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Impact Evaluation of Urbanization on River Ona in Eleyele Catchment, Ibadan, Nigeria

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Strictly as per the compliance and regulations of:

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Keywords: assessment, water quality, parameters, standards, long term effects.

I. Introduction

The impact of urbanization and human activities on surface water quality has received a considerable amount of attention in the recent times (Varis, 1998; Vakkilainen and Varis, 1999; ENCARTA, 2001). Urbanization leads to increase in population and proliferation of industries with consequent increase in waste generations, effluent discharges, which eventually find self streamed into a water body through erosion. This could, however, lead to increased cases of waterborne diseases and heavy metal's toxicity in humans (Swerdlow et al., 1992; Besser et al., 1995). In urban and suburban areas, much of the land surface is covered by buildings and pavement, which do not allow rain to soak into the ground. Instead, most developed areas rely on storm drains to carry large amounts of runoff from roofs and paved areas to nearby waterways. The storm-water runoff carries pollutants such as oil, dirts, chemicals, and lawn fertilizers directly into streams and rivers, where they seriously harm water quality (EPA, 2003). These activities, therefore, affect the physical process of river growth, modify stream structure and further influence the functions of river system (Yuan et al., 2006). According to Strahler and Strahler (1973), whenever there's a rainfall, varieties of ions from atmosphere and land surfaces are deposited into surface and ground waters resulting into pollution. The vulnerability of surface water and sometimes groundwater to ecological degradation depends on a combination natural landscape features, such as geology, topography, soils, climate and atmospheric contributions; human activities related to different land use and land management practices. WHO reported that the pollution of surface and underground water spreading across the world could be attributed to population expansion, rapid urbanization, industrial and technological expansion that often leads to generation of enormous wastes from domestic and industrial sources (Fawole et al., 2008). This research work aimed at evaluating the long term-effect of urbanization on water quality of River Ona along Eleyele catchments.

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II. Materials and Methods

a) Description of the Study Area

Eleyele catchment's area is located in Ibadan the capital of Oyo State (Fig. 1). Ibadan is located between latitude 7° 20' N – 7° 25' N and longitude 3° 51' E – 3° 56' E. River Ona is dammed at Eleyele creating a reservoir. There are two streams (one of which takes its source from the north of the International Institute of Tropical Agriculture (IITA) and flows through the Institute, while the other takes its source from the south east of IITA, and form a confluence at Ojoo area and then flows into the reservoir at Eleyele (Fig. 1). The River is also abstracted by the Oyo States Water Corporation at Eleyele Treatment Works for treatment and supply of potable water to Ibadan's people. Ibadan is the largest city in West Africa and the second largest in Africa, with land size covering an area of 240 km^2 (Filani, 1994). Ibadan is a major transit point between the coast and areas to the north. It is inhabited by the Yoruba speaking people of Nigeria, and it is the centre of trade for a farming area producing cocoa, palm oil, yams, cassava,

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corn and fruits. Industries in Ibadan city include- the processing of agricultural products, brewing, vehicle assembly, and the manufacture of cigarettes. The city is the site of several major research institutes like International Institute of Tropical Agriculture (IITA), Cocoa Research Institute (CRI), Forestry Research Institute (FRI), National Horticultural Research Institute (NHRI), and Nigerian Institute of Social and Economic Research (NISER). Most of Nigeria's leading publishing companies are based in the city. Ibadan is drained by two major rivers: River Ona and River Ogunpa with the River Ona located in Eleyele catchment (Figure 1). River Ona has a total area of 2,148,617.61 km^2 while Eleyele catchment area has a total land area of 323 km^2 (GKW, 2003).

