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Full Length Research Paper

An assessment of the effect of industrial pollution on Ibese River, Lagos, Nigeria

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This paper deals with pollution aspect of environmental management and monitoring of the river for its sustainable development. The water quality assessment of Ibese River, which is the principal river of the Igbogbo Abayeku Areas of Ikorodu in Lagos, was performed. Assessment was undertaken according to different physical and chemical parameters including biological oxygen demand (BOD), dissolved oxygen (DO), electric conductivity (EC), total dissolved solids (TDS), alkalinity, acidity, total hardness (TH), grease content, major cation and anion, and some heavy metals. Results showed that the river, which was of good water quality at its upstream, in terms of the aforementioned parameters, becomes progressively polluted by the waste materials discharged along its course. A general downstream trend of increase in organic and inorganic pollution was declared. Thus, Ibese River currently faces a number of serious environmental and ecological challenges. Urbanization and industrialization of the watershed at Ibese area in Ikorodu contributed to the water quality deterioration with regional consequences on the aquatic ecosystem and on the health of the downstream's user groups. This synergetic effect is of concern for the sustainable use of the resources.

Key words: Nigeria, Ibese River, water pollution, major cation and anion, heavy metals, water quality deterioration.

INTRODUCTION

The Ibese River currently faces a number of serious environmental and ecological challenges. Uncontrolled discharge of untreated wastewater and solid wastes into the river in the mid section has degraded the quality of surface water beyond the acceptable limits. Ajayi and Osibanjo (1981); Paudel (1998); Osibanjo (1990) conducted a research on the effect of effluents from two breweries on Ikopoba River in Benin, Nigeria, where a rise in pH, a decrease in dissolved oxygen and increase in biological oxygen demand (BOD), chemical oxygen demand (COD)and total suspended solids, were noticed to have their own bearing on the aquatic life of the river. The impacts of water quality deterioration have regional consequences on the aquatic eco-system and on the health and cultural, religious and aesthetic values of the downstream user groups (Awomeso et al., 2009). The overall damage caused by the continuous discharge of unregulated and uncontrolled solid and liquid wastes into the Ibese River has provided impetus to community, environmentalists, policy makers and all other stake-holders to brainstorm on the environmental perspectives for the overall sustainability of the environment. The present study was performed to evaluate the pollution extent of the River. The Ibese River is located in Ibese Igbogbo Abayeku Areas of Ikorodu (Figure 1) in Lagos State of Nigeria. The River up streamed from about 1.2 km to the north of Abuja Village and flows along the river channel to Abuja Village to join the Lagos Lagoon at Oripodi. The study area has a relatively flat terrain with topographic elevation of less than 25 m above sea level

