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Water Quality Study of Ontamiri River in Owerri, Nigeria

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Abstract:

Water quality levels of Otamiri river was studied to seek explanations for the variations of water quality indicators in the river and also tried to evaluate the influence of urban land use activities and season on the water quality. Water sampling and laboratory analyses were carried out using standard procedures to determine the concentrations of selected parameters in the sample. The data obtained ranged from 10.3 to 161.4 µohms/cm EC, 18.6 to 882.2mg/l TDS, 42.2 to 160.1mg/l total Hardness, 4.2 to 72.6mg/l NO_3^-, 0.8 to 5.6 PO_4, 38.1 to 189.6mg/l SO_4^{2-}, and 6.6 to 28.2mg/l Cl^-. Other results ranged from 2.7 to 5.1 mg/l DO, 2.3 to 18.1mg/l BOD_5, <0.02 to 0.09mg/l. Pb, <0.01 to 0.03 Cd, and 8.0 to 86.0Mpn/1000ml total coliform. There was significant difference (P=0.05) between the dry season and rainy season values, with dry season having higher levels. The results further showed that the midstream area that receive wastes from urban land use activities was polluted with parameters such as EC, NO_3^-, PO_4^-, Cl^-, DO, BOD, Pb, Cd and Total Coliform being higher than the permissible limit.

Keywords: Otamiri River, Water Quality, Seasonality, Owerri.

1.0 Introduction:

Water is an important constituent of biotic community, and it plays a significant role in the continuity of life due to its unique qualities (Pat, 1992; Kegley and Andrews, 1998; Narayana, 2009). Large quantity of water is needed for irrigation, power generation, recreation, industrial and municipal purposes. The largest water requirement is for municipal use but the standard of purity required for this purpose is quite different from that demanded for industrial and commercial use (Bhatia, 2009). Clean, fresh water is necessary for drinking, bathing, swimming, and food processing. Land uses generate physical, biological and chemical pollution that jeopardize water quality. Although some water pollution may occur naturally such as eroding stream banks, most water pollutants are the result of human activities (Daniels and Daniels, 2003; Akintola and Amadi, 2003). The impact of such polluted water on human health is quite enormous (Njoku and Osinlu, 2007; Chukwu, 2008).

In Owerri municipal council, Otamiri river and underground water supply from private boreholes are the main sources of water for domestic and other uses, especially when the public water supply becomes epileptic. Otamiri river drains areas of diverse geology, soils and land use, and like other surface water, the river is liable to pollution from atmospheres and also from the composition of the soils and rocks through which the surface basin filters down into rivers. In addition, pollution of the river can result from human activities such as urban agriculture, dumping of solid waste, and discharge of effluent from industries into the river. Since Owerri urban and its environs depend partly on water from Otamiri river for their domestic, uses, there is a need to assess the quality of the river water. Also of importance are the influence of urban land use activities and seasonal variation on the quality of the water.

2.0 Methodology:

2.1 Water Sampling:

Four areas A,B,C, and D were selected for sampling along the river (fig.1) Area A is upstream and close to the source, and also acts as control. Areas B and C are in the midstream and are the areas where urban land use activities has greater impact. Section D is downstream with lesser land use impact. The sampling was carried out in both dry season and rainy season. Four clean plastic containers of a litre capacity were used in collecting the samples. This was done by first rinsing the containers with the river water before collection. Each sample was immediately covered and labeled before preserving them at low temperature of 4^{o}C using ice chest.

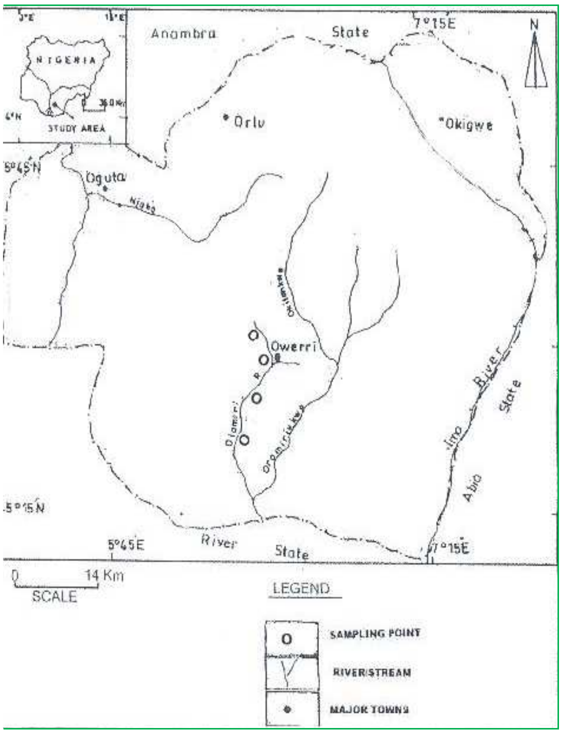

Fig. 1: Map of Imo State showing drainage patterns and sampling locations.

