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The Effect of Industrial Waste Effluent on Waterquality: A Case Study of Otamiri River, Owerri, Imo State

N. C. Mmonwuba [a++*], Anaduaka Mmaduabuchi [a], Ohamadike Azubuike [a], Nweke Nzube Theophilus [a] and Chioke Chukwuemelie [a]

[a] *Chukwuemeka Odumegwu Ojukwu University, Uli Campus, Anambra State, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study assessed the impact of effluent discharges on the quality of Otamiri River in Imo state, Nigeria. Six water samples were collected at discharge points where the industries discharge their effluents and abattoir. Samples that were collected upstream and downstream were analyzed in the field and in the lab using standard procedures. The source of pollution is attributable to industrial and abattoir activities whose effluent discharges impact the quality of Otamiri River. Therefore, without any treatments, the River cannot be used for any residential purposes in its current condition. It is advised that the river be periodically monitored and that cost-effective manufacturing technology, such as on-site waste separation and reduction, effluent recycling techniques, be introduced.

[++] *Engineer;*
**Corresponding author: Email: nc.mmonwuba@coou.edu.ng;*

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1. INTRODUCTION

For humans to survive, as well as for animals and plants, water is a vital essential. It is wished for consumption as well as for an increase in agricultural output, which supports life on earth. In addition, water is used for a multitude of reasons, such as recreation, navigation, and the production of hydropower. If water is properly used, it can be a great benefit and cost to humanity. If it is not properly regulated, it could turn out to be a curse and the source of human suffering and disaster. A. Abdulrzak [1].

People may also no longer place a great deal of thought into the quality of their water supply in wealthy nations. Residents of many first-world countries may turn on a faucet to get fresh, drinkable water that may also be supplemented with health-promoting ingredients. However, a significant portion of the population in emerging nations, particularly frequently in Africa, no longer has access to a water body that is tightly closed [2]. Water's physical, chemical, and biological characteristics are referred to as "water splendid." An extreme top environmental component that has an impact on health is the quality of drinking water. Water that is no longer safe to drink might become more contaminated with heavy metals and other diseases. Drinkers of this water risk developing terrible health and passing away. Unfortunately, even in places where the water is reportedly no longer safe, individuals would still recklessly drink it out of desperation. Specific sanitary issues, such as open sewers and insufficient trash collection, may coexist with a lack of access to drinkable water. The despicable is the character that is most impacted by many of these public health problems.

It is vital for people to have access to readily transportable water in order to survive and maintain their health and wellbeing. However, many people who reside in high-density, low-income communities continue to be without access to the basic options [3]. The United Nations (UN) interagency institution for freshwater and sanitation issues, UN-Water, estimates that 748 million men, women, and young adults lack access to an adequate supply of drinking water in its Global Analysis and Assessment of Sanitation and Drinking Water (GLAAS, 2014) study. According to a study by Maloma, Okufarasin, Olorunniwo, and Omode (A.A.), 81,000 people in Nigeria, a country with a reported population of around 177 million, died of diarrhea as a result of poor water quality, sanitation, and hygiene [4]. Effluent have an impact on on water great is a aspect of pinnacle notch concern. This is because, it has been placed that the remarkable of water human beings use has a pinnacle notch have an effect on on their health. If great care is no longer taken to affirm the characteristics or composition of the discharged effluent, then environment is uncovered to a differ of hazards. One may additionally additionally moreover ask what an effluent truly is. An effluent is described as an industrial liquid waste. It is characterized through feasible of the elements used in such industries. This implies that the composition or points of effluent varies from enterprise to industry. “Wastes entering these water bodies are both in solid and liquid forms. These are mostly derived from Industrial, agricultural and domestic activities. As a result, water bodies which are major receptacles of treated and untreated or partially treated industrial wastes have become highly polluted. The resultant effects of this on public health and the environment are usually great in magnitude” Osibanjo,O. Daso A P. and Gbadebo A M. [5].