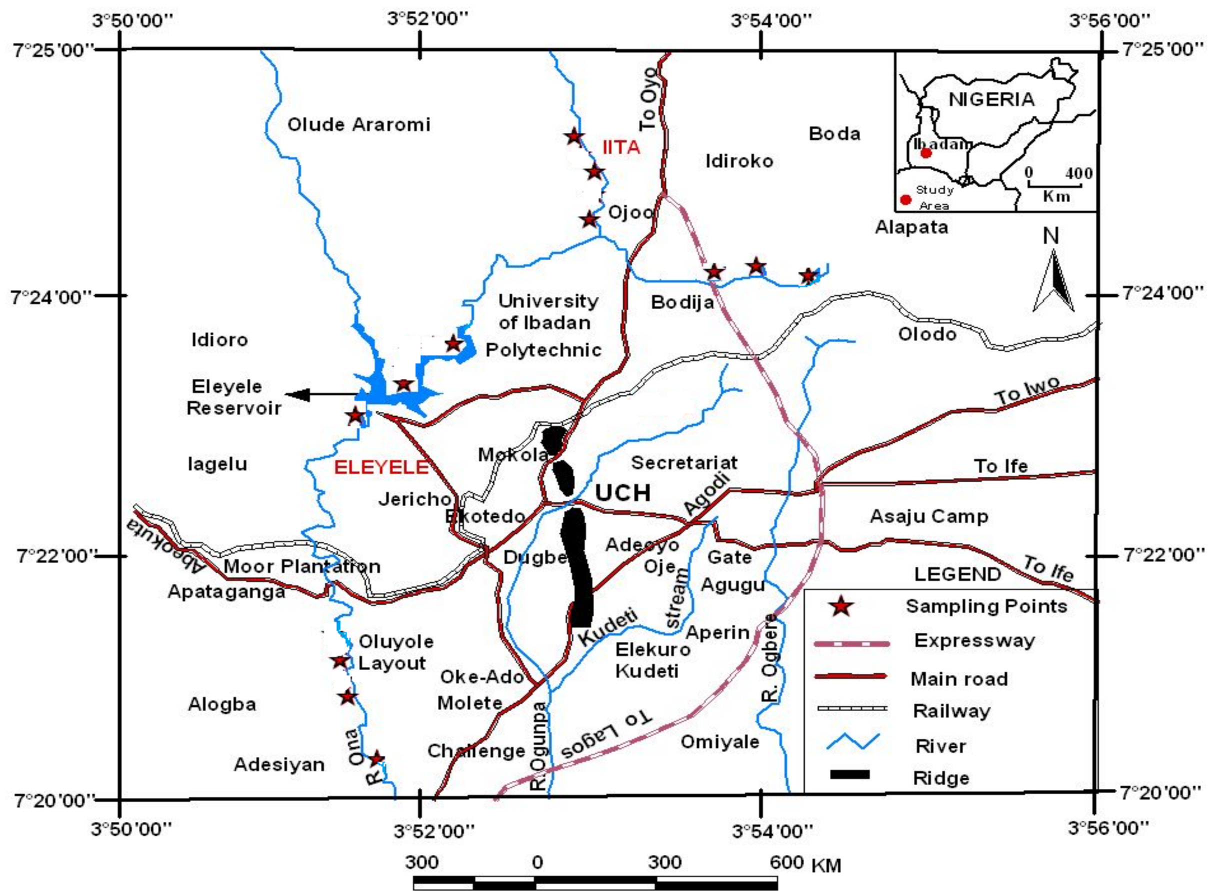


Figure 1 : The map showing the sampling locations.