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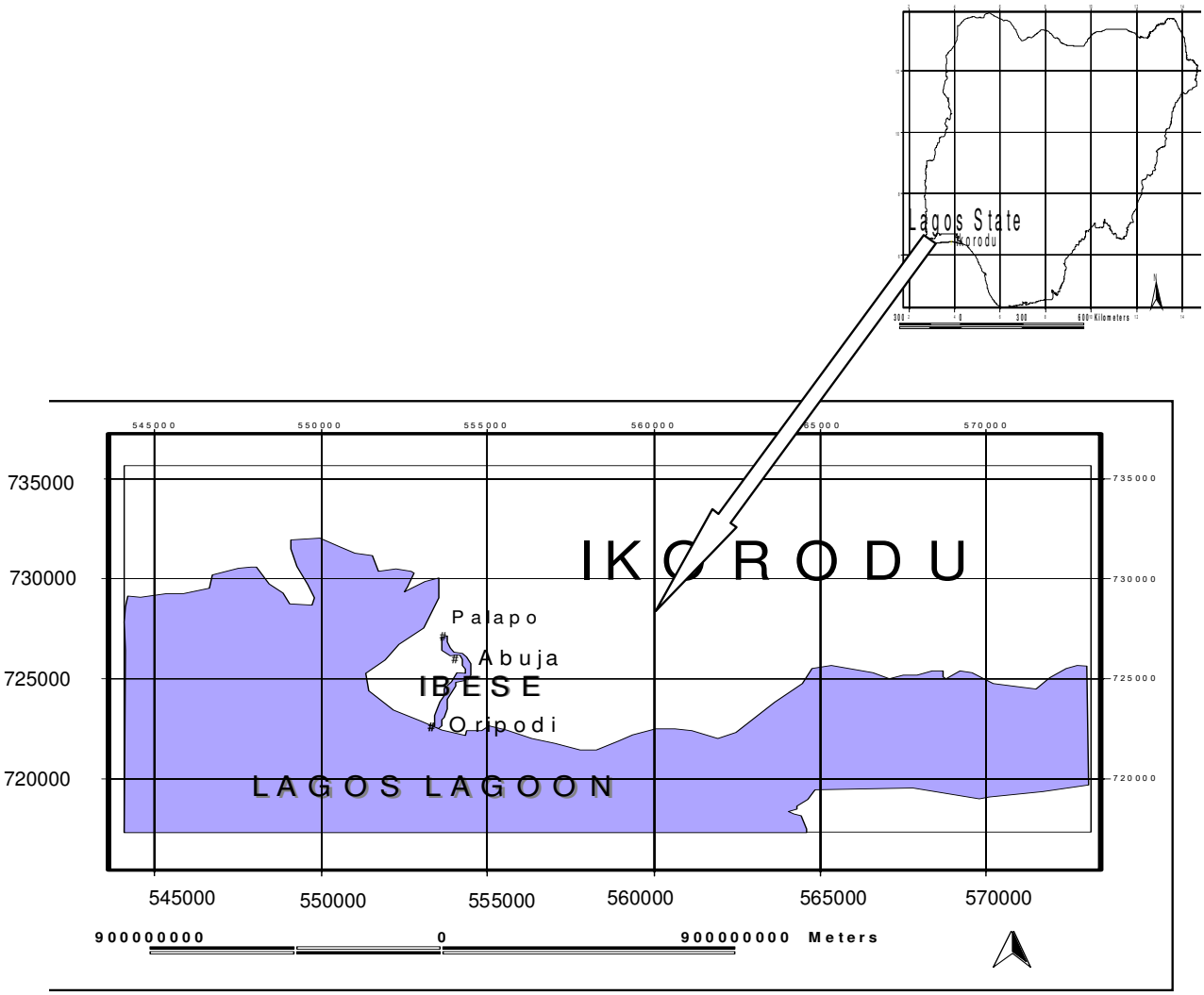

Figure 1. Map showing the Ibese River, Ikorodu, Lagos State.

(masl) and is surrounded by coastal zones of creeks and lagoon. marked by two prominent seasons. The rainy season extends generally from March to November with intermittent dry spells. This is the period when the southwesterly wind prevails. The dry season usually occurs from December and March when the area is under the influence of the northeasterly wind. The Ibese township and its environs are typical of the country's Southern zone with relatively moderate temperature and fairly excessive humidity particularly during the rainy season. The average annual rainfall in the study area is about 1500 mm. The average slope of natural drainage lines in the present undeveloped regions of the study area is about 1:10,000. Unfortunately, some of these natural drainage lines have been blocked by development in the eastern coastal areas, resulting in the creation of large swamps and a rise in the groundwater table in the neighboring undeveloped areas. The study area consists of outcrops of two main geological formations. The coastal plain sands which form the low, gently sloping dissected uplands, reaching in places a height of about 30 m, and the recent coastal deposits which form the extensive and swampy alluvial plains of the major rivers and creeks along the coast overlying the coastal plain sands.

MATERIALS AND METHODS

Six sampling stations were established for the study; they are the river source at Palapo, outlet from Palapo into the river at Abuja, inlet into the river at Abuja (behind a textile company), company's discharge point, 1 km away from inlet into river at Abuja and inlet of Ibese River into the Lagos Lagoon at Oripodi. The choice of the six sampling stations was based on their accessibility and their suitability for the future survey. All the stations were accessible by roads except Oripodi which is navigated by boats.

Table 1. Water quality analysis of Palapo.