“The coastal residential environment in any industrial effluent site is always under considerable stress due to the prevailing harsh environmental conditions, especially high temperature and salinity, restricted benthic fauna diversity and overall development of a fragile ntertidal ecosystem. The fauna inhabiting the intertidal zone is most likely dominated by a few species probably living at their limit of tolerance” Awomeso, J.A., Taiwo, A.M., Gbadebo, A.M. and Adenowo, J.A. [6]. “Organic pollution is always evident and the pollution is made worse by land-based sources such as the occasional discharge of raw sewage through storm water outlets, and industrial effluents from refineries, oil terminals, and petrochemical plants”. Adekunle, A. S.and Eniola, I. T. K. [7].

Wastes produced by the textile industries have characteristically high concentration of chemicals. The net effect is a variation of the acid or basic nature of the water. Textiles industries produce chemicals with high concentration of caustic chemicals resulting in high pH values varying between 10.0 -11.0. The discharge from the textiles, also bear intense colouration derived from the dyes fibrous materials.

1.1 Subsurface Liquid

Ground water is defined as water that percolates through the ground and drains into bodies of water including rivers, lakes, ponds, and impoundments. Surface water must be treated before use because it is susceptible to pollution by natural and inorganic pollutants, gases, and microbes. It is possible to step up efforts to monitor what is happening internally in the areas around the flooring water. The most essential freshwater resources for man are rivers. Unfortunately, runoff from numerous human activities, industrial waste, and sewage disposal results in river waters becoming contaminated, This influences its physical, chemical, and biological diversity (AIRBDA, 2014).

1.2 Fluvial Otamiri

The Otamiri, a significant river in Imo State, flows through Owerri Municipal City. The river begins at Egbu and travels through Owerri town, Nekede, Ihiagwa, Eziobodo, Olokwu, Umuisi, Mgbirichi, and Umuagwo in Rivers State before reaching the Atlantic Ocean. The Otamiri River spans around 105 kilometers [8]. From its source to where it converges with the Uramiriukwa River near Emeabiam, the Otamiri River is 30 kilometers long.

The goal of this investigation is to determine how industrial waste effluent affects the quality of drinking water. To conduct physical-chemical examinations of the Otamiri River and the surrounding region. Study the Otamiri River's unique features and determine whether it is fit for human consumption. Must take into account the World Health Organization's (WHO) recommended values for physicochemical characteristics for water.

The problems encountered is that the hazardous have an effect on of the effluent flows from biril paint corporation to otamiri river is our component of concern. This turns into a hassle due to the truth the waste ought to be channelled to a sewer remedy plant formerly than being discharged due to this fact into the river. This is to help restriction the depth of the wastewater. It is as a result pertinent to verify the composition of these effluents and pertaining to it with the impact they have on the river quality. The significance of this study is to proffer solution on the extremely good strategies of discharging effluent into rivers.To serve as a reference to all who will take care of associated initiatives in future.

Water is an inorganic, clear, flavorless, odorless, and almost colorless liquid or chemical that makes up the majority of the hydrosphere on Earth as well as the bodily fluids of all recognized living things (in which it serves as a solvent). All known forms of life depend on it, despite the fact that it doesn't give them any food, energy, or organic micronutrients. The word "water quality" refers to the chemical, physical, and biological properties of water, usually in terms of how well suited it is for a certain usage. Water quality is determined by scientific measurements; it is the characteristic of natural water that is good for aquatic plants and animals. Water use and economic development both have a direct impact on water quality.