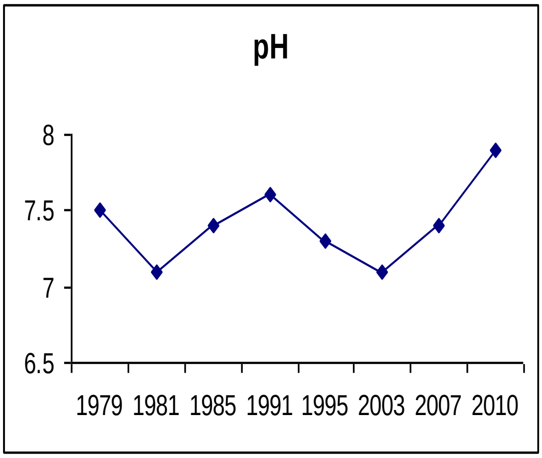
b) Methodology

Fifteen water samples were collected from four sampling sites (stream besides IITA, Bodija, Eleyele reservoir and River Ona) as shown in Figure 1. Water samples were also collected at Eleyele Water Works. The samples were analyzed for temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, acidity, total hardness, total alkalinity, Ca, Mg, Na, Cl^-, NO_3^-, SO_4^{2-}, Cu, Cr, Ni, Pb, Cd, Zn, Mn and Fe. Temperature was determined with the aid mercury in glass thermometer while the pH/TDS/EC meter was used to determine the values of pH, TDS, and electrical conductivity. Total hardness and chloride were measured by titrimetry (APHA, 1989). Total alkalinity was determined using the Alkalinity Test Kit (HI3811) while turbidity was determined with the aid of electric operated DRT 100B HF Scientific Turbidimeter. Sulphate and nitrate were analyzed by turbidimetry and sodium-salicylate methods respectively (Ademoroti, 1996). Samples for cations' determination were digested by addition of 2 ml concentrated HCl into 100 ml of the sample after which the samples were heated for 30 minutes. The samples were then allowed to cool, filtered and were made up to the 100 ml mark with of distilled water. Digested samples were analyzed using Atomic Absorption Spectrophotometer (AAS) for Cu, Cr, Ni, Pb, Cd, Zn, Mn and Fe respectively while Na and K was determined using a flame photometer.

Water quality data of River Ona from 1979-2007 were collected from Oyo State Water Corporation. These data were plotted along with the field data collected in 2010 for a true picture of long-term effect urbanization on the study River.

III. Results and Discussion

The impacts of long- effect urbanization (1979-2010) on River Ona water quality were shown in Fig. 2 (a-j). pH values ranged from.5 – 8.0, temperature, 26-29 °C, total solids (TS), 200-300 mg/L, dissolved oxygen, 1.06-8.0 mg/L, total alkalinity (TA), 90-130 mg/L, total hardness (TA), 70-100 mg/L, calcium, 20-60 mg/L, chloride, 5.0-120 mg/L, iron, 0.0-2.0 mg/L, and nitrate, 1.0-40.0 mg/L. Table 1 and 2 showed the results of physico-chemical parameters of the River from different sampling points in 2010. These field analyses were complimentary to the results of water parameters collected from Eleyele water works.



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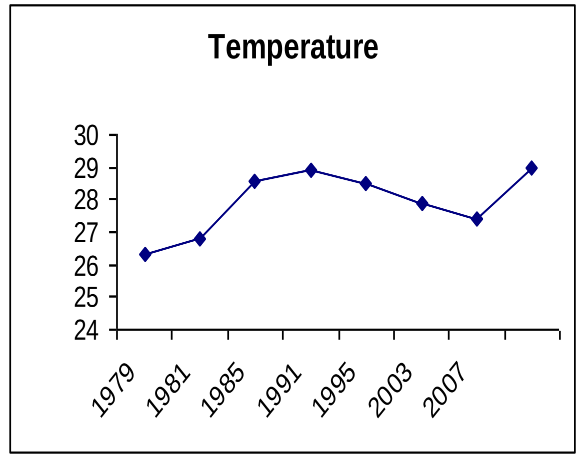

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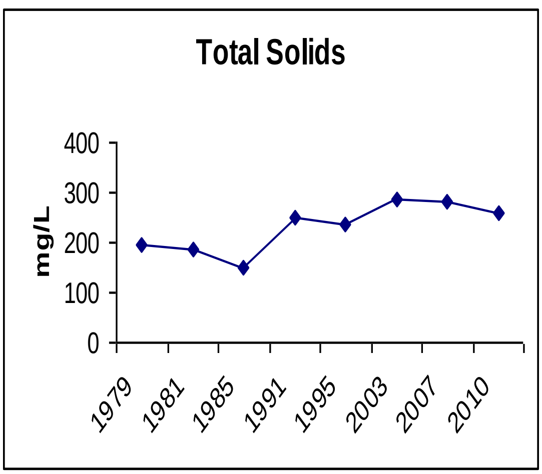

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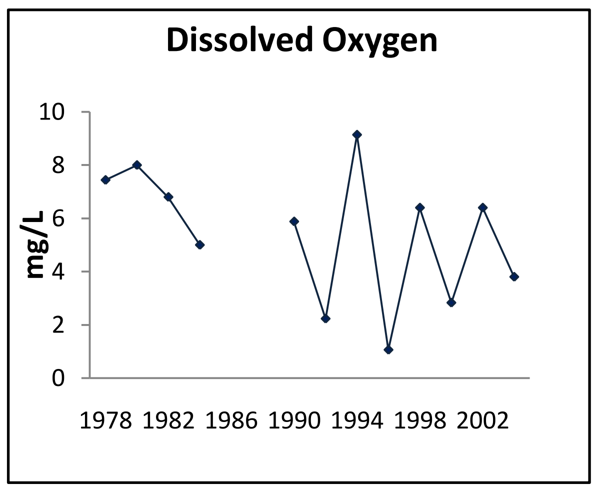