Parameter	Source mean value (I_1)	Outlet mean value ($IO_{1)}$	WHO limit
Appearance *in situ*	Clear	Clear	Clear
Odor	Odorless	Odorless	Odorless
Temperature (℃)	28	28	20-33
pH	6.6	6.2	6-8
Conductivity (µs/cm)	170.0	130.0	NS
TDS (mg/L)	80.0	60.0	200.0
Alkalinity (mg/L)	45.0	42.0	NS
Acidity (mg/L)	25.0	20.0	NS
Total Hardness (mg/L)	46.0	28.0	NS
DO (mg/L)	5.0	8.0	<2.0
BOD (mg/L)	44.0	70	15
COD (mg/L)	96.0	141.0	80
Oil grease (mg/L)	0.5	0.5	10
Chloride (mg/L)	12.0	7.5	600
Sulphate (mg/L)	0.32	0.04	500
Nitrate (mg/L)	0.75	0.70	20
Potassium (mg/L)	1.50	1.70	50
Sodium (mg/L)	11.01	6.29	50
Iron (mg/L)	0.96	0.93	20
Nickel (mg/L)	0.04	0.03	<1
Cadmium (mg/L)	0.06	0.05	<1
Copper (mg/L)	0.23	0.24	<1
Lead (mg/L)	0.05	0.06	<1

Water samples at different locations collected for laboratory analyses were taken at the mid-streams of the rivers at different depths (surface and sub-surface) and labeled immediately on the field. The samples were transported in ice chests to the different laboratories where they were either analyzed immediately or stored at 40℃ or less to monitor the present status of source pollution indicative parameters. Water samples for physico-chemical analyses were collected vertically in replicates on boats, midstream at different depths of Ibese River. This was needed in order to establish an initial baseline of information for the future studies. It is also necessary so as to assess the river according to its self-purification capacity and to determine the pollution extent. Standard laboratory methods were employed for the analysis.

RESULTS

Water quality at Palapo - The source of the Ibese River

From water quality analysis results obtained from the field measurements at the Palapo presented in Table 1; it is found that the physico-chemical parameters such pH (6.6), conductivity (170 µs/cm), acidity (25 mg/L), alkalinity (45 mg/L) and total harness (46 mg/L) upper limit for the source and outlet were all within the specified limit by WHO for good fresh water quality. Furthermore, heavy metals and major ions also conform to specified limit for fresh water quality. The cations such as chloride, sulphate and nitrate had mean values of 10, 0.3 and 0.7 mg/L as against the specified limits of 600, 500 and 20 mg/l, respectively (WHO, 2004). Also the heavy metal nickel, cadmium, copper and lead were below the specified limit with mean values of 0.03, 0.05, 0.4 and 0.04 mg/L, respectively as against a limit of 1 mg/L for all by WHO. However, the organic pollutants such as dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) were high in water. They have mean values of 6, 60 and 10 mg/L, respectively as against 2, 15 and 80 mg/L specified by WHO. The results obtained were similar throughout the Ibese river strip at Palapo.

Water quality of the Ibese River at Abuja village

Table 2 showed that the water at Abuja village was of very poor chemical quality, and unsuitable for any freshwater fauna and flora. It was observed that the river at this location has higher values of COD, BOD, DO, TDS, electric conductivity, oil and grease, sodium, hardness and acidity particularly around the discharge

Table 2. Water quality analysis of Abuja village.

Parameter	Sampling location			
	Inlet mean value (I_1)	Industry discharge point mean value (D_1)	Outlet mean value ($IO_{1)}$)	WHO limit
Appearance *in situ*	Pale	Blue	Black	Clear
Odor	Unpleasant	Unpleasant	Unpleasant	Odorless
Temperature, ℃	28.0	28.0	28.0	20-33
pH	6.7	3.0	6.2	6-8
Conductivity (µs/cm)	155.0	305.0	125.0	NS
TDS (mg/L)	85	155	60	200.0
Alkalinity (mg/l)	135	45	255	NS
Acidity (mg/L)	12	160	16	NS
Total Hardness (mg/L)	505	262	35	NS
DO (mg/L)	5.5	3.5	6.0	<2.0
BOD (mg/L)	80	115.0	129	15
COD (mg/L)	155	245	287	80
Oil grease (mg/L)	30	25	20	10
Chloride (mg/L)	14	15.5	90	600
Sulphate (mg/L)	0.65	1.0	0.9	500
Nitrate (mg/L)	1.6	23	3.3	20
Potassium (mg/L)	33	21.5	37	50
Sodium (mg/l)	11.5	15.5	9.3	50
Iron (mg/L)	3.5	3.5	8.0	20
Nickel (mg/L)	0.06	0.11	0.15	<1
Cadmium (mg/L)	0.07	0.08	0.05	<1
Copper (mg/L)	0.35	0.26	4.50	<1
Lead (mg/L)	0.6	0.5	0.5	<1

