# EFFECT OF POLLUTION ON THE PHYSIO-CHEMICAL CHARACTERISTIC OF OTAMMIRI RIVER, IMO STATE.

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**ABSTRACT** : This study was conducted to assess the physiochemical characteristics of Otammiri River in Imo state Nigeria. Samples were taken from three different points along the river. The physio-chemical parameters of the water samples were measured both in-situ and in the laboratory. The parameters measured included Temperature, `pH, biological oxygen demand (BOD) dissolved oxygen (DO), chemical oxygen demand (COD), Electrical conductivity (EC), Turbidity, Total dissolved oxygen (TDS), Alkalinity, Nitrate, Sulphate, chloride, Total hardness. The range values of the measured parameters were compared with world health organization (WHO) standards. The finding showed that all the physio-chemical parameters measured were below the tolerable values ranges except (DO), pH, Temperature. The dissolve oxygen of the water was found to be between 15.62 – 16.73mg/L indicating the abundance growth of phytoplankton with less water flow, which led to the increased generation of oxygen ($O_2$) by photosynthesis activities in the study area as opposed to WHO (10.00mg/L). pH was found to be 5.79 – 6.12; showing the acidity of the study area exceeding WHO (2003) limit of (6.50 ± 8.50) while Temperature was $28^0$C all through the stations. 28.00°C is within the WHO (2003) limit of (20 – 30°C). Some of these parameters studied were significant at ($P<0.05$) at all the sampling stations. This study has revealed that though Otammiri River is not heavily polluted, but the observed fluctuation of the investigated parameters along the sampling points could be as a result of human activities and environmental degradation through industrialization. It is therefore recommended that adequate monitoring and control of pollution within the River should be encouraged.

**Keywords**: Physio-chemical, pollution, water quality, Otammiri River.

## INTRODUCTION

Pollution is the presence in or introduction into the Environment of a substance which has harmful or poisonous effect, according to oxford dictionary. The water resources of our planet are the most threatened aspect in life existences. Present estimation of consumable water levels is placed at 1% with ground water levels also threatened by pollution (Davis and Cornwell 1991, Ekhaise and Anyasi 2005).

Otammiri River is among the major rivers found in Owerri, the capital of Imo state in southeastern Nigeria. As surface water in a developing country, and in accordance to NEST and UNEP (1991) (Oloyede et al., 2003), it may be predisposed to pollution due to high pollution growth and indiscriminate waste disposal. Some industries may also discharge their waste water into the river. The regular use of the river banks for agricultural activities can cause the washing of agrochemicals during heavy rainfall period into the river. Otammiri River serves as a source of domestic water to local population living along it's banks also, it is the sources of water to Owerri municipal water treatment plant and provide fishing ground to local communities (Victor et al., 2007).

River water quality monitoring is necessary in present day society, especially for rivers affected by urban effluent studies on water quality in to aquatic environment are still popular in the Evaluation and management of rivers Ecosystem in many countries. (Watts and Smith 1994; Njenga 2004). This is due to changes in water chemistry of rivers and drainages can be the results of domestic, industrial or agricultural discharges which may in turn lead to aquatic Ecosystem degradation (Pereire et al., 2007) such as deterioration of water quality in the rivers.

Therefore, the determination of physiochemical parameters of the water samples can acts a indicators of water pollution due to both natural and anthropogenic input (Amadi et al., 2010, Yisa and Jimoh 2010). According to (Tahri et al., 2005) the importance of the provision of potable water supply in any nation cannot be over emphasized with increasing population wealth and economic activities. Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizer and unsanitary conditions. In most towns in Nigeria with rivers passing through them, such rives have been converted into dump sites or latrines, with the consequence adverse effects on the health of the downstream users. In addition, once the surface water is contaminated, it's quality cannot be restored by stopping the pollutants from the source (Ramakrishnaiah et al., 2009). It therefore becomes imperative to regularly monitor the quality of the water and to device ways and means to protect it.