Wastewater is the water that is produced after freshwater, raw water, drinking water, or salt water has been intentionally used in a variety of applications or processes. "Used water from any combination of domestic, industrial, commercial, or agricultural activities, surface runoff / storm water, and any sewer inflow or sewer infiltration" is another definition of wastewater. Sewage, also known as sewerage, domestic wastewater, or municipal wastewater, is the term used most frequently in ordinary speech to refer to wastewater produced by a community of people. The process of turning wastewater—water that is no longer required or appropriate for use—into bilge water that can be released back into the environment is known as wastewater treatment. It can be created by a variety of processes, such as bathing, washing, using the bathroom, and rainwater runoff. Wastewater treatment is a technique used to clean up impurities from wastewater and turn it into effluent that can be reintroduced into the water cycle. The effluent is reused for a variety of purposes or returns to the water cycle, having an acceptable influence on the environment (called water reclamation).

In a wastewater treatment facility, the treatment procedure is carried out. Different types of wastewater are treated at the right kinds of wastewater treatment facilities. The treatment facility is known as a sewage treatment plant for household wastewater (also known as municipal wastewater or sewage). Either a separate industrial wastewater treatment facility or a sewage treatment plant is used to treat industrial wastewater (usually after some form of pre-treatment). Leachate treatment plants and agricultural wastewater treatment facilities are additional varieties of wastewater treatment facilities.

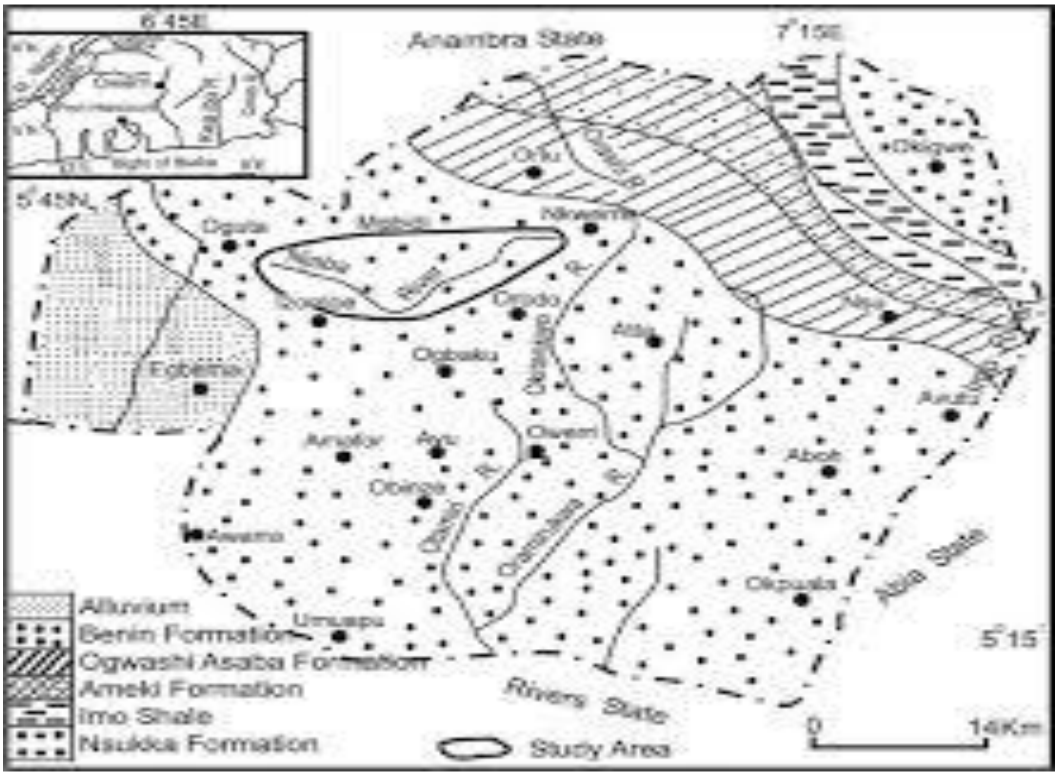

Fig. 1. The Otamiri River, one of many rivers in Nigeria's Imo State

The kind of wastewater that needs to be treated might help distinguish different wastewater treatment facilities. Depending on the kind and degree of contamination, a variety of techniques can be employed to treat wastewater. Physical, chemical, and biological therapeutic procedures are all included in the treatment steps.