point of the textile company located in the area. It was also noticed to be highly acidic when compared with WHO Standard (WHO, 2004). This implies that the Ibese River water within this point at Abuja village is highly polluted with the activity of the textile industry in that location. The river water quality in this location of the Ibese River strip is rapidly declining, so much that the river is merely a sewer in the dry season and is not fit for any purposes. It was also observed from Table 2 that the water quality of the Ibese River at the inlet into Abuja up to mid-stream point (industrial discharge point) of the river is of very good chemical quality and suitable for any freshwater fauna and flora, recreation and irrigation purposes. However, the result indicated fairly high values of COD and BOD in the industrial discharge point of the river when compared with WHO Standard (WHO, 2004). This implied that the Ibese River strip is rapidly improving in its water quality as it flows gradually into the Lagos Lagoon. This may be due to the increase of the assimilative capacity of the river.

Water quality of the Ibese River at Oripodi discharge point into lagoon

It can be deduced from Table 3 that the water quality of the Ibese River at Oripodi discharge point into Lagoon indicated that the river is of very good quality chemically and suitable for any freshwater fauna and flora and recreation purposes. However, the water quality like every other Lagoon has considerably high value of sodium. It was also observed to have a fairly high value of COD and BOD in the location of the river when compared with WHO standard.

Water quality profile of the Ibese River

Figure 2 shows the variations in hydrogen ion and conductivity concentrations along the River. It is noted that water from the River is slightly acidic and with moderate conductivity all through the river reach except at the Abuja industrial discharge section of the River that is highly acidic and having high conductivity value. Furthermore, the Oripodi which is the outlet of Ibese to the Lagos Lagoon has the highest conductivity value. Figure 3 also shows the variations in the water profiles especially in terms of measured field parameters such as TDS, acidity, alkalinity and total hardness. it is observed that the river has the highest values of these parameters at the Abuja section of the river. The parameters TDS,

Table 3. Water quality analysis is of Oripodi discharge point into Lagoon.

Parameter	Oripodi mean value	WHO limit
Appearance *in situ*	Dark	Clear
Odor	Unpleasant	Odorless
Temperature (℃)	28.0	20-33
pH	6.8	6-8
Conductivity (µs/cm)	540.0	NS
TDS (mg/l)	60	200.0
Alkalinity (mg/L)	75	NS
Acidity (mg/L)	26	NS
Total hardness (mg/L)	125	NS
DO (mg/l)	7.0	<2.0
BOD (mg/L)	68	15
COD (mg/L)	150	80
Oil grease (mg/L)	0.5	10
Chloride (mg/L)	52	600
Sulphate (mg/l)	0.5	500
Nitrate (mg/L)	0.5	20
Potassium (mg/L)	26.5	50
Sodium (mg/L)	44	50
Iron (mg/l)	8.0	20
Nickel (mg/L)	0.15	<1
Cadmium (mg/L)	0.05	<1
Copper (mg/L)	4.50	<1
Lead (mg/L)	0.5	<1