The physiochemical composition of surface water and it's properties in a particular region is basically governed by natural processes and human activities which can either be point or non-point sources. Human activities are a major factor determining the quality of surface water through atmospheric pollution, effluent discharges, use of chemicals and eroded soils. Also urban land uses create impervious surface resulting in storm runoff events that negatively affect stream ecosystems and water quality. (Sickman et al., 2007) was of the view that rivers in urban watershed with substantial urban land use experience increased inputs and varying compositions of organic matter

## METHODOLOGY

### STUDY AREA DESCRIPTION

Otammiri River is one of the main rivers in Imo State, Nigeria. The River takes it's name from "Otammiri", a deity who owns all the water that are called by it's name, and who is often the dominating god of Mbari house. It is located on latitude 50 23'N and 50 30'N and longitude 60 58'E and 70 04'E. The river runs south from Egbu pass Owerri and through Nekede, Ihiagwa, Eziobodo, Obowuumuisu, Mgbirichi and Umuagwo to Ozuzu in Etche Local Government Area of River State from where to flows to the Atlantic ocean. The length of the river form it's source to it's confluence at Emeabian with Uramiriukwa River is 30km. The Otammiri watershed covers about 10,000km2 with annual rainfall of 2250-2500mm.

The watershed is mostly covered by depleted rain forest vegetation, with mean temperature of 270C throughout the year (Ihenyen and Aghimien 2002). The Otamiri is joined by the Nworie River at Nekede in Owerri, a River about 9.2km in length.

Otamiri River is subject to intensive human and industrial activities and is used as a source of drinking water by some of the surrounding communities when the public water system fails. (Jones, 2012).

### 3.2 WATER SAMPLE COLLECTION

Surface water samples were collected from the Otammiri River. The samples were collected in a properly labeled 2 liter plastic can filled and tightly corked. Before filling the cans, each of the cans was rinsed with the sample water before collection. A total three (3) water sample were collected at three (3) different stations. The water sample in the plastic cans was labeled with a masking tape according to the respective stations where they were collected. i.e. Station A: (Emmanuel College refuse dump site), station B (Mechanic village), Station C (Nekede sand dredging site).

Parameters such as dissolved oxygen, biological oxygen demand, Alkalinity, turbidity, temperature, pH, total hardness, conductivity, total suspended solid, total dissolve solid, chloride, COD, nitrate, sulphate, odour, colour, total solid was analyzed in-situ and taken to the laboratory to determine the concentration of pollution on water quality.

### 3.3 PHYSIO-CHEMICAL PARAMETER MEASUREMENT

#### 3.3.1 DISSOLVED OXYGEN (DO)

Water sample for dissolved oxygen was collected in 250ml glass sampling bottles. The dissolved oxygen was determined using wrinkle's methods. The bottles were filled with water and cork under water, making sure that no air bubble was trapped in the bottle. The bottle was then carefully open and fixed in-situ with 1ml each of manganese sulphate and Alkali-iodide, sealed well and inverted thoroughly, and the precipitate was allowed to settle down described by (APHA, 2001).

**calculations**

1ml of 0.02N sodium thiosulphate = 0.2mg of oxygen

(0.2) (1000 ml of sodium thiosulphate)

Dissolved Oxygen =--200mg/

#### 3.3.2 BIOLOGICAL OXYGEN DEMAND (BOD)

The biological oxygen demand was determined using wrinkles method. The sample for BOD was collected in 250ml Amber sampling bottle and incubated in a dark polythene bag and transported to the laboratory. The sample was later fixed after 5days with 1ml of manganese sulphate and Alkali-iodide each, using a 10ml pipette. Sealed well and inverted thoroughly, and the precipitate was allowed to settle down, described by (APHA, 2001). The biological oxygen demand (BOD) was calculated by subtracting dissolved oxygen value BOD from DO (BOD-DO).

**ALKALINITY**

Acid titration method was used in the determination of alkalinity,.

**Calculation**

Alkalinity (mg $CaCO_3/1$) = volume N/50 acid (ML) 10.

**3.3.4 TEMPERATURE**

Water temperature was measured with mercury in glass thermometer, which was immersed into the water and allowed to assume the water temperature before reading. The value of the temperature was taken by switching the mode and was allowed to stabilize for three minutes before the value was recorded.

