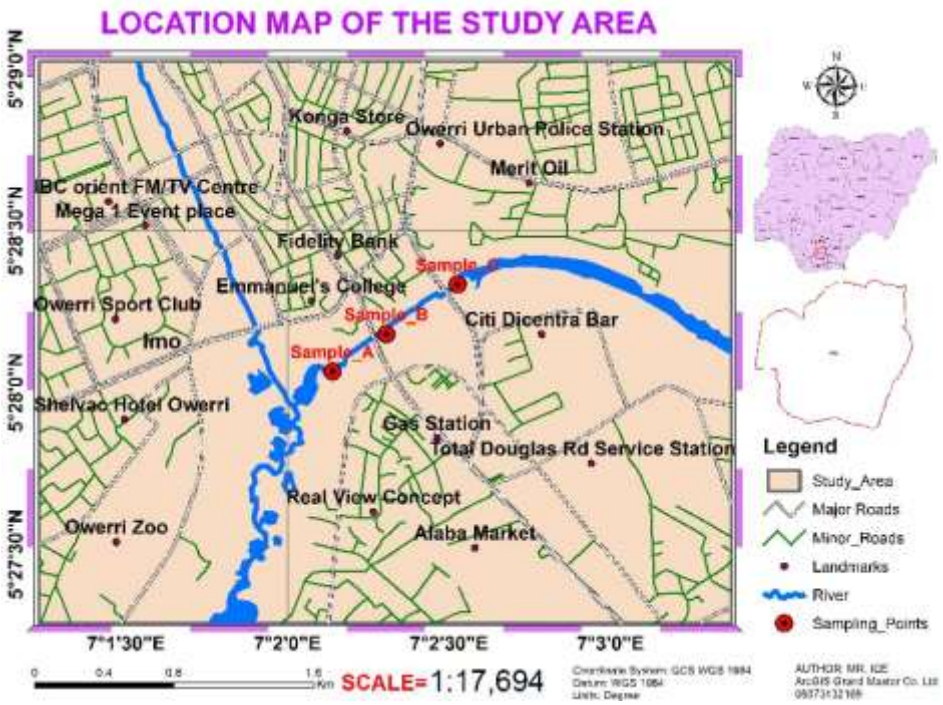

Figure 1: Location map of the study area showing sampling points

Sample Collection

It was done using Okechi & Chukwura's (2020) methodology. Three locations along the river were sampled, namely A, B, and C. The Global Positioning System (GPS) was used to geo-reference the sampling locations and the resulting coordinates were used to produce the map (Fagorite et al., 2019). At a depth of 30 cm, water samples were taken in sterile 250 ml containers and pooled together in sterile 1L plastic container. Sediment samples were similarly collected using Eckman grab sampler into sterile black polythene bags and combined. After being put in ice buckets, all of the samples were brought to the laboratory for examination.

Assessment of Physicochemical Parameters of Water and Sediment samples

The physicochemical characteristics of water samples were examined using standard techniques. As per the guidelines provided by APHA (1995), the pH, electrical conductivity, and turbidity were measured using a pH metre (PHS-3C), conductivity metre (DDS: 11A), and turbidity metre (AQ4500), respectively. A mercury-in-glass thermometer (Okechi & Chukwura, 2020) was used to measure the temperature. Nitrate, chloride, and total dissolved solids were measured using the APHA (1998) method. The dissolved oxygen and biological oxygen demand were measured using a digital JPSJ-605 Oxygen Analyser (APHA, 1992), and the phosphate was measured using the APHA (1999) method. To measure the phosphate and nitrate in sediment, the technique of Samira et al. (2009) was modified. The water sample's colour and odour were both assessed equally.