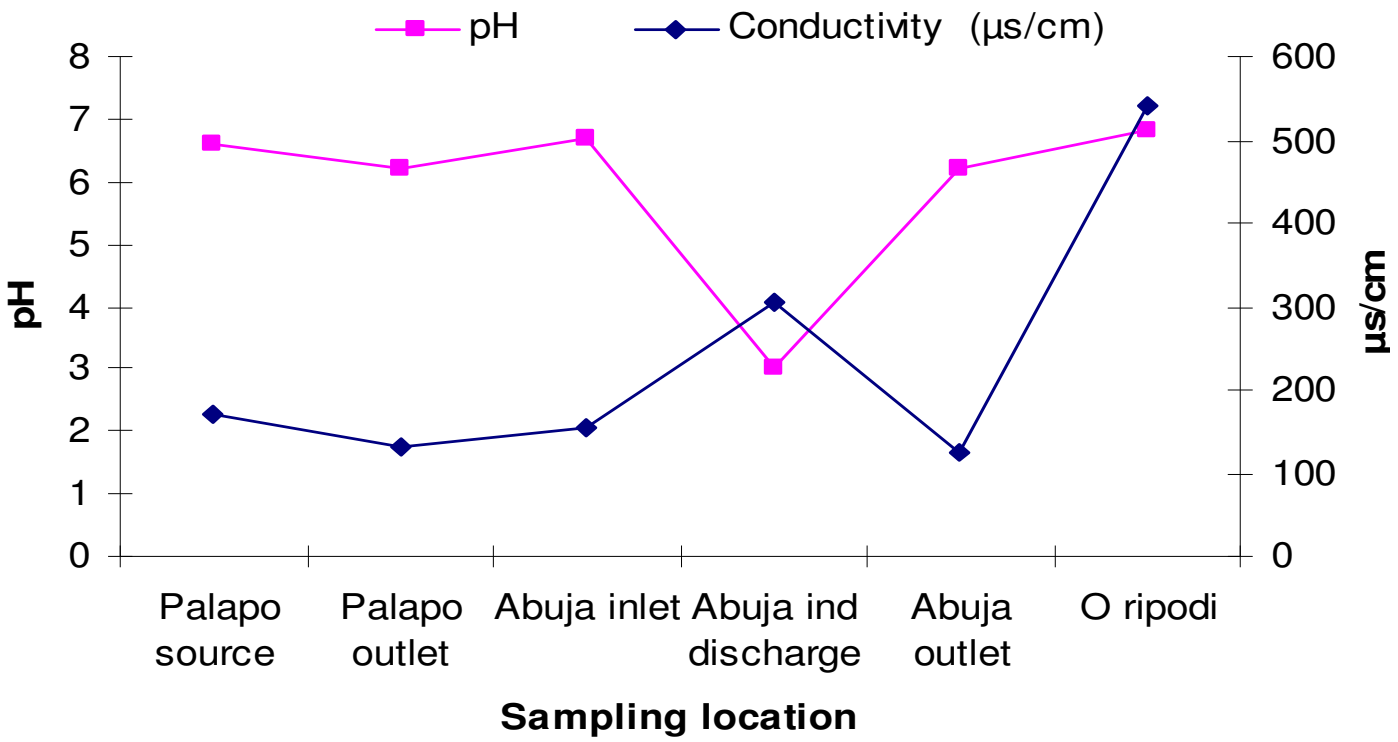

Figure 2. Map showing the pH and conductivity profile of Ibese River, Ikorodu, Lagos State.

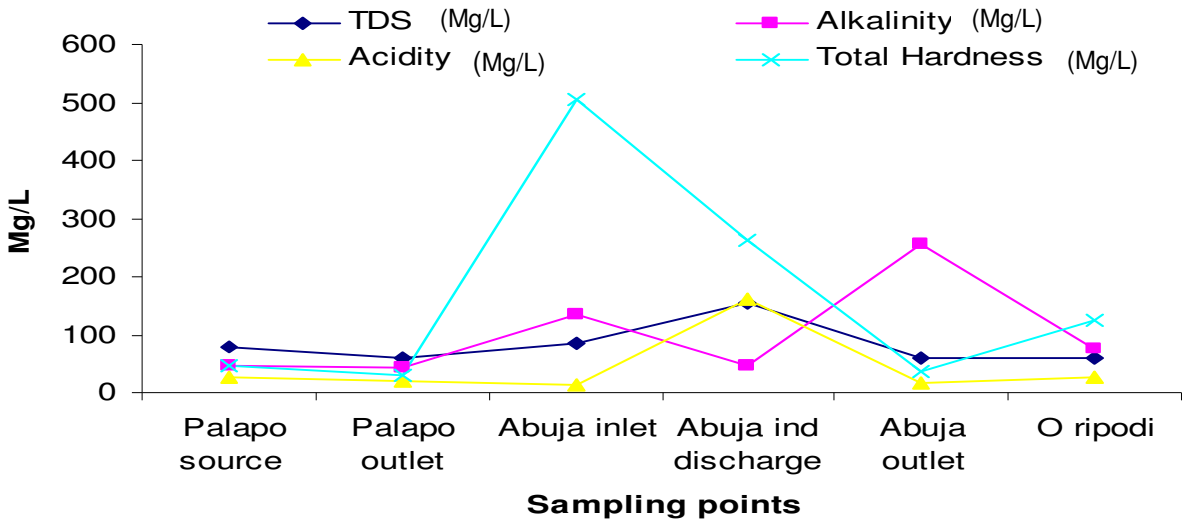

Figure 3. Map showing the TDS, acidity, alkalinity and total hardness profile of Ibese River, Ikorodu, Lagos State.