Types of wastewater treatment plants include:

- Sewage treatment plants
- Industrial wastewater treatment plants
- Agricultural wastewater treatment plants
- Leachate treatment plants

The procedures used to treat wastewater produced by industry as an unwanted by-product are referred to as industrial waste management treatment plants. After treatment, the industrial wastewater (or effluent) may be recycled, released into the environment's surface waters or sanitary sewers, or both. Some industrial operations produce wastewater that sewage treatment plants can treat.

The majority of industrial processes, including chemical and petrochemical plants, petroleum refineries, and chemical plants, have their own specialized facilities to treat their waste waters so that the pollutant concentrations in the treated wastewater comply with the regulations regarding disposal of wastewater into sewers or into rivers, lakes, or oceans. This holds true for enterprises that produce wastewater that contains high levels of harmful contaminants, such as heavy metals and volatile chemical compounds, as well as nutrients like ammonia and organic matter (like oil and grease). Some industries set up a pre-treatment system to get rid of some pollutants (such hazardous chemicals), and then they release the wastewater that has undergone this partial treatment into the public sewage system.

Domestic wastes in the country like in many other developing countries may now contain modern environmental health hazardous substances thus posing additional risk to public health. Due to population and industrial growth, inland waters (rivers, lakes, etc.)become often the recipient of organic matter in amounts exceeding their natural purification capacity, while in the past, natural purification and dilution were usually sufficient.

Secondary organic pollution is defined as the surplus of organic matter,which is the sum of undecomposed organic material introduced into the water body with primary pollution and of the material resulting from an extremely increased bio-productivity within the polluted ecosystem itself, Nweke, O.C. and Sander, W.H.[8]. Organic wastes mineralize in the receiving water bodies and the resulting nutritive elements stimulate plant production, leading to eutrophication. In this situation, the biomass increases considerably and goes beyond the assimilation limit by herbivores. This secondary organic pollution is considerably greater than the primary organic load. The excessive production of organic matter leads to the build up of "sludge" and the mineralization process consumes all dissolved oxygen from the water column, which causes fish kills, Adefemi, S. O. and E. E. Awokunmi [9].

One of the sources of waste water is palm oil mill effluent (POME). Palm oil mill effluent is an important source of inland water pollution when released without treatment into local rivers or lakes. In Nigeria palm oil is processed locally and industrially through the oil palm belt stretching from Cross River to Lagos State. Beside the main product i.e. the crude palm oil (CPO), the mills also generate many by-products and liquid wastes, which may have a significant impact on the environment if they are not dealt with properly. Palm oil mill effluent (POME) is one of the major sources of pollutant produced during oil palm processing. The palm oil mill effluent (POME) is generated from three major sources, namely sterilizer condensate, hydrocyclone waste and separator sludge.. On an average 0.9–1.5m3 of POME is generated for each ton of crude palm oil produced. Davis, J.B. and Reilly, P.J.A. [10]. POME is rich in organic carbon with a biochemical oxygen demand (BOD) higher than 20 g/L and nitrogen content around 0.2 g/L as ammonia nitrogen and 0.5 g/L total nitrogen. It contains various suspended components including cell walls, organelles, short fibres, a spectrum of carbohydrates ranging from hemicellulose to simple sugars, a range of nitrogenous compounds from proteins to amino acids, free organic acids and an assembly of minor organic and mineral constituents. Also, palm oil mill wastewater treatment systems are one of the major sources of green house gases due to their biogas emission (36 % CH4 with a flow rate of 5.4 l/min.m2) from open digester tanks and/or anaerobic ponds, Wu, T. Y. Mohammad, A. W. Jahim, J. Md.and Anuar, N. [11]. POME has generally been treated by anaerobic digestion, resulting difficult to perceive the magnitude of pollution being caused to the receiving waters by such discharges.