Heavy Metal Analysis

The samples' heavy metal content was determined using a Varian AA240 Atomic Absorption Spectrophotometer (AAS) (APHA, 1998). The method in Okechi & Chukwura (2020) described how water and sediment samples were digested. The evaporated pooled water sample was reduced to one-fourth of its initial volume (Nazia et al., 2020). A 5 ml of concentrated nitric acid was added into a digestion flask containing 100 ml of thoroughly mixed filtered

water sample from the pool and boiled till the volume reduced to around 20 ml. Then, at intervals, 5 ml of the nitric acid was added until the residue was completely dissolved. After cooling, the mixture was transferred to a 100 ml volumetric flask and filled with distilled deionized water to a final volume of 100 ml. The pooled sediment sample was dried at 65^0C in the Oven (DHG 9053A) for 48 hours and sieved at 160 µm before digestion. Two grams (2g) of dried material were weighed into a digestion flask and digested with 20ml of an acid mixture (650ml concentrated nitric acid, 80ml perchloric acid, and 20 ml concentrated sulphuric acid) until a clear digest was achieved. Distilled deionized water was used to dilute the digest to 100ml. Heavy metals such as lead, arsenic, zinc, copper, mercury, nickel, cobalt, cadmium, and iron were detected in the digested samples using AAS at their respective wavelengths and the concentration (mg/l) of each metal determined from the calibration curve.

Analysis of Cationic and Anionic Surfactants

Water and sediment samples were prepared and analysed using gas chromatography (AOAC, 1990). Using 20 ml of n-hexane, 5 ml of pooled water sample was extracted and mixed during the process. The mixture was separated using a separating funnel. The extract-containing hexane layer was concentrated by evaporation, and 1 ml was then put into a vial for Buck 530 Gas Chromatography analysis.

In order to absorb moisture, 20g of the homogenised pooled sample and 40g of anhydrous sodium sulphate (Na_2SO_4) were combined in an agitator mortar to create the sediment sample. In a Soxhlet extraction apparatus, the homogenate was extracted for three hours using 400 ml of n-hexane. With a rotary evaporator (RE52-2) set at 40^0C, the crude extract was evaporated until it was completely dry. First, 1.0g of activated florisil (made by heating it in an oven at 130^0C for an entire night and then transferring it to a 250 ml beaker and placing it in a desiccator) (60–100 nm mesh) was packed into an 8 ml column that had been blocked with glass wool. Next, 0.5g of anhydrous sodium sulphate (Na_2SO_4) was added on top. The GC's stopcock was opened to let n-hexane drain out of the prepared column until the florisil had thoroughly settled in it. This was done to condition the column. Using a sterile disposable Pasteur pipette, the crude extract from the evaporating flask was put onto the column. The column was then filled with 1.0 ml sections of n-hexane, which had been used to rinse the flask twice. After the solvent was eluted, the eluate was collected in an evaporating flask and rotary evaporated until it was completely dry. Next, the dried eluate was diluted in 1 ml of n-hexane and subjected to gas chromatography analysis. For cationic and anionic surfactants, different GC temperature conditions were used.

Sample Enrichment

In Erlenmeyer flasks, 10% of the water sample and 90% of sterilised Bristol culture media were combined to enrich the water sample (Schuelter et al., 2019). For sediment, a 10g pooled sample was agitated vigorously in 90 ml of sterile deionized water after being suspended in it. A 90 ml of sterile Bristol medium were combined with 10 ml of the supernatant after the suspension had had time to settle (Geetha, Sanket & Shailesh, 2013). The preparation of the medium followed the instructions provided by Oyewumi & Olukunle (2018). Ten grammes of sodium nitrate, 1g of calcium chloride, 3g of magnesium sulphate, 3g of potassium phosphate monobasic, 7g of potassium phosphate dibasic, and 1g of sodium chloride were each dissolved in 400 ml of sterile deionized water and stirred. Then, 10 ml of each salt solution were added to 900 ml of sterile deionized water. According to Oyewumi and Olukunle (2018), the flasks were incubated in natural low light (Veranda reflection) with 12/12h light/dark photoperiods. They were also periodically shaken on a Shaker (HY-4AKS) at a speed of 150 rpm (Baha'uddeen et al., 2022). All cultures were with atmospheric carbondioxide (CO_2) by plugging the culture flask with sterile cotton wool (Abdelaziz *et al*., 2014).

Isolation of microalgae

Following the enrichment phase, serial dilution of the enriched culture and micro-pipetting were used to isolate microalgae (Adersen & Kawachi, 2005).

A drop of the dilute sample was placed on a glass slide, and observed at a 10x magnification under a Leica M125 digital stereo microscope (PN MDG 36/10 450 126) equipped with a camera.