2.2 Laboratory Analysis:

Standard analytical procedures were used in the determination of selected physical, chemical and biological water quality parameters of the sample. A mercury thermometer with calibration 0-100^{o}c was used to measure the temperature of the water samples. The turbidity was measured using the ranch laboratory turbidity meter (2100 A model). The values were recorded after standardization (Vogel, 1961 and Franson, 1975). The pH was determined using electronic pH meter (Jaiswal, 2003). EDTA titrametric method (Vogel, 1961) was used to determine the hardness of the samples. The total dissolved solid (TDS) was determined by the procedure described by APHA (1995) while the total suspended solids (TSS) was measured by gravimetric method. A self-contained conductivity bridge with suitable conductance cell was used in measuring electrical conductivity. Nitrate was determined using the phenol di-sulphuric acid method (APHA, 1995) while phosphate determination involved two steps: conversion of a given phosphate form into soluble orthophosphate and colorimetric determination of the later (Ettre and Snell, 1971). Sulphate concentration was measured by turbidimetric method according to Tabatabai (1974). The chloride in the samples was determined by the Argentometric method. Alkalimity was also determined by titration method (APHA, 1995). Dissolved oxygen (DO) was measured by titrametric method while biological oxygen demand (BOD) was determined by first incubating the sample for 5 days in a BOD bottle, the BOD is then determined by measuring the DO of the sample before and after the five day incubation. The atomic absorption spectrophotometery procedure was employed in determing the following metals; Ca, Mg, Pb and Cd. The method used to determine the total coliform count was the membrane filter technique according to Eltre and Snell (1971).

3.0 Results and Discussion:

The results of the physical, chemical and microbiological analysis carried out on the various water samples are shown in tables 1 and 2, and figures 2 to 11.

Table 1: Concentrations of Otamiri Water Quality Parameters in the Dry Season.

Parameter	A	B	C	D	WHO STD
Temperature (^{O}C)	31.41	31.90	30.60	32.20	<40
Turbidity (NTU)	4.8	22.4	16.1	10.3	5.0
Conductivity (µohms/cm)	10.3	161.4	115.1	72.6	100
pH	6.6	6.4	6.3	6.5	6.0 – 8.5
Dissolved Solids (Mg/l)	18.6	882.2	609.0	217.3	2000
Total Hardness (Mg/l)	42.2	160.1	102.1	75.3	500
Calcium Hardness (Mg/l)	38.6	153.5	97.5	69.4	NS
Magnesium Hardness (Mg/l)	3.6	6.6	5.4	4.7	NS
Calcium (Mg/l)	5.6	17.3	12.6	8.4	75 – 200
Magnesium (Mg/l)	4.4	4.9	3.6	2.9	30 – 150
Nitrate (Mg/l)	4.2	72.6	56.3	38.1	10
Phosphate (Mg/l)	0.6	5.6	2.3	0.9	0.1
Sulphate (Mg.l)	38.1	189.6	102.8	60.3	200
Chloride (Mg/l)	6.6	28.2	19.3	13.6	1.0
Alkalinity (Mg/l Ca CO_3)	10.5	50.4	38.1	22.3	NS
Dissolved Oxygen (Mg/l)	5.1	2.7	3.1	3.4	NS
BOD_5 (Mg/l)	3.3	22.1	16.4	8.3	4.0
Lead (Mg/l)	ND	0.09	0.06	0.02	0.05
Cadmium (Mg/l)	ND	0.03	0.02	0.01	NS
Total Coliform (Mpn/100ml)	4.0	25.0	12.0	8.0	NS