The characteristic problems associated with palm oil mill effluents are pH, dark color, high levels of biochemical oxygen demand (BOD), chemical oxygen demand (COD), color, and suspended solids. High values of COD also indicate the recalcitrance of chemicals that have escaped biodegradation. These chemicals may be persistent in nature and may cause severe environmental problems like bioaccumulation.

2. MATERIALS AND METHODS

2.1 Materials

The following materials were used for the study:

i. Reagent bottles: 50 ml reagent bottle fragments required for sample and specimen collection.
ii. For oxygen fixation, Winkler's solutions A and B are required.
iii. Plastic 1-liter containers that are useful for collecting samples for heavy metal analysis.
iv. Nitric Acid
v. Distilled Water: Nitric acid must be diluted with 2ml of distilled water. Nitric acid that has been diluted is crucial for maintaining the oxidation state of the elements and preventing metals from clinging to the container's walls.
vi. Ice chests and refrigerators are necessary to keep samples safe before examination.
vii. Spectrophotometer: The amount of heavy metals in the samples was determined using a Unicam 919 model atomic absorption spectrophotometer.
viii. The temperature of the samples was determined using a mercury-in-glass thermometer (0–100 oC).
ix. A HATCH pH meter was used to measure the hydrogen ion concentration (pH).
x. Indicator: Ferrous ammonia, sulphate, and ferroin were used as indicators when determining the COD by titration. Four predefined sampling points were located along the length of the river, and river water samples were taken from each of them for physiochemical, microbiological, and heavy metal examination.

2.2 Methods

2.2.1 Sample collection

In a sterile, clean one-liter plastic container, samples for bacteriological and physiochemical analysis were collected.

In a 50 ml reagent bottle, samples for dissolved oxygen (DO) and biochemical oxygen demand (BOD) were collected. In order to fix the oxygen in the samples on-site, Winkler's solutions A and B were added in a 1 ml ratio to the samples. For the purpose of heavy metals analysis, samples were gathered in sterile, clean 1-liter plastic containers; 2 ml of diluted nitric acid was added to each sample; they were then transported to the lab, where they underwent additional preservation in a refrigerator before analysis. This was done to maintain the oxidation state of the elements, preserve the stability of the samples, and stop the metals from clinging to the container walls. Each point source's downstream and upstream samples for DO, BOD, heavy metals, and all the other metrics were taken twice. For each of the factors that determined pollution, the process was repeated.

2.2.2 Sampling

The sampling locations were planned in accordance to the industries shown in All samples were put into one-liter plastic bottles that had been carefully cleaned (with diluted nitric acid and rinsed with distilled water before to use) and then sealed. Before final sample collection, each bottle was rinsed with the appropriate quantity of sample. These samples were taken to the lab for analysis after being kept in a cooler box and shielded from the sun.

2.2.3 Sample analysis

Na+, K+, Cl,-1Ca2+, Pb2+, Cd2+ and Cu2+ were determined from the Uganda National Bureau of Standards (UNBS) Chemistry Laboratory while COD, BOD, turbidity, colour, TP, and TN were determined from National Water and Sewerage Corporation (NWSC) analytical laboratory. Samples were analysed according to Standard Methods for Examination of Water and Waste water (APHA, 1998) and the Association of Official Analytical Chemists (AOAC).