Sterile micropipettes attached to tubing were used to pick up different cells and placed into individual bijou bottles filled with sterile Bristol media and incubated for two weeks under the aforementioned conditions. To verify the cells' purity, a microscope was used to examine them.

Molecular Characterization of Microalgae Isolates

The three microalgal isolates were subjected to molecular characterization at Inqaba laboratory, South Africa.

DNA extraction: Extraction was done by using a DNA miniprep extraction kit supplied by Inqaba laboratory, South Africa. A 100 mg (wet weight) of each isolate was suspended in 200 µl of isotonic buffer (PBS) in a ZR BashingBead^{TM} lysis tube and 750 µl of lysis solution was added to the tube. The tubes were secured in a bead beater fitted with a 2 ml tube holder assembly and centrifuged in a microcentrifuge at 10,000x*g* for 1 minute.

Four hundred (400) µl of supernatant were transferred to a Zymo-Spin IV spin Filter (orange top) in a collection tube and centrifuged at 7000 x*g* for 1 minute. One thousand two hundred (1200) µl of DNA binding buffer were added to the filtrate in the collection tubes bringing the final volume to 1600 µl, 800 µl was then transferred to a Zymo-Spin IIC column in a collection tube and centrifuged at 10,000 x*g* for 1 minute, the flow through was discarded from the collection tube. The remaining volume was transferred to the same Zymo-spin and spun. Two hundred (200) µl of the DNA Pre-Was buffer was added to the Zymo-spin IIC in a new collection tube and spun at 10,000 x*g* for 1 minute followed by the addition of 500 µl of fungal/bacterial DNA wash buffer and centrifuged at 10,000x*g* for 1 minute. The Zymo-spin IIC column was transferred to a clean 1.5 µl centrifuge tube, 100 µl of DNA elution buffer was added to the column matrix and centrifuged at 10,000x*g* for 30 seconds to elute the DNA. The ultra-pure DNA was then stored at -20^0C for other downstream reaction.

18S rRNA Amplification

Using the primers 18F: 5'-CCTGGTTGATCCTGCCAG-3' and 18R: 5'-TTGATCCTTCTGCAGGTTCA-3', the isolates' 18S rRNA regions were amplified for 35 cycles in an ABI 9700 Applied Biosystems thermal cycler at a final volume of 40 µl. The X2 Dream Taq Master Mix (Taq polymerase, DNTPs, $MgCl_2$), primers at a concentration of 0.5µM, and the extracted DNA as template were all included in the PCR mix. It was provided by Inqaba, South Africa. The following were the PCR conditions: 72ºC for five minutes is the ultimate extension after 35 cycles of initial denaturation at 95ºC for five minutes, denaturation at 95ºC for thirty seconds, annealing at 52ºC for thirty seconds, and extension at 72ºC for thirty seconds. After being resolved for 30 minutes at 130V on a 1% agarose gel, the result was visible.

Sequencing

Inqaba Biotechnological, located in Pretoria, South Africa, used the BigDye Terminator kit on a 3510 ABI sequencer to sequence the 18S rRNA. A final volume of 10 µl was used for the sequencing.10 µl of primer PCR primer, 2.25 µl of 5 x BigDye sequencing buffer, 2-10ng PCR template per 100bp, and 0.25 µl of BigDye® terminator v1.1/v3.1 were among the components. 32 cycles of 96°C for 10s, 55°C for 5s, and 60°C for 4min were the sequencing conditions. The bioinformatics algorithm Trace edit was used to alter the acquired sequences. BLASTN was used to obtain similar sequences from the National Centre for Biotechnology Information (NCBI) database. With MAFFT, these sequences were aligned.

Phylogenetic Analysis

The Neighbor-Joining approach in MEGA 6.0 was used to infer the evolutionary history (Saitou & Nei, 1987). The evolutionary history of the taxa under study was assumed to be represented by the bootstrap consensus tree that was estimated from 500 replicates (Felsenstein, 1985). The Jukes-Cantor method (Jukes & Cantor, 1969) was utilised to calculate the evolutionary distances.

Results

Table 1: The Coordinates and Anthropogenic Activities in the Sampling Sites

Sampling site	Coordinate	Anthropogenic activity
A	5.467233N, 7.035272E	Sand mining, Trash dumps along the river bank
B	5.469679N, 7.038247E	Agricultural activity
C	5.472170N, 7.042115E	Washing and swimming

Table 2: Physicochemical Characteristics of Otamiri River Water and Sediment.