**3.3.5 pH (HYDROGEN ION CONCENTRATION)**

pH was determined using a pH meter (Jenway model 3505). The glasses electrode of the meter was immersed in the water and was allowed to stabilize for three minutes before the value was taken.

**3.3.6 TURBIDITY AND TRANSPARENCY.**

Turbidity was measured in-situ using seechi-disc, the seechi disc was lowered into the water at the respective sampling point. The depth at which it disappeared in the water (D1) was noted.

Likewise transparency; the secchi disc was lowered into the water at the respective sampling point. The visibility point of the disc was measure (D2) was noted. Thereafter with a meter rule and recorded also in meter (m).

**calculation**

Turbidity and transparency (secchi disc) = (D1-D2)

Where D1= Depth at which the secchi disc disappear

D2 = Depth at which the secchi disc appears

### 3.3.7 ELECTRIC CONDUCTIVITY

Electric conductivity was determined by using conductivity meter jenway 4505.the meter was dipped into the water sample and allowed to stay for two minutes before the readings were noted for a stable value expressed in micro-Siemens (μS/cm).

### 3.3.8 CHLORIDES ($Cl^-$)

Volumetric flask was used to measure 50ml of the sample and was poured into the conical flask. Automatic pipette was used to collect 1ml of 5% potassium dichromate and added to each of the sample, turning the solution yellow. Then silver nitrate was collected using 10ml of glass pipette and was titrated until a yellow colour turned to light brown thus signifying the end-point of titration.

**Calculation**

CL- = M X T X MA X 103 PPM

Aliquot (vol. of water sample used)

Where M =molarity of Agno3 =0.01

T = Titre value (vol. of Agno3 used)

MA = molar mass of chloride (35.5)

### TOTAL DISSOLVED SOLIDS (TDS)

The filter paper and a 250ml conical flask were dried in an oven at 500c for 3hours, after which they were placed in a dessicator to cool and then weighed separately. One hundred ml of water sample was filtered through the filter paper into the conical flask. The conical flask containing the water was then gently placed on a heated hot plate and left to evaporate to dryness until a constant weight was obtained. The filter paper was also dried in the oven at 500c until a constant weight was obtained; weights of the flask and the filter paper were recorded separately.

**Calculation**

Weight of empty conical flask =Ag

Weight of flask + sample =Bg

Weight of flask + residue =Cg

TDS =Bg –Ag x 100

Cg – Ag

**SULPHATE ($SO_4^{2-}$)**

One hundred ml of the sample was filtered into a nessler's tube containing 5ml of conditioning reagent (50ml of glycerol was mixed in a solution containing 30ml of concentrated hydrochloric acid, 30ml of distilled water(10% HCl), 100ml of 95% ethyl Alcohol or isopropyl and 75g Nacl. after which about 0.2g of barium chloride crystals was added with continued stirring. A working standard was prepared by taking 1ml of the give 100 NTU. The turbidity developed by the sample and the standards were measured using a nephelometer and the results were recorded.

**Calculation**

Sulphate = (Nephlometric reading x 0.4) mg/l

**NITRATE ($N0_3^-$)**

Nitrate was determined by brucine sulphanillic acid colorimetric method (APHA, 1989; ASTM, 1986).

**3.3.12 TOTAL HARDNESS ($ca^{2+}$ and $mg^{2+}$)**

Volumetric flask was used to measure 50ml of the sample and was poured into the conical flask. Automatic pipette was used to measure 2ml of ammonium buffer and was poured in each of the sample. Then 3drops of calcium and magnesium indicator was added into the sample and was shaked properly a purple colour was observed, 10ml glass pipette was used to collect EDTA and titrated until the colour turned from purple to blue.

**Calculation**

Mg =Titre for mg = Titre (A)- (B)

Ca or mg (mg/L) =Titre x 0.8

**CHEMICAL OXYGEN DEMAND (COD)**

Chemical oxygen demand (COD) was determined by close reflux titrimetric method (APHA, 1989; ASTM, 1986).