2.2.4 Laboratory analysis

The atomic absorption spectrophotometer Unicam 919 model was used to measure the presence of the heavy metals Cadmium (Cd), Copper (Cu), Iron (Fe), and Lead (Pb). A calibrated mercury in glass thermometer (0-1000 C) was used to measure the temperature to the nearest 0.050C. The hydrogen-ion concentration (pH) was determined using a HACH pH meter. Using Winkler's technique, dissolved oxygen (DO) and biochemical oxygen demand (BOD5) were calculated. Utilizing a calorimeter, phosphate and nitrate were determined. Titration analysis was used to calculate the chemical oxygen demand (COD) utilizing ferrous ammonia, sulphate, and ferroin as indicators. On-site measurements of the turbidity were made with a microprocessor turbidimeter. According to the method of, the bacteriological parameter being watched was fecal coliform. further bacterial isolation and identification

2.2.5 Physicochemical analysis

A. pH

Samples examined at various locations had pH readings ranging from 4.38 to 8.42 upstream and downstream, respectively. The results show that water samples from sites 1, 2, and 5 are slightly alkaline, whereas samples from sites 3 and 4 are acidic in nature. pH was measured using a pH meter (mettle Toledo 320 model). pH levels should be between 6.5 and 8.5, according to WHO.

B. Turbidity

Turbidity levels were measured in nephelometric turbidity unity (NTU`s) using the HACH2100A turbidity meter. Turbidity at sites 1, 2, and 4 is under the WHO standard limit for both upstream and downstream samples, which is any value less than or equal to 29. Turbidity is the highest allowable limit for surface water by the WHO.

C. Total hardness

Total hardness concentrations were highest (19.87-14.16) in effluents from the abattoir site and lowest (2.3-4.4mg/l) in the Star-line industry area, according to the test results. Water hardness often reflects the amount of calcium and magnesium ions present, and a high degree of this may be caused by the mixing of sewage effluents with river water.

D. Total alkalinity

The total alkalinity values in the current study range from 4.89 mg/l to 67.22 mg/l. According to WHO regulations, the upper limit for alkalinity in surface water is 600 mg/l. Alkalinity levels in water samples taken from various locations were below the WHO's upper limit.

E. Chloride

By titrating the material with silver nitrate, this anion was found. Potassium chromate was added to a 100 ml sample, and the presence of a buff color was first detected after titrating with 0.1 M silver nitrate solution. The amounts of waste and effluents from the chemical industry that contain chlorides at all of the locations are within the range of chloride concentrations in water and may introduce unacceptable restrictions. The distribution system may corrode due to the higher chloride content, and the significant sewage flow upstream may be to blame.

F. Sulphate

It is important to note that sulphate concentrations of water samples varied from concentration from abattoir samples. Sulphates are highest even 3.25mg/l which are all less than the standard through lower than WHO limit.

G. Nitrate

Nitrate concentrations in water samples from the study ranged from 0.54 mg/l to 55.22 mg/l, exceeding the allowable threshold may indicate at places with upstream and downstream pollution effects from feedlot runoff, sewage, or fertilizers. The upstream value at both research' conclusions suggest that pregnant women, young children, and the elderly may be harmed by consuming water with nitrogen concentrations greater than 10 mg/l.

H. Phosphate

In the current investigation, phosphate levels in water samples ranged from 3.32 mg/l to 12.97 mg/l. The investigation unequivocally demonstrates that the levels of contaminants in every water sample are substantially below the ideal range.

I. Total Dissolved Solids (TDS)

The WHO has set maximum and acceptable TDS levels for surface water at 500mg/l and 1000mg/l, respectively. According to the study, the water sample taken from all of the sites had a value that was acceptable because it ranged from 16.32 mg/l to 56.14 mg/l.

J. Total Suspended Solids (TSS)

The water sample from site 3 that had the highest TSS value in the investigation had a value of 10.54 mg/l upstream. All TSS concentrations, however, fall below the allowable WHO concentration level. All TSS concentrations, however, fall below the acceptable WHO guidelines. TSS levels beyond a certain threshold indicate that river water is seriously contaminated.

K. Biochemical oxygen demand (BOD)

BOD levels in the study's water samples ranged from 1.89 mg/l to 14.86 mg/l. Four of the locations had concentration levels that are over WHO recommended limits. The Otamiri River may have been polluted by untreated sewage solid and industrial waste that was dumped into each site, as indicated by the presence of high BOD values, which can be attributable to the percolation of waste water that was filled with biodegradable components.