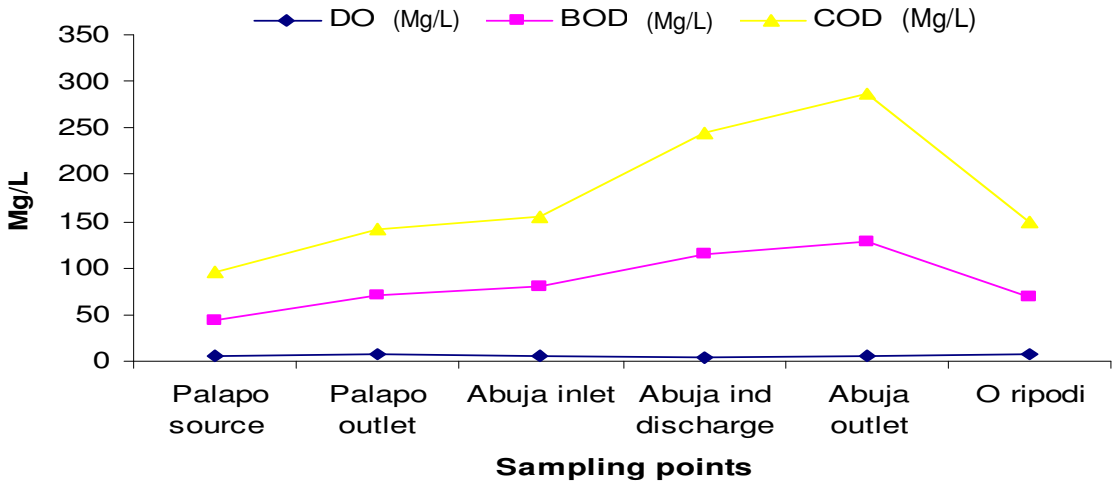

Figure 4. Map showing the DO, BOD and COD profile of Ibese River, Ikorodu, Lagos State.

acidity, alkalinity and total hardness were low at the Palapo area, increases gradually from the inlet into Abuja till they got to the peak at the Abuja outlet section before declining as it approaches the outlet of Abuja to Oripodi inlet to Lagos Lagoon.

Figure 4 shows the variations in the water profiles especially in terms of measured organic pollutants DO, BOD and COD. It is observed that the river has similar DO all through the river reach. However, the BOD and COD increases gradually from the source of river at Palapo until it got to the peak at the outlet of Abuja section of the river before declining as it enters into the Lagoon at Oripodi.

Figure 5 shows that the chloride, sulphate and nitrate were low and similar in level all through the river strip except for the very high concentration of nitrate experienced at the Abuja outlet which declined inwards into the Oripodi inlet to Lagos Lagoon. The dominant anion all through the river was the nitrate.

Figure 6 shows the variations in the cation (potassium, sodium and iron) profiles of the Ibese River. It is observed that the dominant cation of the river was potassium; however, the sodium concentration was the highest at the Oripodi inlet to the Lagoon. It was also observed from the figure that the parameters have higher concentration at the Abuje strip of the river than other sections. Figure 7 shows that the heavy metal, nickel, copper, cadmium and lead were lower than WHO limit all through the river except for the copper that was extremely high from Abuja industrial discharge point through to the Lagoon. Furthermore, it was also observed from figure that though the values of nickel, cadmium