**Statistical Data analysis**

The SPSS was used to analyze the data obtained. Data collected from the water samples was analyzed statistically using one –way analysis of variance (ANOVA) at 0.05(5%) level of significance to verify the significance differences in the physiochemical parameters.

**RESULTS**

Table 1; shows the values of physio-chemical parameters and statistical data analysis of Otammiri River. While the line graph shows the concentration of physiochemical properties in different samples.

**TABLE 1: MEAN PHYSIOCHEMICAL PARAMETERS OF OTAMMIRI RIVER.**

| PARAMETERS | STATION A | STATION B | STATION C | WHO STANDARD (2003) |
|---|---|---|---|---|
| Alkalinity(mg/L) | $18.03\pm0.15^{e}_{c}$ | $26.03\pm0.09^{b}_{a}$ | $22.00\pm0.58^{c}_{b}$ | 600.00 |
| BOD (mg/L) | $5.03\pm0.09^{j}_{b}$ | $5.03\pm0.09^{j}_{b}$ | $5.73\pm0.18^{i}_{a}$ | 10.00 |
| Chloride (mg/L) | $10.00\pm0.0^{Lh}_{b}$ | $10.03\pm0.03^{h}_{b}$ | $11.61\pm0.01^{g}_{a}$ | 250.00 |
| COD (mg/L) | $22.03\pm0.09^{d}_{a}$ | $18.33\pm0.33^{d}_{c}$ | $20.00\pm0.29^{d}_{b}$ | 40.00 |
| DO (mg/L) | $15.62\pm0.03^{f}_{c}$ | $16.2\pm0.03^{e}_{b}$ | $16.73\pm0.16^{e}_{a}$ | 10.00 |
| Electrical Conductivity (µs/Cm) | $26.41\pm0.02^{c}_{b}$ | $24.00\pm0.01^{c}_{c}$ | $30.66\pm0.17^{a}_{a}$ | 100.00 |
| Nitrate(mg/L) | $1.03\pm0.00^{k}_{b}$ | $0.95\pm0.01^{k}_{c}$ | $1.27\pm0.01^{j}_{a}$ | 10.00 |
| Ph | $6.08\pm0.00^{i}_{b}$ | $6.12\pm0.00^{i}_{a}$ | $5.79\pm0.00^{i}_{c}$ | 6.5-8.50 |
| SO4 (mg/L) | $6.29\pm0.00^{i}_{b}$ | $5.35\pm0.01^{j}_{c}$ | $8.27\pm0.00^{h}_{a}$ | 400.00 |
| Temperature (0C) | $28.00\pm0.00^{b}_{a}$ | $28.00\pm0.00^{a}_{a}$ | $28.00\pm0.00^{b}_{a}$ | 20 -30 |
| Total dissolved Solids (mg/L) | $16.00\pm0.01^{f}_{ab}$ | $15.33\pm0.33^{f}_{b}$ | $16.67\pm0.33^{e}_{a}$ | 250.00 |
| Total Hardness (mg/L) | $32.03\pm0.09^{a}_{a}$ | $28.00\pm0.58^{a}_{b}$ | $20.00\pm0.06^{d}_{c}$ | 500.00 |
| Turbidity (NTU) | $15.00\pm0.58^{g}_{a}$ | $14.33\pm0.33^{g}_{ab}$ | $13.00\pm0.58^{f}_{b}$ | 50.00 |
| Odour | Rotten | Rotten | Fowl | ND |
| Colour | White | White | White | ND |

Values with different superscript on the same row & column are significantly different