Parameter	River	Sediment	NSDWQ(2015)	WHO (2017)
Colour	Slightly turbid	-	Clear	Clear
Odour	Objectionable	-	Unobjectionable	Unobjectionable
pH	6.61	5.5	6.5-8.5	6.5-8.5
EC (µS/cm)	123	-	100	100
Turbidity (NTU)	20.4	-	5	5
Temperature (ºC)	26.3	-	Ambient	Ambient
TDS (mg/L)	5.0	-	500	500
DO (mg/L)	8.33	-	5	10
BOD (mg/L)	6.21	-	-	5
Nitrate (mg/L)	13.83	11.96	50	50
Phosphate (mg/L)	2.39	5.271	-	3.5
Chloride (mg/L)	2.15	-	100	250

Table 3: Heavy Metal Contents of Otamiri River Water and Sediment

Heavy metal	Wavelength (nm)	Detection Limit (mg L^{-1})	River water (mg L^{-1})	Sediment (mg kg^{-1})	Water standards (mg/l)	
					WHO	NSDWQ
Nickel	231.6	0.0001	0.00	0.063	0.02	0.02
Cobalt	292.2	0.0003	0.031	0.048	-	-
Copper	324.8	0.0001	0.00	0.005	2.0	1.0
Iron	267.7	0.0001	0.542	1.789	0.2	0.3
Lead	220.3	0.0003	0.013	0.064	0.01	0.01
Zinc	232	0.0003	0.104	0.229	3.0	3.0
Cadmium	226.5	0.0001	0.00	0.056	0.003	0.003
Mercury	405	0.0003	0.045	0.495	0.001	0.001
Arsenic	193.7	0.0003	0.023	0.004	0.01	0.01

Table 4: Cationic and Anionic contents of Otamiri River and Sediment

Surfactants	River (mgL^{-1})	Sediment ($mgkg^{-1}$)
Cationic		
Laurylpyridinium chloride	1.2244	1.0722
Cetylpyridinium chloride	0.7267	1.1939
Diethyl heptadecyl imidazolinium chloride	0.5408	1.0617
Benzalkonium chloride	1.5631	0.9758
Benzethonium chloride	3.9634	2.2385
Anionic		
Sodium decyl sulfate	2.0938	5.6551
Sodium dodecyl sulfate	0.3204	0.7566
Sodium tetradecyl sulfate	0.0521	0.4943
Sodium hexadecyl sulfate	0.3778	0.9330
Sodium octadecyl sulfate	0.5838	0.0000

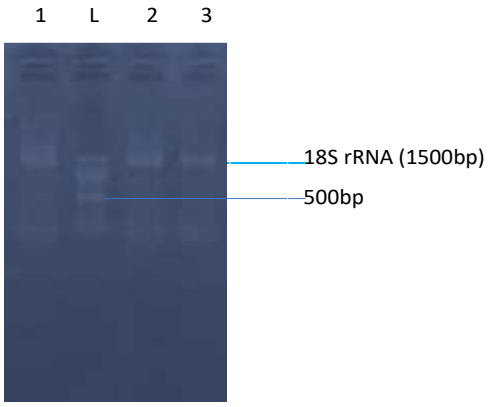

Plate 1: Agarose gel electrophoresis of the 18S rRNA of the agal isolates. Lanes 1-3 showing the amplified 18S rRNA bands while L represents 100bp ladder.