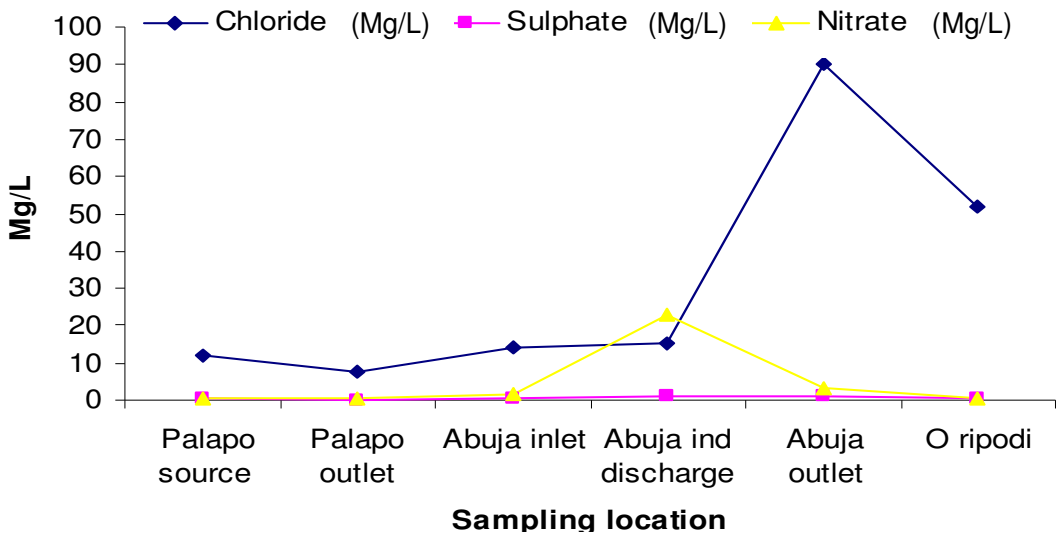

Figure 5. Map showing the chloride, sulphate and nitrate profile of Ibese River, Ikorodu, Lagos State.

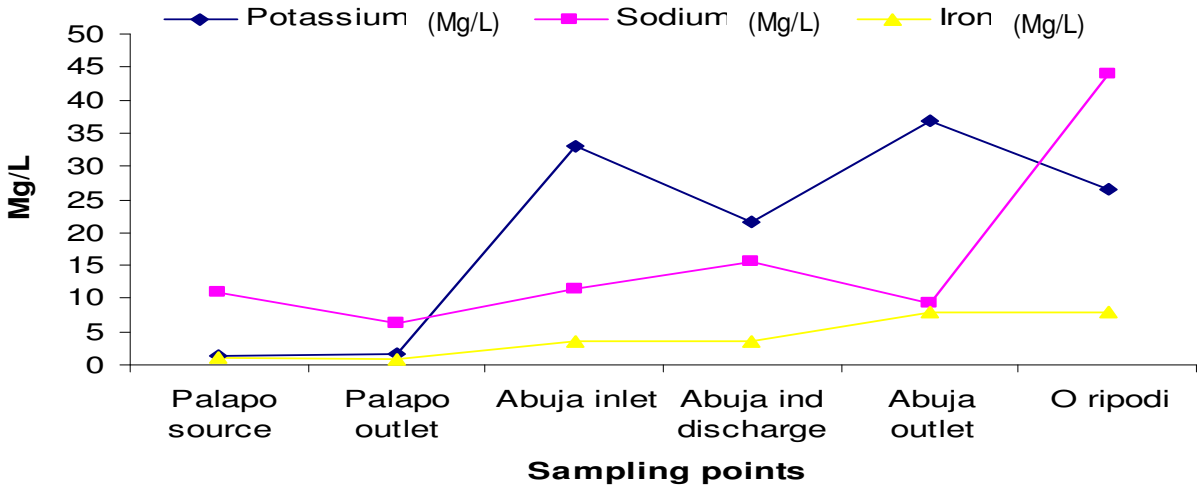

Figure 6. Map showing the potassium, sodium and iron profile of Ibese River, Ikorodu, Lagos State.

and lead were lower than specified WHO limit, concentration was high at the Abuja section of the river than the Palapo section.