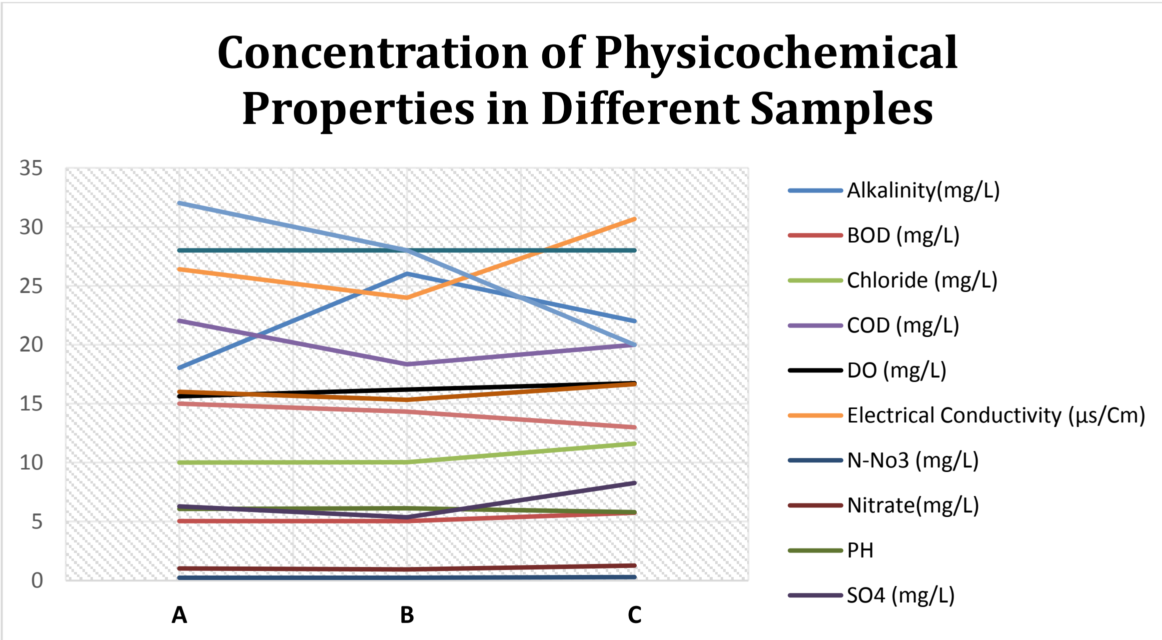
Ns = not significant

* = significant at Alpha

ND = Not detected

Values are means ± standard deviation of triplicate determination

Line graph




PHYSIOCHEMICAL PARAMETERS

**TEMPERATURE**

The temperature values of the three sampling stations had the same values 28.00±0.000c across the three stations.

**pH**

The ph values ranged between 5.79 -6.12.The highest ph value (6.12±0.00) was recorded in station B; while the least ph value (5.79±0.00) was recorded in station C.

**BIOLOGICAL OXYGEN DEMAND (BOD)**

The value of BOD range between 5.04mg/l and 5.73mg/l. The highest BOD value (5.74±0.18mg/l) was obtained in station C while the lowest value (5.03±0.09mg/l) was obtained in station A and B.

**DISSOLVED OXYGEN (DO)**

The analysis showed that dissolved oxygen concentration varied between 15.62mg/l and 16.73mg/l. The highest value of dissolved oxygen was recorded in station C (16.73±0.16mg/l) while the lowest value was recorded in station A (15.62±0.03mg/l).

**CHEMICAL OXYGEN DEMAND (COD)**

After the analysis, COD values ranged from 18.33mg/l and 22.03mg/l. The station which recorded the highest value of COD was station A (22.03±0.09mg/l) while station B had the lowest COD value (18.33±0.33mg/l).

**ELECTRICAL CONDUCTIVITY (EC)**

Electrical conductivity values of the water samples varied between 24.00µs/cm and 30.66µs/cm. Higher value was recorded in station C (30.66±0.17µs/cm) while the lowest value was recorded in station B (24.00±0.0.01µs/cm).

**TURBIDITY**

The turbidity values varied between 13.00cm and 15.00cm.The highest turbidity value was recorded in station A (15.00±0.58cm) while the lowest value was recorded in station C (13.00±0.58cm).

**TOTAL DISSOLVED SOLIDS (TDS)**

The TDS values varied between 15.33mg/l and 16.00mg/l. The highest value was recorded in station C (16.67±0.33mg/l) While the lowest value was recorded in station B (15.33±0.33mg/l).