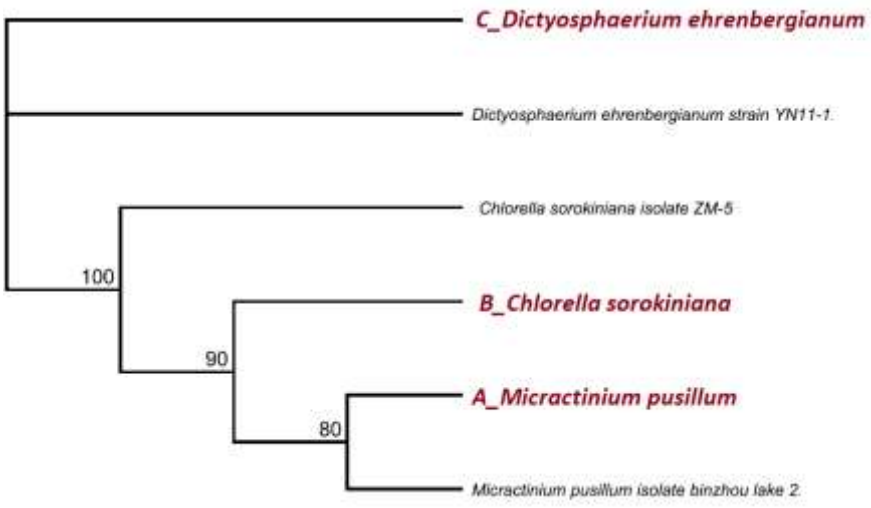

Figure 2: Phylogenetic tree showing the evolutionary distance between the algal isolates

Discussion

Tables 2 give the findings about the physicochemical characteristics of Otamiri river water and sediments. The river's pH was 6.61, but the sediment's was 5.5. The sediment had a higher pH than the river water, according to the data, which indicated that both had a somewhat acidic pH. Nonetheless, the pH levels were within the range of the NSDWQ (2015) and WHO (2017) guidelines for safe drinking water (6.5–8.5). The outcome is consistent with research by Eze et al. (2021); Okechi & Chukwura (2020), who reported pH values of 6.42 and 6.5, respectively. Moreover, Otamiri river water was

determined to have a pH range of 5.8–6.45 by Fagorite et al. (2019). The majority of chemical and biological reactions in surface waters are impacted by the pH of the water. Because some freshwater creatures cannot withstand increased acidity, bottom-dwelling bacteria start to die, causing unprocessed leaf litter and other organic detritus to accumulate on the bottom. Planktons become hungry as a result, and eventually perish (Ahiarakwem, 2013).

The electrical conductivity (EC) of water is a measure of water's abilityto conduct electrical current. The observed EC value of 123µS/cm was determined to exceed the standards set by the WHO (2017) and the NSDWQ (2015). As reported by Okechi & Chukwura (2020); Okeke & Adinna (2013), the higher value recorded may be the consequence of the high ion content in the river water.

The turbidity value of 20.4 NTU was recorded and this exceeds the permissible limit (5.00 NTU) recommended by WHO and NSDWQ. Turbidity in water arises from the presence of very finely divided solids (which are not filterable by routine methods). It can be caused by erosion, runoff, debris, wastewater containing residual particles, and the decomposition of organic. The existence of turbidity in water will affect its acceptability to consumers and it will also affect markedly its utility in certain industries (Okechi & Chukwura, 2020). Temperature affects dissolved oxygen level in the river water and by extension may have detrimental effect on aquatic biota. The temperature of the river was 26.3^0C. The result is in line with the report of Okechi & Chukwura (2020) who reported a temperature of 26.1^0C. However, an average temperature range of 26.9-28^0C was reported for Otamiri river by Okoro *et al* (2016). The total dissolved solid (TDS) was found to be 5.0mgL^{-1}. The result conformed to WHO (2017) and NSDWQ (2015) standards (500mg/L) for safe drinking water and indicates that the river is fresh. The level of total dissolved solid, TDS, in water affects the taste of water (Fagorite *et al*., 2019).

The amount of oxygen used by microorganisms in water to break down organic matter is measured by BOD. It stands for the quantity of organic stuff found in a water source. The BOD (6.21 mgL^{-1}) was discovered to be greater than the 5.0 mgL^{-1} WHO recommendation from 2017. Conversely, DO quantifies the amount of dissolved gaseous oxygen in water. The DO (8.33 mgL^{-1}) was less than the 10.0 mgL^{-1} WHO recommendation. The high warmth, fertiliser application, decomposing organic matter, and ongoing disposal of garbage (both biodegradable and non-biodegradable) along the riverbank could all be contributing factors to the high BOD and low DO levels. In the water of the Otamiri River, Frank-Ogu et al. (2023) found DO concentrations ranging from 4.9-7.3 mgL^{-1}. However, a somewhat greater DO of 9.8 mgL^{-1} was observed by Okechi & Chukwura (2020).