Ns = Not Specified, Nd = Not Detected

Table 2: Concentrations of Otamiri Water Quality Parameters in the rainy Season

Parameter	A	B	C	D	STD
Temperature (^{O}C)	27.4	27.1	27.6	27.8	< 40
Turbidity (NTU)	2.5	96.2	64.3	47.1	5.0
Conductivity (µohms/cm)	6.2	141.3	82.6	51.01	100
pH	6.4	6.5	6.3	6.4	6.0 – 8.5
Dissolved Solids (Mg/l)	16.5	268.7	179.9	86.7	2000
Total Hardness (Mg/l)	22.3	85.9	50.4	38.4	500
Calcium Hardness (Mg/l)	18.2	76.6	38.1	34.4	NS
Magnesium Hardness (Mg/l)	4.1	9.3	12.3	4.0	NS
Calcium (Mg/l)	3.1	11.4	7.6	5.6	50
Magnesium (Mg/l)	2.4	4.1	3.6	2.8	0.3
Nitrate (Mg/l)	3.2	55.3	40.6	26.1	10
Phosphate (Mg/l)	0.4	2.1	1.3	0.4	0.1
Sulphate (Mg/l)	16.1	62.4	41.1	32.3	200
Chloride (Mg/l)	4.3	19.2	1.4	8.1	1.0
Alkalinity (Mg/l Ca CO_3)	2.4	30.3	18.4	12.1	NS
Dissolved Oxygen (Mg/l)	6.8	2.1	3.5	3.8	NS
BOD_5 (Mg/l)	1.8	15.2	10.3	7.4	4.0
Lead (Mg/l)	ND	0.06	0.04	0.01	0.05
Cadmium (Mg/l)	0.01	0.02	0.01	ND	0.01
Total Coliform (Mpn/100ml)	8.0	62.0	41.0	22.0	1.0

Ns = Not Specified, Nd = Not Detected

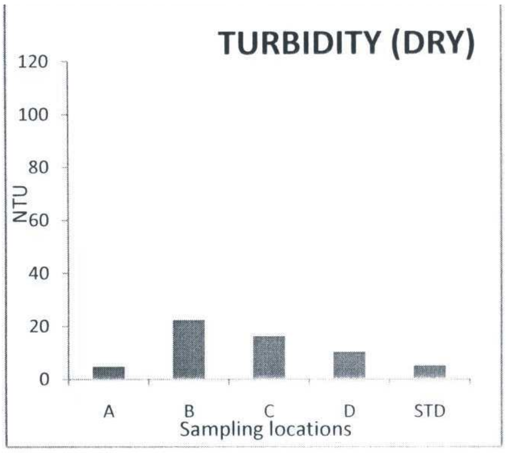

Fig. 2 Turbidity compared with standard (Dry Season)

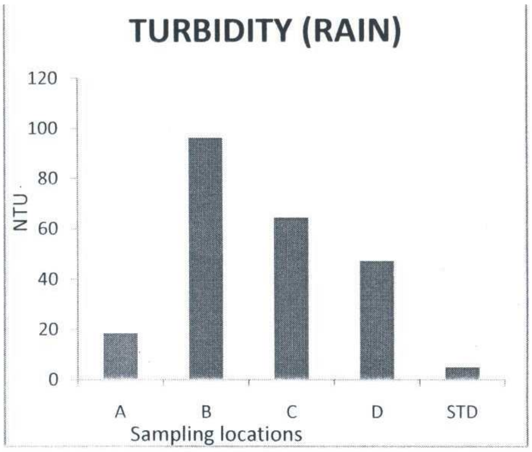

Fig. 3 Turbidity compared with standard (Rainy Season)

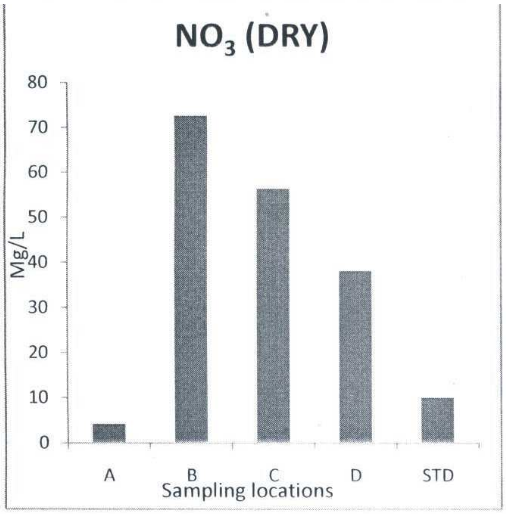

Fig. 4 Levels of NO_3 compared with standard (Dry Season)