**ALKALINITY**

Alkalinity values of the water samples taken varied from 18.03mg/l and 26.03mg/l. The highest value of alkalinity was recorded in station B (26.03±0.09mg/l) while the lowest value was recorded in station A (18.03±0.15mg/l).

**CHLORIDE ($Cl^-$) CONCENTRATION**

The chloride value of the water samples taken varied from 10.00mg/l and 11.61mg/l. The highest value was recorded in station C (11.61±0.15mg/l) while the lowest value was recorded in station A (10.00±0.0mg/l).

**TOTAL HARDNESS**

The Total hardness values varied from 20.00mg/l and 32.03mg/l. The highest value of total hardness was recorded in station A (32.03±0.09mg/l) while the lowest value was recorded in station C (20.00±0.06mg/l).

**SULPHATE ($SO_4^{2-}$) CONCENTRATION**

Sulphate values recorded ranged between 5.35mg/l and 8.27mg/l. Station C recorded the highest mean concentration of sulphate (8.27±0.00mg/l) while station B had the least concentration of sulphate (5.35±0.01mg/l).

**NITRATE CONCENTRATION**

The concentration of nitrate recorded ranged between 0.95mg/l. and 1.27mg/l. The highest nitrate value was recorded in station C (1.27±0.01mg/l) while station B had the least concentration of nitrate (0.95±0.01mg/l).

**DISCUSSION, CONCLUSION AND RECOMMENDATION**

**DISCUSSION**

The result of the physiochemical parameters carried out in Otammiri River as a case study here found to revealed that some of the water parameters were not within the permissible standard while few water parameter were within the permissible standard established by WHO (2003) of surface water. Good water quality monitoring is essential in the aquatic environment for the survival, growth and reproduction of aquatic life as well as humans who consume the aquatic organism and water.

**TEMPERATURE**

Being the degree of coldness or hotness of a substance and which affects the biochemical activities of aquatic organism was found to fluctuate 28.00oC across the three sampling stations. The value was within the acceptable levels of 20 – 30oc for survival, metabolism and physiology of aquatic organisms as stated by Afzal et al., (2007). The temperature range (28.00+0.00oC) increased significantly ($P < 0.05$) along the sampling points. The range falls within WHO standard. The temperature difference at any aquatic habitat is affected by weather, and the extent of shade from direct exposure to sunlight (Ekhaise and Anyasi 2005). Also, biodegradation of organic matter that enter the water, may increase heat. (Ekhaise and Anyasi 2005). The degree of temperature determines the type and species of aquatic organism that inhabits a particular water body. High temperatures causes thermal stratification and increased metabolic activities of organism and also affect the level of dissolved oxygen available in a given aquatic ecosystem (Akpan and Offem, 1993).

**HYDROGEN –ION CONCENTRATION (pH)**

Is the measure of acidity or alkalinity of a substance (potential hydrogen ion concentration) was recorded to range from 7.9±0.00 in station c to 6.12±0.00 in station B. the pH increase significantly ($P < 0.05$) along the sampling points and does not fall within WHO standard (6.5.±8.50) The observed pH range of this study are in line with the pH range earlier reported on the River by Ibe et al., (1990). The observed low pH in Otammiri River could be due to existence of compounds like chloride or iron or aluminium, which hydrolyze in excess water to produce solutions (Lewis acids) which may have affected the pH of the river (Ose, 1990). The values obtained from the sampling station show a moderate acidic condition in the river. According to (Oso and Fagbuaro, 2008; Morrison et al.,2001). severe changes in the pH values of the water bodies can have a drastic effect on aquatic life as these organisms have adapted to life in water of specific ph and even slight changes may result in death.

