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Water Quality Assessment of River Ogun Around the Cattle Market of Isheri, Nigeria

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Abstract: Water samples were collected from Ogun River around the cattle market, Isheri, along Ibadan-Lagos express road, during the wet season to determine following parameters: temperature, pH, Total Solids (TS), Total Dissolved Solids (TDS), Oil and Grease (OLG), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Alkalinity (ALK), Total Hardness (TH), Chloride (Cl^-), Sulphate (SO_4^{2-}), Nitrate (NO_3^-) and Phosphate (PO_4^{3-}). In addition, heavy metals-Zn, Cd, Ni, Cu, Pb, Fe and Mn were also determined. The concentration of most metals in the water around the cattle market was generally higher than average world river water concentration and mean dissolved metal concentrations in inland and coastal waters in Africa. The levels of Cu and Zn were below the maximum permissible limits of Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment. Nitrogen: Phosphorus (N: P) ratio of the water around the market was greater than 0.5. This may be attributed to atmospheric fall out from vehicular emission, run off, other burning activities taking place in the market and decomposing organic matter arising from the market. This can accumulate over time to cause eutrophication, loss of microorganisms and other aquatic organisms including fish, by increasing their susceptibility to other environmental stresses due to prolonged exposure to low dissolved oxygen levels and high levels of toxic pollutants, which may be injurious to life forms in the water. Thus, the water around the cattle market is presently stressed and subjected to pollution mainly from the market.

Key words: Cattle market, river, heavy metals, acid digestion, water quality

INTRODUCTION

A quite number of researches had been carried out in the field of river pollution assessment and control in Nigeria[1-5]. River is a major source of water supply to man for his activities. Apart from air-borne particulates which contain many trace elements derived from high temperature combustion sources[6,7] e.g., fossil-fuelled power plants, municipal incinerators, automobile exhaust etc. several industrial wastewaters are also important contributors of trace metals in natural water[1]. Toxic chemicals in effluents and thermal discharges kill aquatic organisms and some bioaccumulate toxic substances, which became bioconcentrated or biomagnified in the food chain having harmful effects on man. The effects of this can be seen in human disaster episodes in which an example is the Minamata disaster in Japan where people were poisoned by eating fish from bay polluted by methyl mercury[8].

The principal contaminants of water include suspended solids, biodegradable organics, pathogenic organisms and dissolved inorganic and heavy metals. Heavy metals gain access into the river system from both natural and anthropogenic sources and get distributed in water body, suspended solids and bed sediments during the course of their transportation[9]. The major water pollutants arising from animal manures are oxygen demanding matter (principally organic matter), plant nutrients and infectious agents[10]. Colour and odour are potential polluting constituents of secondary importance. The effects of pollution on water body are varied, usually resulting in a deterioration of water quality and changes in overall ecosystem characteristics[11].

Rivers in Nigeria are subjected to both domestic and industrial pollution because of poor enforcement of water pollution control laws and regulations. The supply of freshwater for irrigation, animal husbandry, industrial uses and recreation is the most important economic roles of rivers. For these reasons, the quality of river waters must be constantly monitored.

The aim of this study was to determine the concentration of heavy metals and physico-chemical

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characteristics of Ogun river water around the cattle market, Isheri, along Ibadan-Lagos express road. To assess the impact of the cattle market on the water and comparing the results with world standards for drinking water and other river water standards.

MATERIALS AND METHODS

River Ogun is one of the main rivers in the southwestern part of Nigeria with a total area of 22.4 km^2 and a fairly large flow of about 393 m^3sec^{-1} during the wet season. The river traverses Oyo, Ogun and Lagos states where it discharges into the Lagoon. The water is used for agriculture, transportation, human consumption, various industrial activities and domestic purposes. During its course, it constantly receives effluents from breweries, slaughterhouses, dyeing industries, tanneries and domestic wastewater before finally discharging to Lagos lagoon.