L. Chemical Oxygen Demand (COD)

Analyses of all water samples revealed that they are all below the WHO threshold. The low amounts of COD found in water samples taken from various locations clearly show that the wastes released into these bodies of water have modest oxygen demands and do not cause the water's dissolved oxygen to become depleted.

M. Electrical Conductivity (EC)

The study's values ranged from 20.01 to 69.10 cm/cm, and the standard is any value less than or equal to 100 cm/cm. The obtained values fall below the 100 cm/cm limit set by the WHO standard (WHO, 2007). An extensive positive association between electrical conductance and chloride concentration has been found in earlier investigations.

3. RESULTS AND DISCUSSION

This table presents result of the physiochemical texts on the samples collected upstream and downstream of the selected locations.

Table 1. Measured physiochemical parameters and who standard (WHO, 2007)[8]

Parameters	Site 1		Site 2		Site 3		WHO STD
	NBC (UPS)	NBC (DS)	PZ (UPS)	PZ (DS)	Abattoir (UPS)	Abattoir (DS)	
pH(at 29c)	8.42	7.94	6.33	4.23	7.90	7.01	6.5-8.5
Total dissolved solids	37.64	32.40	27.22	19.32	22.44	18.32	500-1000
Total hardness	11.02	8.12	13.21	9.34	19.87	14.16	-
Sulphate	9.30	7.63	8.50	5.45	20.32	3.41	250
Electrical Conductivity	51.19	48.16	30.54	22.43	41.54	20.01	
Alkalinity	51.26	39,91	23.30	19.72	67.22	9.01	600
Total suspended solid	3.87	2.96	10.54	4.54	9.23	3.52	35
Biochemical Oxygen demand	12.87	9.88	2.90	1.87	4.48	3.52	4-7
Chemical Oxygen Demand(COD)	42.43	20.64	16.43	11.87	32.23	24.64	120

A. pH

Samples examined at various locations had pH readings ranging from 4.38 to 8.42 upstream and downstream, respectively. A pH meter was used to monitor pH. pH levels should be between 6.5 and 8.5, according to WHO. A nutritional imbalance or the presence of a hazardous ion in water that is beyond the usual pH range can have a negative impact on the growth and development of aquatic life. It might be argued that pH has an indirect impact on health since it influences the unit processes in water treatment that help remove hazardous organisms. In general, water gets more corrosive as the pH decreases, although water that is overly alkaline can also be corrosive.

B. Total hardness

According to test results, total hardness concentrations were highest (19.87–14.16) in effluents from the abattoir site and lowest (2.3–4.4mg/l) at the location of the pz industry. Water hardness often reflects the amount of calcium and magnesium ions present, and a high degree of this may be caused by the mixing of sewage effluents with river water. Hardness results in incrustations in water delivery systems and excessive soap usage in laundry.

C. Total alkalinity

The current study's total alkalinity measurements range from 4.89 mg/l to 67.22 mg/l. According to WHO regulations, the upper limit for alkalinity in surface water is 600 mg/l. Alkalinity levels in water samples taken from various locations were below the WHO's upper limit. The high alkalinity level may be related to the river's higher pH readings, chloride, sulfate, and phosphate concentrations, as well as other ions that may have been impacted by effluent discharges.

D. Sulphate

It is significant to note that the sulphate contents in the water samples were different from those in the samples from the abattoir. Sulphates are at their greatest level even at 3.25mg/l, which is lower than the WHO limit and all less than the standard.