**DISSOLVED OXYGEN (DO)**

This plays a very important role in the aquatic environment, and serves as an indicator of the physical, chemical and biological activities of the water body was recorded to range from 15.62mg/l – 16.73mg/l, were higher than recommended WHO standard. Ukaga and Onyeka, (2002) stated that the desirable range of dissolved oxygen (DO) for normal fish growth is between 5.5 to 7.8mg/l hence the dissolved oxygen of Otammiri River may affect the growth of fish in the river. (DO) values recorded in this study are higher than those of Akaninwor and Egwim, (2006), Ekhaise and Anyasi (2005). This could be as a result of an increase in primary productivity by aquatic flora, that led to the release of oxygen during photosynthesis during the daytime, when dissolved oxygen in water is usually at it's peak. Generally the study was carried out during the rainy season, but some authors Hall et al., 1977 and Akpan, 1993) have argued that dissolve oxygen increase with increase in rainfall due to the increased current flow that enables the diffusion and mixing of atmospheric oxygen into the water. This might be the reason for the high value recorded.

**BIOLOGICAL OXYGEN DEMAND (BOD)**

It is defined as the amount of oxygen required to biologically break down a contaminant. BOD is a standard water treatment test for the presence of organic pollutants and directly shows that amount of degradable organic matter by microbial metabolism on the assumption that water medium has no bactericidal effect (Amadi et al., 1997). The BOD values recorded in this study were lower than recommended WHO standard (10.00). Moore and Moore, (1976) categorized BOD water values as 1-2mg/l for clean water, 2-3mg/L for fairly clean water, 4-5mg/L for fairly polluted water and 10mg/L for bad and polluted. The three sampling station of Otammiri River is fair polluted based on Moore, (1976).

**CHEMICAL OXYGEN DEMAND (COD)**

The chemical oxygen demand analysis results ranged between 18.33-22.03mg/L. the values recorded in the present study were lower than WHO standard (40.00). The station B has lower concentration of COD and this could be as a result of absence of Anthropogenic activities and also station A and C has a fairly polluted chemical oxygen demand. The COD determination provides a measure of the oxygen equivalent of the portion of organic matter in water that is susceptible to oxidation by a strong chemical oxidant. It determines the quantity of oxygen required for oxidation of organic and inorganic pollutant (Otukune and Biukwu, 2005). The low COD values obtained in this present study suggest that there is little organic and inorganic contaminants from dumpsite, agricultural and runoff. High COD in water is due to organic and inorganic contaminants from animal sources are entering the River. The decrease of the COD at the three sampling point could be as a result of the flushing action of the river according to Akaninwor and Egwim (2006) and Ekhaise and Anyasi (2005).

**ELECTRICAL CONDUCTIVITY**

This measures the water ability to conduct electric current and dissolved salts such as sodium chloride and potassium chloride mostly influence it. Conductivity values decrease significantly ($p<0.05$) along the sampling points. The observed values from the three sampling point are lower than WHO standard (100.00). According to Egborge, (1994) water with conductivity values below 1000µs/cm are classified fresh and those above 40,000µs/cm are marine and those between the two limits are considered brackish. This implies that the study area is a fresh water body. The values from the analysis shows a decrease in conductivity across the sampling stations and this decrease could be because of low ionic content of the water.

**TURBIDITY**

Turbidity values of the present study ranged between 13.00±0.5 -15.00±0.58 NTU. The values were lower than WHO standard and decrease significantly ($p<0.05$) along the sampling points. According to Obasi et al., (2004), the higher the turbidity value, the more energy and chemical is required to treat it and this could be attributed to the presence of organic matter pollution, other effluents, run off with high suspended particles and heavy rainfall (Chapman, 1996).

**TOTAL DISSOLVED SOLIDS (TDS)**

The TDS value obtained in this study was lower than the WHO standard (250.00). The values decreased significantly ($P < 0.05$) along the sampling point and are comparable to the values of Akaninwor and Egwim, (2006). The obtained values ranged from 15.33 ± 0.33 – 16.00 ± 0.01mg/L. maccutcheon et al., (1983) have indicated that the palatability of water with TDS level less than 600mg/l is considered good where as water with TDS level greater than 1200mg/L gets increasingly unpalatable. (Hagan et al, 2011). Nutrients are vital for the synthesis of organic materials by plants upon which all lives depends. The nutrient load of a river determines its richness or fertility. Sikoki and Veen, (2004) acknowledged constant changes in the concentration of substance present in a water body. All aquatic organisms require concentrations of these compounds to survive, reproduce and grow.