Nine sampling points were selected around the cattle market during the wet season of 2000. Sampling points 1 and 2 were located far from the market and from all activities taking place in the market. Activities taking place in the market include bone and horn burning, slaughterhouses, hot discharges, burning of cow skin, cooking of blood and unregulated sand-mining etc. None of this was in progress during sample collection. Points 3 to 5 were around the market but far from the express road. Points 6 and 7 were closer to the express road while points 8 and 9 were far from both the road and the market but point 9 was closer to human settlement. Sand mining was a major activity around points 7, 8 and 9 which was across the express road.

Two samples were collected from each point and mixed to form a composite sample. To avoid contamination during sampling and sample preparation, all bottles, beakers, conical flasks, filtration apparatus and other laboratory glasswares were pre - washed thoroughly with detergent, soaked with (1+1) HCl then rinsed with distilled water[12]. The sample bottles were rinsed with the river water at the point of collection. After collection, sample bottles were tightly covered to prevent contamination during transportation and then refrigerated in the laboratory to inactivate microbes, which may be present in the water.

Two litre water samples were collected separately at each sampling point using acid pre-washed polyethylene bottles for physical, chemical and heavy metal determination. Samples for heavy metal determination were preserved immediately with 5 mL concentrated HNO_3 acid. Samples for oil and grease and dissolved oxygen were collected separately in 250 mL BOD bottles. The dissolved oxygen in the samples was fixed immediately at the point of collection with 1 mL each of manganous solution and alkali-iodide-azide reagent. The samples collected were filled to the brim to prevent atmospheric oxygen from the surface of the water and the reagents to prevent loss of dissolved oxygen in the water. All samples were then refrigerated at 4°C in the laboratory[12].

Refrigerated samples were allowed to attain room temperature prior to treatment and analysis. Temperature and pH were measured immediately on the field with a mercury thermometer (range 0° to 100°C) and a digital portable pH meter, respectively. Total dissolved solids, total solids and oil and grease were determined by weighing, total hardness, alkalinity, dissolved oxygen (Winkler's method), chemical oxygen demand (open reflux) and chloride (silver nitrate method) were determined by titrimetry, sulphate by turbidimetry using PYE UNICAM SP 6-200 spectrophotometer and phosphate by photometry using ammonium molybdate and potassium antimonyl tartrate reagents according to APHA[13]. Nitrate was determined by phenoldisulphonic acid method[14]. Acid digestion of the acidified sample with concentrated HNO_3 acid was used for heavy metal determination prior to analysis with atomic absorption spectrophotometer buck scientific model-200[13]. Blanks and replicate measurements were carried out to check and remove possible errors from reagents. All instruments used were calibrated with appropriate standard solutions prior to sample analysis and measurement.

RESULTS AND DISCUSSION

The results obtained from the analysis of water shows that all the parameters were found to be higher (Table 1) than what was obtained by Udousoro[5] at the same points around the cattle market except the dissolved oxygen and total hardness, which were lower around this point. Most of the physical and chemical parameters were below the permissible limits of Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment (Table 2) and World Health Organization (WHO) standards for drinking water (Table 3). This can be attributed to the fact that there are physical, chemical and biological processes which self-purify and restore streams, lakes, creeks, estuaries, rivers and oceans to their pristine conditions[15] although, they are never restored back to their natural condition[16] thus, some level of pollution can be observed around this point.

Pollutants generated in abattoirs include organic wastes, blood, fats, bone and hairs and its effects are extremely high BOD, high pH and eutrophication[10].

Table 1: Mean concentration and range of physico-chemical parameter of ogun river around the Cattle Market, Isheri, along Ibadan-Lagos Express Road