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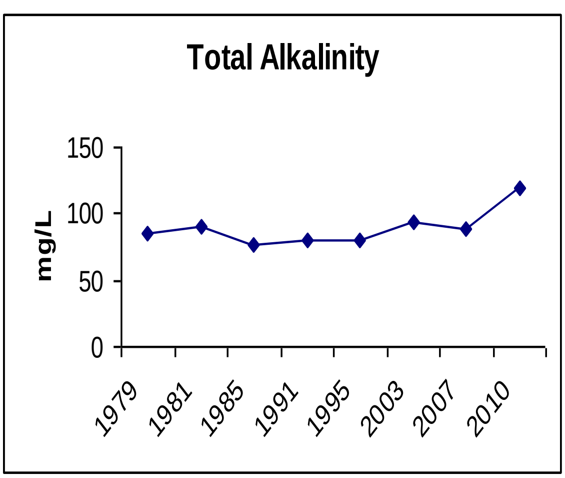

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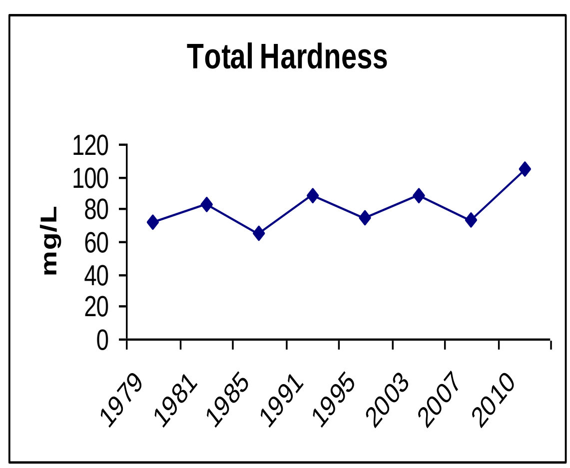

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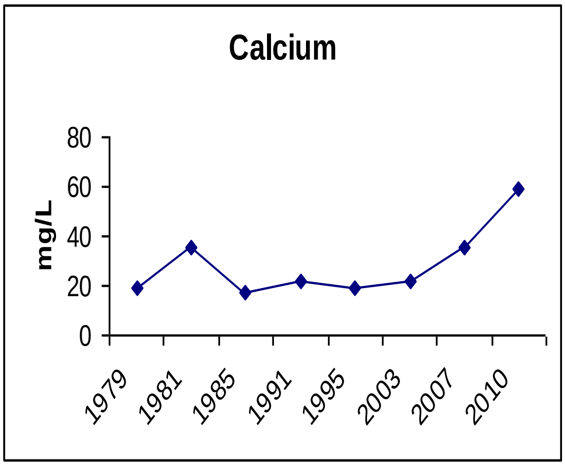

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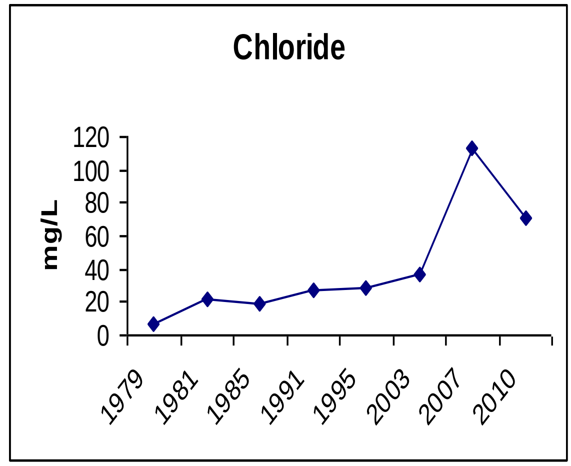

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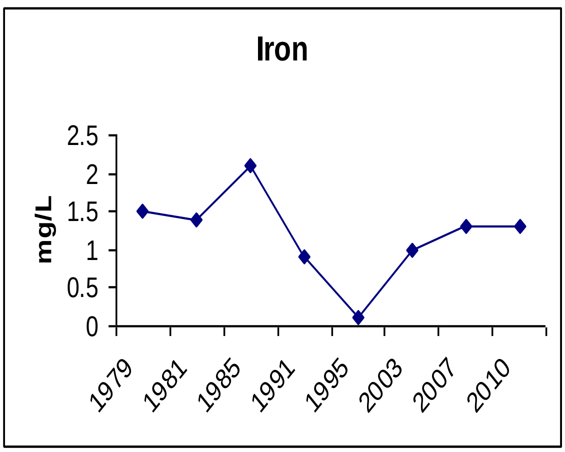