**ALKALINITY**

Total alkalinity values increased significantly ($p < 0.05$) along the sampling points but the values were lower than WHO standard. The increase could be attributed to the eroding of the soil with bicarbonate, carbonate or hydroxide compounds into the river (APHA 2005). The low alkalinity of Otammiri River, may also further support the soft nature of it's water as stated above. The observed values of total alkalinity in this study are comparable to those of Ibeh and Mbah (2007). The values ranged from 18.00 ± 0.15 – 26.03 ± 0.09mg/l.

**CHLORIDE ($CL^-$) CONCENTRATION**

Chloride values recorded in this study ranged between 10.00 ± 0.00 – 11.6 ± 0.01mg/l. The values were lower than WHO standard (250mg/L), though chloride contents in water are not harmful. Chloride concentration in excess of about 250mg/L, can give rise to detectable taste in water, although the threshold depends on associated cation (HACH, 1992). High chloride concentration in any body has a pronounced effects on the nitrate level of the water. This could be the reason for the low values of nitrate observed in the study as chloride value out weighs the nitrate value through the three sampling of the study. This high chloride concentration indicate that the river nitrate toxicity is reduced as it support ILMB, (1998). Suggestion of decrease in nitrate toxicity with increasing chloride concentration.

**SULPHATE ($SO_4^{2-}$) CONCENTRATION**

The sulphate results obtained had a minimum of 0.95mg/L and a miximum of 1.27mg/L and the result showed that sulphate concentration was low in Otammiri River. The observed values were lower than recommended WHO standard (400.00) and increased significantly ($p < 0.05$). The sulphate levels observed in Otammiri, may have entered the river from Agricultural land surrounding the river, since their levels in water reflects the influence of human activities like farming on lands surrounding a water body (APHA, 2005).

**TOTAL HARDNESS ($Ca^{2+}$ and $Mg^{2+}$) CONCENTRATION**

The total hardness values recorded showed a range of 20.00 ± 0.06mg/L – 32.03 ± 0.09mg/L respectively. The total water hardness values recorded from Otammiri water samples were lower than recommended WHO standard. Water with total hardness value of less than 15mg/L, is classified as a very soft water (Ray et al., 1992). Magnesium and calcium are the major cause of water hardness and a high concentration could have a laxative effect, especially on new users of the water (Bond et al., 1973), however it does not pose any health risks. Calcium plays an important role on the biological processes of aquatic organism including fish, as it is necessary for bone formation, blood clotting and other metabolic activities and since magnesium and calcium is lo its indicate that aquatic organisms health are at risk.

## CONCLUSION

This study reveals that almost all the physiochemical parameters of 0tammiri River were within the permissible surface water standard recommended by WHO (2003).The study of the physical and chemical qualities of a water body helps in adequate understanding of the Ecological status of the ecosystem, as the quality of water affects the composition, abundance, productivity and the physiological conditions of organisms (fish) of the aquatic ecosystem. The reduced level of nitrate concentration which is the parameters that induce nutrients, which further increase the primary production of the development is an indication that Otammiri River is not as a result of inflow of both agricultural, industrial waste and sewage discharge and other antropogenic activities in and around the river and not by algal bloom.

## RECOMMENDATION

To limit or control pollution of Otammiri River the following recommendations are made.

i. Farming activities near the river must be such that will not be done with artificial fertilizer. Those who want to engage in farming in the area must be meant to sign an undertaken not to use artificial fertilizer.
ii. Industries located close to the River should ensure that wastes are treated before releasing them into the river water.
iii. Government should ensure that no part of the River or it’s watershed should be used either by residents or industries to dump wastes.
iv. Adequate waste and sewage disposal methods should be employed and projects on water recycling should be adopted and funded by government.
v. Adequate and regular monitoring of the River quality should be encouraged by government through funding of research.
vi. Policies and regulations should be put in place with heavy punishment for offenders by government.
vii. Aquatic environmental managers should be employed or deployed to the area to enforce laws and management.

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