	Sampling points											
Parameters	1	2	3	4	5	6	7	8	9	Mean	SD	Range
Temp (°C)	27.0	27.5	27.5	28.1	27.5	27.5	27.5	27.4	26.9	27.4	0.34	27.0-28.1
pH	6.68	6.68	6.67	6.60	6.60	6.71	6.69	6.80	6.73	6.68	0.06	6.60-6.80
TS (mg L^{-1})	200	220	360	180	260	220	110	180	300	225.7	73.3	110-300
TDS (mg L^{-1})	140	120	280	140	180	140	50	120	160	147.8	61.2	50-280
SS (mg L^{-1})	60	100	80	40	80	80	60	60	140	77.8	29.1	40-140
OLG (mg L^{-1})	ND	90	160	45	2.080	15	2.410	370	685	650.6	933.3	15-2.410
DO (mg L^{-1})	6.12	4.35	3.78	4.35	2.87	3.89	3.54	5.58	4.69	4.35	1.01	2.87-6.12
COD (mg L^{-1})	96	120	121.3	110.6	98.6	84	117.3	113.3	93.3	106.0	13.4	84-121.3
TH (mg L^{-1})	54.8	48.4	50.0	51.1	45.8	45.8	50.0	51.1	45.8	49.2	3.1	45.8-54.8
Cl^- (mg L^{-1})	43.8	44.9	50.3	47.6	50.3	43.8	46.5	50.3	46.5	47.1	2.7	43.8-50.3
SO_4^{2-} (mg L^{-1})	2.45	3.0	2.05	2.2	3.75	1.86	3.81	2.14	3.52	2.75	0.78	1.86-3.81
NO_3^- (ug L^{-1})	1.87	3.3	2.18	3.08	3.68	2.12	2.43	2.8	2.6	2.67	0.6	1.87-3.68
PO_4^{3-} (ug L^{-1})	2.78	2.2	2.28	3.39	3.66	2.62	2.55	3.74	3.93	3.02	0.67	2.2-3.93
Cd (mg L^{-1})	<0.01	<0.01	0.02	0.03	0.09	0.06	<0.01	0.02	0.15	0.044	0.048	<0.01-0.15
Cu (mg L^{-1})	0.11	0.18	0.14	0.35	0.27	0.49	0.22	0.14	0.41	0.26	0.13	0.11-0.49
Fe (mg L^{-1})	1.89	1.71	2.42	2.33	3.04	5.17	2.62	2.03	3.17	2.71	1.05	1.71-5.17
Ni (mg L^{-1})	<0.01	0.04	0.27	0.35	0.26	0.47	0.28	<0.01	0.51	0.24	0.19	<0.01-0.51
Pb (mg L^{-1})	0.12	0.24	0.22	0.53	0.71	0.85	0.41	0.26	0.65	0.44	0.26	0.12-0.85
Mn (mg L^{-1})	0.29	0.17	0.43	0.51	0.83	0.54	0.71	0.26	0.63	0.49	0.22	0.17-0.83
Zn (mg L^{-1})	0.18	0.21	0.35	0.29	0.36	0.42	0.40	0.35	0.28	0.32	0.08	0.18-0.42

N.D: Not detectable

Table 2: Federal Environmental Protection Agency (FEPA) now federal ministry of environment water quality criteria and domestic water supply[18,19]

Quality characteristics	Permissible criteria (mg L^{-1})	Desirable criteria (mg L^{-1})
Physical characteristics		
Colour	75	<10
Odour	Virtually absent	Virtually absent
Taste	Virtually absent	Virtually absent
Turbidity	25 turbidity unit	-
Inorganic chemicals		
pH	6.0-8.5	6.0-8.5
Alkalinity ($CaCO_3$)	30 - 500	30-500
NH_3	0.5	<0.1
As	0.05	Absent
Ba	1.0	-
B	1.0	-
Cd	0.01	-
Cl^-	2.5	<2.5
Cr (IV)	0.05	Absent
Cu	1.0	Virtually absent
DO	4.0	Air saturation
F^-	0.8-1.7	1.0
Fe (filterable)	<0.3	Virtually absent
Pb	<0.05	Absent
Mn	<0.05	Absent
NO_3^- plus NO_2^-	<10	Virtually absent
P	10-30 ug L^{-1}	10 ug L^{-1}
Se	0.01	Absent
Ag	0.05	-
SO_4^{2-}	250	<50
TDS	500	<200
Zn	5	Virtually absent
Uranyl ion	5	Absent

Table 3: World Health Organization (WHO) standards for drinking water[20]