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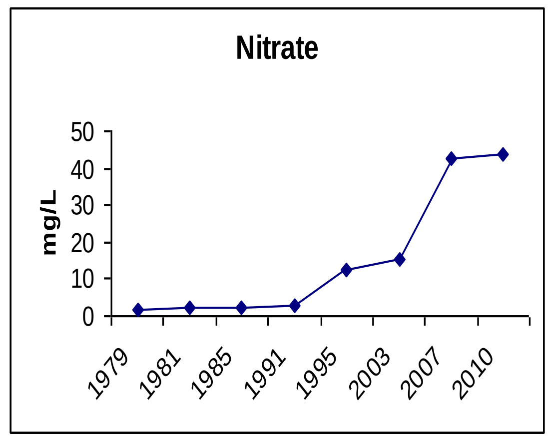

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Fig. 2 : Long-term Impact of urbanization on River Ona water quality.

Table 1 : Some measured water quality parameters along Eleyele catchment.

Sample Locations	Temperature (°C)	pH	EC (µS/cm)	TDS (mg/L)	Turbidity NTU	Total hardness (mg/l)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)	Cl^- (mg/L)	Total alkalinity (mg/l)
Iita	26	7.3	570	280	0.52	82	300.0	50.0	163.30	99.0
Bodija	28	6.9	800	400	0.58	70	380.0	50.0	248.50	102.0
Eleyele Reservior	26	7.6	560	280	0.17	58	88.0	44.0	44.73	74.0
River Ona Downstream	29	7.9	530	260	0.09	105	100.0	48.0	71.00	120.0
Eleyele Water Works	28	7.5	400	200	0.05	54	180.0	22.0	40.47	46.5

Table 2 : Metal of the study areas

Sample Locations	Na (mg/L)	Ca (mg/L)	Mg (mg/L)	Cu (mg/l)	Cr (mg/L)	Ni (mg/L)	Pb (mg/L)	Cd (mg/L)	Zn (mg/L)	Mn (mg/L)	Fe (mg/L)
Iita	160.40	48.39	26.04	0.05	0.05	0.06	0.54	0.00	0.08	0.20	1.96
Bodija	120.07	45.14	33.40	0.18	0.06	0.27	0.27	0.26	0.26	0.40	1.29
Eleyele Reservoir	120.24	30.34	21.64	0.02	0.01	0.02	0.79	0.01	0.05	0.20	0.49
River Ona Downstream	140.80	59.54	18.84	1.31	0.05	0.21	1.15	0.00	0.18	0.05	1.32
Eleyele Water Works	130.09	28.74	16.05	0.01	0.05	0.13	0.06	0.00	0.04	0.03	0.40

The pH of the River followed a w-shape trend indicating phases of variations over the long period of time. pH of the present study was the highest since 1979. Most of the wastes being dumped or washed into the river via run-off are alkaline in nature. The 28-year pH data were within the SON (2007) range in drinking water. Water temperature of the River was generally high. There is a significant increase in temperature values over the years with a slight decrease in 2007. High water temperature had been associated with degradation of wastes (Baotong et al., 1983). Alabaster and Lloyd (1980) have attributed high-water temperature to insulating effect of nutrient load resulting from industrial discharges. As population increases, waste generation will also increase. The fall in temperature in 2007 may be directly linked to strong enforcement of environmental law by the local government against indiscriminate wastes' disposal. Subsequent increase in temperature may be related to weak enforcement and compliance.

TDS and EC have high values in water samples collected from IITA and Bodija sampling locations. An elevated TDS concentration is not a health hazard but indicator of the concentration of dissolved ions, which may cause the water to be corrosive, salty or brackish, resulting in scale formation (Orewole et al., 2007). Discharges such as sewage could have responsible for a rise in the conductivity at both IITA and Bodija sampling sites because of the presence of chloride, phosphate and nitrate (EPA, 1997). TS values of River Ona have increased over the years (Fig. 2c) as a result of urbanization. However, the values of TDS from 1979 to 2010 are less 300 mg/L, which is within WHO standard.