The Otamiri river's sediment and water had nitrate amounts of 13.83 mgL^{-1} and 11.96 mgL^{-1}, respectively. Both met the WHO's (2017) 50.0 mgL^{-1} drinking water criterion. Plants can utilise soluble nitrate for their purposes. According to Dorleku, Affum, and Nukpezah (2019), some of it may find its way into deeper groundwater and become harmful to people at concentrations of 10 to 15mgL^{-1}. In soil and water, the phosphate concentrations were 5.271 mgL^{-1} and 2.39 mgL^{-1}, respectively. One possible explanation for the elevated phosphate content found in Otamiri silt is the agricultural practises conducted at the river's edge. Despite the fact that the water's phosphate content is under the WHO's 2017 acceptable limit, Nwaugo et al. (2006) stated that phosphate concentrations higher than 0.1 mgL^{-1} will undoubtedly affect rivers and may cause an algal bloom. The water's chloride content, 2.15 mgL^{-1}, was within the WHO (2017) and NSDWQ (2015) acceptable limits. While Fagorite et al. (2019) recorded a mean chloride content of 5.27 mgL^{-1}, Okechi & Chukwura (2020) reported a chloride concentration of 1.08 mgL^{-1}.

The results of the metal contents in water and sediment showed the presence of iron (Fe), mercury (Hg), zinc (Zn), lead (Pb), nickel (Ni), cadmium (Cd), cobalt (Co), copper (Cu) and arsenic (As) as presented in Table 3. The concentration of metals in the water and sediment occurred in increasing order: Pb<As<Co<Hg<Zn<Fe and As<Cu<Co<Cd<Ni<Pb<Zn<Hg<Fe, respectively. However, nickel, copper and cadmium were not detected in the water from the study site. Non detection of nickel, copper and cadmium in water may not mean their absence but their inability to remain in solution (Nweke *et al*., 2006). The findings are consistent with those of Okechi and Chukwura (2020), who found that Otamiri river water and sediment had various quantities of cobalt, iron, copper, lead, cadmium, zinc, nickel, and mercury. The concentration changes could be related to variances in the sampling site, season, level of anthropogenic activity, etc. Certain metals, such copper and zinc, were found to be within the World Health Organization's (WHO, 2017) and the Nigerian Standard for Water Quality's (NSDWQ, 2015) allowed limits. However, certain elements, including Ni, Fe, Pb, Cd, and Hg, do not meet these standards and pose a risk to the river (Fagorite et al., 2019). The presence of heavy metals in water and sediment can be attributed to both natural and man-made factors. For cobalt, there were no guidelines.

In comparison to the water, the sediment had greater quantities of heavy metals. This could be the result of metals building up in the sediment over time. Heavy metal content is higher in sediment than in water when the aquatic environment is steady because metals can stick to both organic and inorganic components and settle at the river's bottom (Hanson et al., 1993). However, compared to the sediment (0.004 mgkg-1), the concentration of arsenic in the water (0.023 mgL-1) was higher. The river may have been physically agitated by swimming and sand mining etc. The levels of iron were greater than those of other metals in the silt (1.789 mgkg^{-1}) and river (0.542 mgL^{-1}). The same pattern was noted by Okechi & Chukwura (2020). The high concentration of iron found in the top crust of southern Nigeria could be the source of this. Apart from changing the quality and utility of the Otamiri river water overall, heavy metals in the water may bioaccumulate in the food chain even at sublethal levels.

Reports on the surfactant content of Nigerian sediments and surface waters, including Otamiri river are generally lacking. Surfactants are categorised as cationic, anionic, nonionic, or amphoteric based on the charge on the hydrophilic head. Because cationic and anionic surfactants are more prevalent in the environment than other kinds of surfactants, they were the focus of the current investigation (Norfazrin et al., 2012). There were notable amounts of five cationic surfactants found in the river water and sediment: laurylpyridinium chloride, cetylpyridinium chloride, diethiy heptadecyl imidazolinium chloride, benzalkonium chloride and benzethonium chloride which are chlorinated surfactants (Table 4). Synthetic quaternary ammonium salt benzethonium chloride (BZC) has antibacterial and surfactant qualities. The values for river water (3.9634 mgL^{-1}) and sediments (2.2385mgkg^{-1}) showed the highest occurrence rates, respectively, at 49.4% and 34.21%. According to Okechi and Chukwura (2020), mechanical motion of the water body may be the cause of the greater BZC level in the water compared to the sediment. According to Nweke & Orji (2009), physical disturbances may result in the

pollutants linked to sediment being redistributed in the water phase. It might also imply that fish and other aquatic life in the river are consuming the leftover. According to Gheorghe et al. (2014), even at low concentrations of less than 10µgL^{-1}, there is still a considerable environmental concern because of the substance's inhibitory effects on algae and other planktonic species.