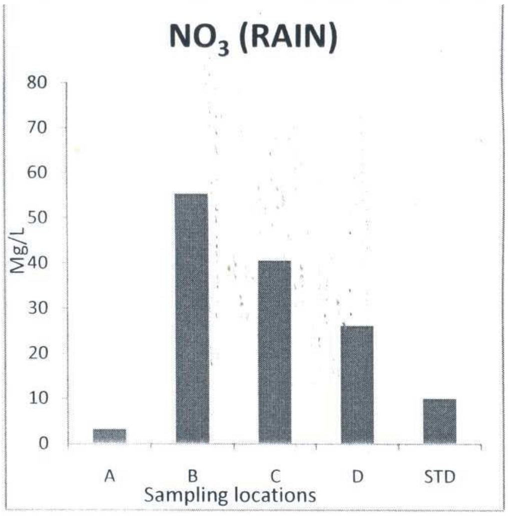

Fig. 5 Levels of NO_3 compared with standard (Rainy Season)

The concentrations of the various water quality parameters varied with the sampling locations and seasons. There was a significant difference (P=0.05) between the dry season and rainy season temperature with the dry season having higher values. The higher temperature observed during the dry season could be attributed to the sampling period (hot dry season). Temperatures levels are higher in the dry season than other seasons because of higher air temperature (Ajayi and Osibanjo, 1984). Higher temperature makes metal more toxic to aquatic life, and it affects the ability of water to hold oxygen. Also growth of microorganisms, taste, odour, colour and corrosion problems may increase (Ezemonye, 2009). The lower temperature determined during the rainy season agrees with the temperature values of some rivers in Southern Nigeria (Bielonwu, 2005). Low water temperature has the effect of decreasing the efficiency of treatment process (Park, 2009). Turbidity values were higher during the rainy season than the dry season. This was probably due to solid waste material and soil particles transported by runoff from urban activities into the river. Locations B and C (midstream) had significantly (P=0.05) higher values than other locations in both seasons because these are the areas that are contiguous to the urban area and receive direct impact of urban activities such as dumping of solid wastes and sand excavation from the river. The values from locations B and C were higher than the standard limit for drinking water. Turbidity affects fish and aquatic life by interfering with sunlight penetration (Park, 2009). He was also of the view that drinking water should be free from turbidity on aesthetic grounds.

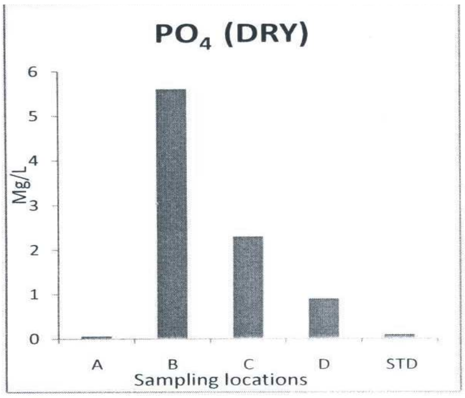

Fig. 6 Levels of PO_3 compared with standard (Dry Season)

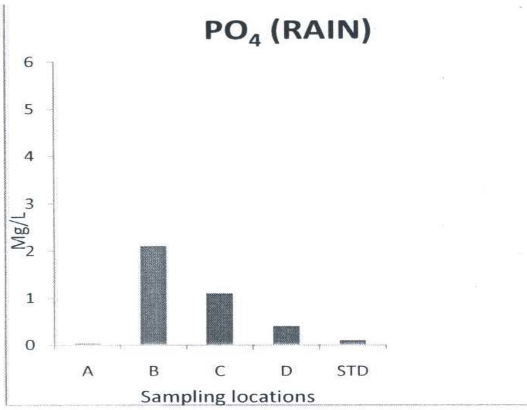

Fig. 7 Levels of PO_3 compared with standard (Rainy Season)

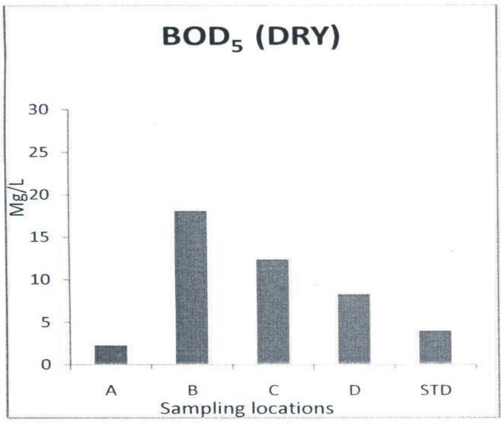

Fig. 8 BOD_5 compared with standard (Dry Season)