There is a sharp decline in DO values of the river over the years (2d). Reduced DO coupled with yearly increase trend of Cl^- and NO_3^- could be linked directly to urbanization as raw untreated sewage and wastes generated from urbanization could lower the DO of the River (Wilcock et al., 1995). Ontario Ministry of the Environment and Energy (1994), Canada had given a minimum range of 4-7 mg/L for DO in rivers because low DO in river could be lethal to aquatic organisms (Einum et al., 2002).

Total alkalinity and total hardness values had not varied significantly over the years unlike chloride and nitrate, which values had soared up (Fig. 2 e,f,h,j). Increase in nitrate values of the river is of health concern, especially for children. For this present study, it was observed that the sampling points at IITA and Bodija were heavily polluted. Water parameters were generally high at these study sites compared to other sites probably due to disposal of laboratory chemicals and wastes into the river.

Sulphate and chloride values at the Bodija sampling point were high (Table 2), while sulphate was higher than WHO standard given as 250 mg/L, chloride was within the permissible limit. High chloride content in drinking water may indicate possible pollution from sewage, animal manure or industrial wastes (Department of National Health and Welfare, 1978). The values of nitrate in this study were relatively intense ranging from 22 – 50 mg/L, although, this was within the maximum acceptable limit of 50 mg/L (WHO, 2008). The health implication associated with elevated concentrations of nitrate greater than 11 mg/L in water is blue-baby syndrome known as Methemoglobinemia in children (Ward et al., 2005) and insulin-dependent diabetes (IDDM) in adult when concentration exceeds 25 mg/L (Kostraba et al., 1992). Adeyeye and Abulude (2004) had attributed high nitrate concentration in groundwater to sewage discharge - is peculiar to urbanization.

Most of the metals (Na, Cu, Mg, Zn, Cr, Mn) determined were below the WHO limits. Calcium and Magnesium are essential elements needed in good quantity by the human body. Ca functions in teeth and bone formation, neuromuscular extractability, good functioning of the contractibility, blood coagulability (František Kožíšek, 2003). Mg concentrations exceeding 125 mg/L in water according to Orewole et al. (2007) may have a laxative effect on some people. Nickel values of the river at Bodija sampling point and River

Ona downstream were higher than acceptable limits of 0.07 mg/L in drinking water (WHO, 2008) while lead values were extremely high at all the sampling points. High lead concentration of the river may result from runoff of lead-containing wastes from dumping sites and vehicular emission (Inanc et al., 1998, Martin et al., 1998). Lead is a pediatric poisonous that affects central and peripheral nervous system and also causing a kidney damage (Hassinger and Watson, 1998; Roberts, 1999). The observed cadmium value of 0.26 mg/L at the Bodija sampling point is outrageous and dangerous to human health. Cadmium is a potential carcinogen and kidney destroyer (Lewis, 1991). Iron concentrations of the river were also very high with the ability of initiating negative effect on taste and corrosiveness of water from the river (Taiwo, 2010).

By comparing River Ona water quality parameters with studies on notable rivers in southwest Nigeria, the influence of urbanization on this River is obvious. Parameters like TDS, nitrate, chloride, Pb, Cd, Zn, Mn and Fe were higher in River Ona than Ogun River as reported by Jaji et al. (2007). Higher concentrations of TDS, turbidity, Ca and Na were also observed in this study than values observed by Olajire and Imeokpara (2001) on Osun River. However, the recent study of Adeogun et al. (2011) on impacts of abattoir and saw mill effluents on Ogun River had shown elevated values of nitrate, phosphate and TDS higher than River Ona.

IV. Conclusion

Elevated values of water quality parameters observed for River Ona had indicated the influence of human activities due to urbanization. Increasing trends observed for long-term values of chloride and nitrate is a direct effect of sewage, urban-runoff and agricultural pollution. Annual decline in DO also established organic contamination of the River. High concentrations of water parameters at IITA and Bodija in addition had showed high level of pollution of River Ona at the upper stream due to possible contamination from agricultural and industrial effluents. It is therefore recommended that effluent treatment should be enforced before disposal into the streams and rivers. In addition, necessary actions should be taken to improve the water treatment process at the water works. Proper disposal of wastes should be ensured around the catchment area of the River.

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