E. Total Dissolved Solids (TDS)

TDS in surface water should not exceed 500 mg/l and should not exceed 1000 mg/l, according to WHO recommendations. Because they ranged from 16.32 mg/l to 56.14 mg/l, the study's water sample taken from all of the sites had an acceptable value. Higher concentrations of chlorides, calcium, magnesium, sulphates, organic and other inorganic particles that came from the discharge of sewage, industrial waste, and solid waste into the river may have an impact on the increased level of TDS. The flavor of the water may change, and severe scale buildup in water heaters, boilers, and home appliances may occur. The growth of many aquatic life forms may be hampered or even killed by TDS concentrations that are too high or too low.

F. Biochemical oxygen demand (BOD)

BOD levels in the study's water samples ranged from 1.89 mg/l to 14.86 mg/l. Four of the locations had concentration levels that are over WHO recommended limits. The Otamiri River may have been polluted by untreated sewage solid and industrial waste that was dumped into each site, as indicated by the presence of high BOD values, which can be attributable to the percolation of waste water that was filled with biodegradable components.

G. Chemical Oxygen Demand (COD)

Analyses of each water sample revealed that each one fell short of the WHO guideline. The low amounts of COD found in water samples taken from various locations clearly show that the wastes released into these bodies of water have modest oxygen demands and do not cause the water's dissolved oxygen to become depleted. Any water sample with higher BOD and COD values is likely to be heavily polluted. It might be ascribed to the wastes dumped into the water bodies' high need for dissolved oxygen, which makes them unfit for drinking, irrigation, and also drastically reduces their utility for recreational purposes.

H. Electrical Conductivity (EC)

The study's values ranged from 20.01 to 69.10 cm/cm, and the standard is any value less than or equal to 100 cm/cm. The obtained values fall below the 100 cm/cm limit set by the WHO standard (WHO, 2007). An extensive positive association between electrical conductance and chloride concentration has been found in earlier investigations. Moreover, there is a strong positive association between electrical conductance and the total water dissolved solids.

I. Pollution Index

Based on the findings above, the river's pollution index was calculated to be 1.317. (1). This suggests that the river is just slightly polluted.

4. CONCLUSIONS

According to the study, industrial effluents significantly affect the receiving river's water quality. This is demonstrated by the fact that the concentration of the examined parameters is generally higher upstream than downstream. Despite the fact that in certain cases the results were below WHO maximum permissible limits, the continuing discharge of untreated effluents into rivers could lead to a serious buildup of harmful chemicals. The numerous manufacturing and animal processing operations will continue to enrich the receiving river with major pollutants and quickly degradable carbon compounds, further depleting the river's oxygen levels. This is due to the area's outdated processing technologies.

In conclusion, waste water from industrial and abattoir operations affects the quality of the Otamiri River; assessing the health of rivers is crucial if Nigeria is to create an effective surface water quality monitoring system in the nation. It changes with the seasons and geographical regions, even when there is no pollution present. As a result, we must monitor and test the water quality closely. It cannot be overstated how important it is to provide high-quality water to Nigeria's ever-growing population. Millions of Nigerians would suffer, agriculture will be impeded, and the leisure industry will suffer without a sufficient supply of water. Also It has been established that the contaminants exist in concentrations that could be hazardous to various organisms. The effluents also have a significant detrimental impact on the receiving water bodies' water quality, making them unfit for human consumption. Therefore, it is suggested that reckless industrial waste dumping without preparation be discouraged. In order to preserve water resources from further deterioration, the regulating body must impose direct levies on industrial effluents and maintain ongoing monitoring and surveillance.

5. RECOMMENDATION

The present worldwide norm should be revised and adopted by local regulatory agencies and environmental law authorities.

To create an internally coherent institutional structure for waste management, the municipal bodies and environmental law authorities should intervene. To guarantee that the effluent emitted is within the permitted limits, the Environment Management Act and waste effluent laws should be strictly enforced. Therefore, it is advised that waste treatment facilities be built with each industry, with appropriate oversight. In addition, effective environmental regulations and societal awareness campaigns must be implemented in light of the possible environmental damage posed by industrial waste and other waste types.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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