Quality characteristics	Maximum permissible limits
Turbidity	25 turbidity unit (FTU)
pH	6.5-9.2
Total solids	1500 mg L^{-1}
Total hardness	500 mg L^{-1} $CaCO_3$
Ca	200 mg L^{-1}
Chlorides	600 mg L^{-1}
Cu	1.5 mg L^{-1}
Fe	1.0 mg L^{-1}
Mg	150 mg L^{-1}
Mn	0.5 mg L^{-1}
SO_4^{2-}	400 mg L^{-1}
Zn	5 mg L^{-1}
As	0.05 mg L^{-1}
Pb	0.1 mg L^{-1}
Cd	0.05 mg L^{-1}
Hg	0.001 mg L^{-1}
Se	0.01 mg L^{-1}
Cyanides	0.05 mg L^{-1}
Nitrates	45 mg L^{-1}

N.B:
FTU: Formazin Turbidity Unit

Table 4: Average world river water concentration (ug L^{-1})[21]

	Cd	Cu	Ni	Pb	Zn
Bowen (1966)	0.08	10	10	5	10
Riley and Chester (1971)	-	5	0.3	3	10
Turekian (1971)	-	7	0.3	3	20
Wilson (1975)	1	7	10	5	25

N.B: No data

Animal waste contaminates several miles downstream, increasing the levels of nitrogen, phosphorus and other nutrients. They also have high faecal coliform bacteria counts. This was the case around this point when the result obtained was compared with what was obtained by Udousoro[5] at the time when there was no cattle market around this point. The results obtained in this work for all the parameters and heavy metals were higher than what was obtained by Udousoro[5]. This showed that the water around the market was presently being polluted and can thus be attributed to the pollutants generated from the cattle market. This can be attributed to the degradation of

Table 5: Mean dissolved metal concentrations in inland and coastal waters in Africa (ng mL^{-1})[22]

Location	Hg	Cd	Pb	Ni	Cu	Zn	Mn	Fe
River Nile, Egypt	-	0.4	-	-	1.3	8.18	0.46	2.5
Kpong Head Pond, Ghana	<1.0	<10	<20	-	<20	<20	45	90
Kaduna River, Nigeria	-	-	-	-	240	200	1,300	3.800
Oyi River, Nigeria	-	-	-	-	100	-	300	1,800
Ona River, Nigeria	-	0.40	5.0	-	8.0	7.5	450	1,247
Calabar River, Nigeria	-	1.35	13.9	-	3.2	10.3	-	188
Knysna River, South Africa	0.01-0.19	<0.1-10	-	<0.1-8	-	<0.1-26	<1.1 - 40	40-510
Lake Victoria, Kenya	-	2-8	7-93.6	-	5-57.6	25-125	50-3,276	-
Ogun River around the Cattle Market, along Ibadan-Lagos Express Road, Nigeria (Present study)	-	44	440	240	260	320	490	2.710

Table 6: Linear correlation coefficient of all the parameters

	Temp.	pH	TS	TDS	SS	Oil and grease	DO	COD	Cl$^-$	Alkal.	T. hard.	SO_4^{2-}
Temp.	1											
pH	-0.515	1										
TS	-0.272	-0.097	1									
TDS	-0.032	-0.238	0.992(**)	1								
SS	-0.619	0.256	0.581	0.222	1							
Oil andgrea.	-0.16	-0.219	-0.329	-0.359	-0.071	1						
DO	-0.438	0.534	-0.181	-0.17	-0.1	-.0.576	1					
COD	0.4	-0.036	-0.088	0.022	-0.269	0.02	-0.091	1				
Cl$^-$	0.27	-0.059	0.323	0.452	-0.137	0.219	-0.306	0.438	1			
Alkal.	0.624	-0.394	0.186	0.514	-0.613	-0.091	-0.237	0.25	0.684(*)	1		
T. hard.	0.023	0.05	-0.36	-0.124	-0.648	-0.16	0.670(*)	0.365	-0.079	0.221	1	
SO_4^{2-}	-0.272	-0.208	-0.133	-0.345	0.389	0.825(*)	-.407	0.038	-0.06	-0.43	-0.356	1
NO_3^-	0.414	-0.392	-0.038	-0.08	0.074	0.224	-0.425	0.234	0.43	0.091	-0.401	0.439
PO_4^{3-}	-0.152	0.127	0.02	-0.047	0.149	0.158	0.151	-0.368	0.405	0.127	-0.214	0.227
Mn	0.08	-0.414	0.037	-0.005	0.104	0.734(*)	-711(*)	-0.336	0.243	0.178	-0.546	0.578
Zn	0.313	0.11	-0.066	-0.007	-0.152	0.391	-0.622	-0.078	0.37	0.358	-0.471	-0.006
Pb	0.155	-0.205	0.067	-0.046	0.265	0.166	-0.563	-0.657	-0.061	-0.004	-0.806(**)	0.187
Ni	0.086	-0.189	0.283	0.163	0.37	0.029	-0.513	-0.464	-0.065	0.056	-0.661	0.122
Cd	-0.398	0.009	0.457	0.204	0.725(*)	0.127	-0.227	-0.616	0.075	-0.221	-0.725(*)	0.396
Cu	0.134-	-0.107	0.056	-0.085	0.32	-0.141	-0.354	-0.658	-0.293	-0.12	-0.698(*)	0.013
Fe	-0.009	0.041	0.127	0.046	0.225	-0.024	-0.416	-0.718(*)	-0.251	-0.051	-0.698 (*)	-0.12