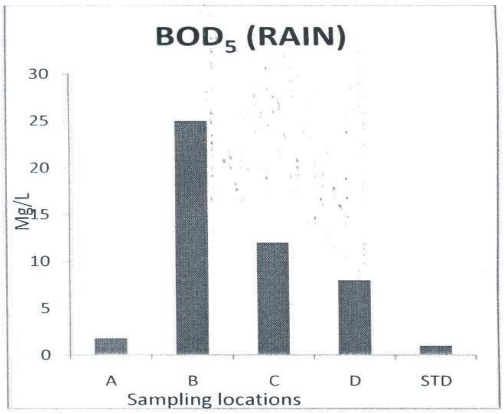

Fig. 9 BOD_5 compared with standard (Rainy Season)

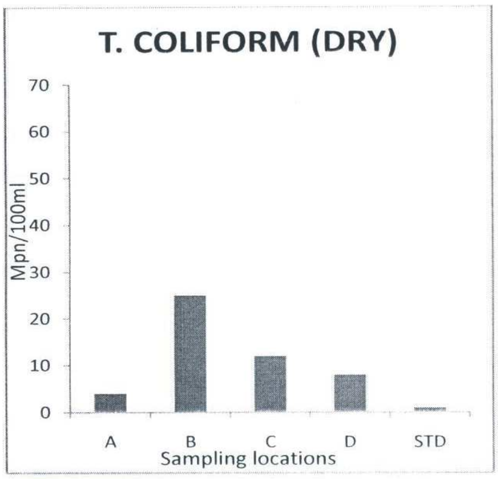

Fig. 10 Total Coliform Count compared with standard (Dry Season)

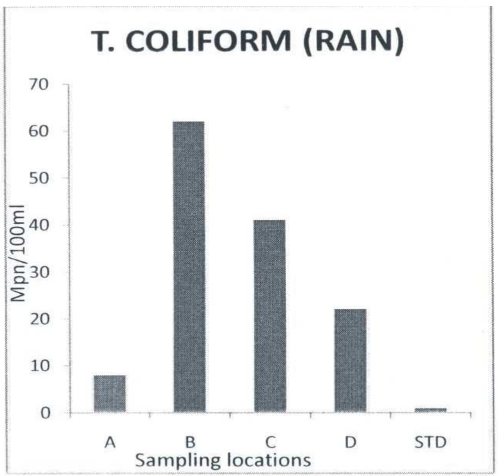

Fig. 11 Total Coliform Count compared with standard (Rainy Season)

Electrical conductivity values for the dry season were significantly (P=0.05) higher than the values for the rainy season. Similarly, the values for locations B and C were significantly (P=0.05) higher than values for locations A and D (upstream and downstream respectively). The dry season values for locations B and C were higher than the standard limit of 100 (μhms/cm) The higher values observed during the dry season could be as result of the influence of season; dry season is characterized by low precipitation, higher atmospheric temperature and evaporation (Ideriah et al., 2010). The high conductivity values for locations B and C was probably due to the impact of dissolved substances from municipal wastes dumped into the river, and also industrial effluent channeled into the water body. Other contributing factors are high turbidity and extent of mineralization. The total dissolved solids varied spatially and temporally. Dry season concentrations were significantly (p=0.05) higher than the rainy season values. The TDS values for both seasons were within permissible limit, except for locations B and C where the dry season samples were higher than the limit (500g/l) recommended for drinking water. Water samples from these areas can only be used for domestic animals such as poultry, pigs and cattle that have higher TDS limits. The relatively high TDS values for locations B and C observed during the dry season could be attributed to the impact of bridge construction and sand excavation activities around the area, that stir sediments and introduce soil particles into the river. TDS can have an important effect on taste of drinking water. Drinking water becomes increasing unpalatable at TDS levels greater than 1200mg/l (Park, 2009). In addition, the presence of high level of TDS may also be objectionable to consumers due to excessive scaling in water pipes, heaters, boiler and household appliance (WHO, 2004; and Park, 2009).