Diethyl heptadecyl imidazolinium chloride recorded the least concentration in the water (0.5408 mgL^{-1}) accounting for its 6.7% occurrence while benzalkonium chloride had the least concentration in sediment (0.9758mgkg^{-1}) which represented 14.91%. These figures were higher than those obtained near a pharmaceutical manufacturing plant by Sujin *et al*. (2020) which recorded concentration of benzalkonium chloride (BKC), 35.8µg/L for dodecyl benzyl dimethyl ammonium chloride (BKC–C12), and 21.6 µgL^{-1} tetradecyl benzyl dimethyl ammonium chloride (BKC–C14). Benzalkonium chloride (BKC) is a commonly used preservative in personal care products and pharmaceutical preparations. In the reports of Ruan *et al* (2014); Li & Brownawell (2010), Quaternary ammonium compounds have been detected in surface water 0.09-191 µgL^{-1}, domestic wastewater (0.38-293 µgL^{-1}) and sediment (0.64-344 µgg^{-1}). In natural waters, the concentration of surfactants ranges from 0.001 to 10 mgL^{-1} and rarely higher than 0.5 mgL^{-1} (Zhu *et al*., 2020). The presence of anthropogenic sources (Table 1) might explain the reason for the high concentrations recorded in this study.

Anionic surfactants have been detected in Otammiri river water and its sediment. Okechi & Chukwura (2020) reported concentrations (mgL^{-1}) of 0.060 sodium methyl sulfate, 0.070 ammonium lauryl sulfate, 0.100 sodium dodecyl sulfate and 0.070 sodium laureth sulfate for the river water while concentrations (mgkg^{-1}) 0.0532, 0.0303, 0.4531 and 0.0018 were reported for the same compounds respectively in the sediment. In the current study, sodium decylsulfate had the highest concentrations of 2.0938mgL^{-1} and 5.6551mgkg^{-1} in water and sediment respectively. This translates to 61.1 % and 72% occurrences respectively. Sodium tetradecylsulfate recorded the least concentration in water (0.0521mgL^{-1}), representing 1.5% occurrence while sodium octadecylsulfate was not detected in the sediment (Table 4). The concentrations of anionic surfactants recorded in this work were higher than those reported by Okechi & Chukwura (2020).

The highest allowable level of surfactants in water, as per the Environmental Protection Agency's 1979 secondary maximum contaminant levels, is 0.5mgL^{-1}. These surfactant concentrations in sediment and river water samples point to possible pollution of the aquatic environment (Table 1). Both cationic and anionic surfactants can disrupt aquatic life, alter the chemistry of water, and cause bioaccumulation in the food chain, among other ecological effects.

The microalgae isolated from the river water were *Micractinum pusillum* and *Chlorella sorokiniana* while *Dictyosphaerium ehrenbagianum* was isolated from the sediment. The microalgae isolates were identified based on their molecular characteristics (Plate 1 and Figure 2). Based on the phylogenetic analysis (Figure 2), isolate A was found to be similar to *Micractinium pusillum* (binzhou Lake 2). The strain of isolate B was identified to be similar to *Chlorella sorokiniana* (ZM-5) while the nucleotide sequence of isolate C were identified as *Dictyosphaerium ehrenbagianum* (YN11-1). These isolates seem to be the first microalgae isolates of Otamiri river water and sediment.

Conclusion

The study evaluated the physico-chemical and Microalgae composition of Otamiri river water and its sediment. The water quality indicators such as BOD, DO etc have been compromised as a result of both natural and anthropogenic activities. Therefore, people who largely depend on the river water for drinking and other purposes should ensure its purity via any feasible treatment procedures.

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