DISCUSSION

The study showed that the water quality of the Ibese River at Palapo, which is the source of the Ibese River, is of very good chemical quality and suitable for any freshwater fauna and flora, recreation and irrigation purposes. However, fairly high value of COD was observed in this area of the river. The river as it stripes toward the Abuja area indicated that Ibese River is of very poor chemical quality, and unsuitable for any freshwater fauna and flora. It was observed that the river at this location has higher values of COD, DO, conductivity, hardness and TDS when compared with WHO standard (WHO, 2004). This implies that the Ibese River water within the Abuja village was not fit for the drinking, recreation and irrigation purposes. Furthermore, the vicinity of the river water from this location could become a major source of land and ground water pollution. Beyond the inlet into the Abuja strip in the vicinity of the industrial discharge area, the river water quality increasingly became more polluted chemically. This implies that the Ibese River water within this point at Abuja village is highly polluted with the activity of the textile industry in that location. The river water quality in this location of the Ibese River strip is rapidly declining,

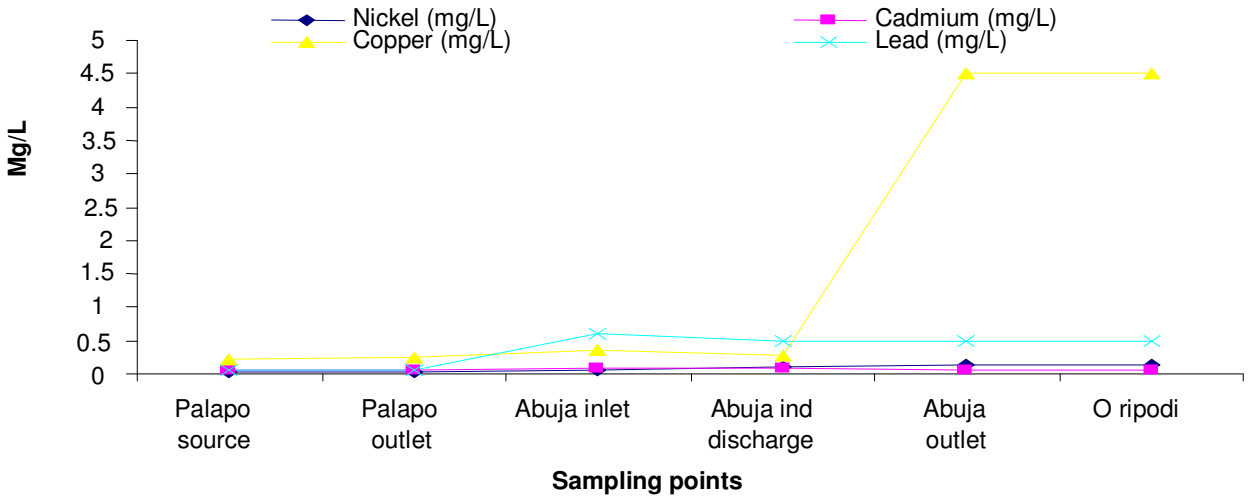

Figure 7. Map showing the heavy metal profile of Ibese River, Ikorodu, Lagos State.

so much that the river is merely a sewer in the dry season and is not fit for any purposes. As the water flows away from the Abuja strip towards the inlet into the Lagos Lagoon at Oripodi, the river water quality improved and gradually changed to fairly good water quality. This may be due to the increase of the assimilative capacity of the river. Finally, It can also be deduced that the water quality of the Ibese River at Oripodi discharge point into Lagoon indicated that the river is of very good quality chemically and suitable for any freshwater fauna and flora and recreation purposes. However, the water quality like every other Lagoon has considerably high value of sodium. It was also observed to have a fairly high value of COD and BOD in the location of the river when compared with WHO standard. The study showed that the dominant salt in the river is the potassium chloride which is synonymous with textile industry.

Mitigation measures

Mitigation measures were formulated with the objective of minimizing the negative impacts on river water. The mitigation measures for river pollution include: enforcement of effluent standards, construction of wastewater treatment plants in the Abuja area on-site sanitation; effective solid waste management and increase assimilative capacity of the river in the upper Ibese River.

Conclusion

Uncontrolled disposal of raw sewage and industrial effluents in the Ibese River system has created serious health concerns for the downstream water user groups. In view of the experiences and the lessons learnt from the past, the concept of Basin-wide planning has been felt necessary for sustainable development in Nigeria. Mitigation measures have been formulated, based on the present environmental conditions and study recommendations, with regard to river water pollution which are envisaged to be effective for the Basin environmental management.

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