The mean pH value of the dry season water samples (6.5) and rainy season (6.4) fell within the stipulated limits of 6.0 – 8.5 for drinking water. Although the dry period had slightly higher values, the difference between the two seasons was not significant (P=0.05). However, the range of pH values observed in the study area is lower than the range reported for some Nigeria rivers such as River Asa (6.8 – 8.9) (Adenji, 1990); river Kaduna 6.4 – 7.2. The lower pH values obtained in the study area could be linked to the predominant soil type in the river (Adeniji, 1978) or probably due to built-up of organic material. As organic substance decay, carbon dioxide forms and combines with water to produce weak acid "carbonic" acid. Some fish cannot tolerate low pH (USEPA, 1976), and pH has synergistic effect on heavy metal toxicity. Total hardness values for both dry and rainy seasons fell within the limit of 500mg/l. Thus the water will not precipitate soap and the deposition of scale and incrustations accumulating in containers will be highly minimized. Nitrate concentrations varied with the sampling locations. It was below 10mg/l limit at location A (upstream), but above the limits at locations B and C (midstream) and D (downstream). There was significant difference (P=0.05) between the seasonal values, with dry seasons having higher values than the rainy season. This agrees with the findings of Ideriah et al. (2010) and they attribute it to the reduction of water volume in the dry season, and the dilution effect in the rainy season. Locations B, C and D had higher values above the limit probably because these are the areas impacted by wastes dumped directly or transported by runoff water into the river. It could also be influence from the effect of diffused NO_3 fertilizer used in urban agriculture.

The implications of river waters having high $N0_3$ concentrations is the stimulation of the growth of plankton and water weeds that provide food for fish. If algae grow too widely, oxygen levels will be reduced and fish will die. Park (2009) adds also that the guideline value for nitrate in drinking water is solely to prevent metamolobinaemia, which depends upon the conversion of nitrate to nitrite. The PO_4^- levels varied along the sampling locations with areas close to the source of the river (A) having lower values than the midstream (B and C) and downstream (D). The range of values obtained in this study agrees with the moderate to high levels of PO_4^- in Southern Nigeria rivers. For examples, Egborge et al. (1994) recorded a range of phosphate value of 0.01 – 7.40mg/l for Yelwa river in Southern Nigeria. However, all the values were higher than the permissible limit of 0.1mg/l. There was significant difference (P=0.05) between the means of the dry and rainy seasons values. The dry season had higher values probably due to the influence of high temperature which encouraged evaporation and reduction of water volume and increase in concentration. Another factor that could contribute to this phenomenon is the input of PO_4 from detergents used in various car wash centres close to the river. Although phosphates are not toxic and do not represent a direct treat to animals and other organisms, they do represent a serious indirect threat to water quality (Dhameja, 2005).

The general concentrations of SO_4^{2-} from this study were within the 200mg/l limit. However, there was significant difference (P=0.05) between the dry and rainy seasons values. Also the levels vary along the sampling points with the midstream having the highest values. Sources of $SO4^{2-}$ to the water could be from effluents from industries, runoffs, dumpsites and organic matter decomposition. When compared with the data from other studies in Southern Nigeria, the present findings show some variations. For example, Okoro (1997) reported a range of 60-1425mg/l while Survicom Services Nigeria Limited (2002) obtained value ranging from 0.16-1.81mg/l. These variations could be a reflection of the type of land use activities in the study areas. Bouwer (1978) reports that sulphate concentrations in drinking water should not exceed 250mg/l because the water will have a bitter taste and can produce laxative effects at higher levels. Chloride concentration was generally below the permissible limit (250mg/l) for both dry and rainy seasons. Although there were inputs of pollutants from municipal wastes into the river, the level was not high enough to significantly increase chloride level above the limit. Thus, the negative impact of high concentration of chloride in water such as causing canned or frozen food to taste "funny", killing of aquatic lives and giving salty taste to water will not be experienced.

Alkalinity measure the substances in water that have "acid-neutralizing" ability, or the capacity of the water to neutralize acid (Bouwer, 1978). It indicates a solution's power to react with acid and "buffer" its pH. Data from this study show that the level of alkalinity of the water samples were within the stipulate limit of 200mg/l, despite the temporal and spatial variations of the values. The low level of the parameter indicates that the underlying rocks which is the main source of natural alkalinity, probably contains low carbonate, biocarbonate, and hydroxide (Dhameja, 2012). Otamiri river water would therefore not have bitter taste and precipitate on pipes resulting from reaction between alkalinity and certain cations. The levels of Ca^{2+} and Mg^{2+} in the dry season were significantly (P=0.05) higher than the concentrations of rainy season samples. However, all the values were within stipulated limit of 75mg/l for Ca^{2+} and 30mg/l for mg^{2+}. By Freeze and Cherry (1979) classifications, the water samples were soft. The higher values obtained during the dry season agrees with the findings of Geolink Service Limited (1995) on Etelebou Field Review in Southern Nigeria, but disagrees with the result of Ideriah et al. (2010). On the distribution and availability of the basic cations in water, Agunwamba (2000) reported that Ca^{2+} is commonly present in all waters and produced through leaching of rocks while mg^{2+} is less available probably due to lower quantity of it found in the earth's crust. The result of the present study followed a similar trend.

Lead concentrations were within the standard guideline in samples from locations A and D, upstream and downstream respectively. While the levels in samples from locations B and C (midstream) were higher than the limit. High values of lead in samples from locations B and C reflect the proximity of the areas to urban and industrial centres. Traces of lead and other heavy metals have been identified as deleterious to aquatic ecosystem and human health (Bhatia, 2009). The dissolved oxygen (DO) varied between sampling locations and with the seasons. Location A (upstream) had DO values within the limit (4-10mg/l). This indicates less organic waste input which provides conducive environment for aquatic life. The midstream, locations B and C however had relatively lower DO values. This could be attributed to impact of municipal wastes dumped in the river directly or through runoff. Microbial breakdown of the organic material leads to higher DO utilization and reduction. Downstream the river (location D), the level of DO was higher than the values for the midstream. This was probably because of self purification of the water body which reduced the amount of organic waste in the river. Rainy season values were significantly higher than that of dry season for location A. This probably was as a result of the influence of temperature on oxygen dissolution. The finding agrees with the report of Obunwo (2003). Similarly, seasonal values from location D followed same trend of having higher values in the rainy season. On the contrary however, locations B and C had values significantly (P=0.05) higher in the dry season than the rainy season and this could be attributed to the effect of biodegradation of waste on 0_2 level.

The BOD values from all the locations were higher than 4.0mg/l standard limit, except for values from location A (upstream) which is within standard. The BOD of 2.3-18.12mg/l (dry season) and 2.01-

15.21mg/l (rainy season) obtained from the present study were lower than values reported by Servicon Services Nigeria Limited (2002) in Imo River, and Ajayi and Osibanjo (1984) in New Calabar River. Based on the values of the BOD reported in the midstream (locations B and C) and downstream (location D), water in these areas can be classified as polluted. Because the oxygen demand probably exceeded the available oxygen. The demand for oxygen is directly proportional to the amount of oxygen waste materials that are to be broken down (Dhameja, 2005). Water in the study area varied in their microbial quality especially the coliform group. The values were higher in the midstream and downstream but low in the upstream. This variation was probably due to the level of municipal wastes received by the respective areas. Similarly, there was significant difference (P=0.05) between the dry season and rainy season bacterial count, with the rainy season having higher values. This agrees with the report of Crowther et al. (2001) and Kistemann et al. (2002) that there were significant increases in organic and bacterial load after a rain storm. All the locations had total coliform count higher than the permissible limit of 0-2mpn/100ml and could be considered polluted. Bacteria polluted water causes both in humans and animals numerous water borne diseases, either as a result of ingestion or direct contact, or inhalation of aerosols generated by contaminated water.

4.0 Conclusion:

Many rivers draining urban environment are negatively impacted by various land use activities in the area. This study demonstrates the influence of urban land use and season on water quality indicators of Otamiri river. The data clearing show that areas outside the influence of urban activities (location A) still maintain their pristine environmental conditions with water quality parameters falling within permissible limits. The water from these areas can sustain aquatic life and are safe for human consumption. However, areas affected by inputs from urban activities (locations B and C) were polluted, and parameters such as TDS, DO, BOD, Coliform count, and Pb having values above stipulated standards. Water in these affected areas is not potable and are harmful to the aquatic ecosystem. A management plan to restrict the dumping of wastes into the Otamiri river is needed in order to reduce the impact on water quality and pollution-related health problems. This can be achieved through effective waste management strategy and provision of reliable public water supply.

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