Table 6: Continued

SO_4^{2-}	NO_3^-	PO_4^{3-}	Mn	Zn	Pb	Ni	Cd	Cu	Fe
Temp									
pH									
Ts									
TDS									
Oil and grace									
DO									
COD									
Cl^{-1}									
Alkal.									
T. hard									
SO_4^{2-}									
NO_3^-	1								
PO_4^{3-}	0.377	1							
Mn	0.21	0.357	1						
Zn	-0.029	0.054	0.586	1					
Pb	0.24	0.385	0.716(*)	0.559	1				
Ni	-0.085	0.218	0.688(*)	0.494	0.314(**)	1			
Cd	0.206	0.652	0.572	0.126	0.699(*)	0.685(*)	1		
Cu	0.051	0.291	0.508	0.387	0.920(**)	0.873(**)	0.658	1	
Fe	-0.222	0.052	0.507	0.642	0.852(**)	0.750(*)	0.49	0.829(**)	1

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

Table 7: Some parameters (indicative of gross organic pollution) used in the classification of surface water quality[8]

	Category A		Category B	Category C	
Analytical parameters	Class I	Class II	ClassIII	Class IV	Class V
pH	6.5-8.0	6.0-8.4	5.0-9.0	3.9-10.1	<3.9->10.1
Dissolved oxygen ($mgO_2\ L^{-1}$)	7.8	6.2	4.6	1.8	<1.8
BOD_5 ($mgO_2\ L^{-1}$)	1.5	3.0	6.0	12.0	>12.0
NH_3 ($mg\ L^{-1}$)	0.1	0.3	0.9	2.7	>2.7
COD ($mgO_2\ L^{-1}$)	10	20	40	80	>80
Suspended solids ($mg\ L^{-1}$)	20	40	100	278	>278

N.B: Class I-Excellent Quality, Class II-Acceptable Quality, Class III-Slightly Polluted, Class IV-Polluted , Class V-Heavily Polluted
Category A-Excellent and acceptable quality, Category B-Slightly polluted , Category C-Polluted and heavily polluted

the cattle waste, cattle feed, burning of cow skin and horns using tyres and hot discharges, which are mostly oxygen demanding.

The concentrations of the metals also increased downstream around the market. The mean concentration obtained for some of the metals were higher than the maximum permissible limits of Federal Ministry of Environment (Table 2), Average World River Water concentration (Table 4) and mean dissolved metal concentration in inland coastal waters in Africa (Table 5). This may be due to the run off from the busy express road.

Vehicular emission from the busy express road which is washed by rain and run into the water is a major contributor of heavy metals and other oxygen demanding substances in this area. Gasoline, heavy-duty oil and lubricating oil are all supplemented with additives, such as metallic soaps and organic metal compounds e.g., tetraethyl lead in gasoline and molybdenum sulphide in lubricating oil[11]. These metals then found their ways into the environment when the oils are combusted or disposed of in an environmentally inappropriate ways.

Unregulated sand mining in this area also contributed to high heavy metal content and degradation of the water quality since heavy metals in the bottom sediment are dissolved when exposed during the mining and after mining when rain washes the sand and the water runs into the river since the river is the final sink of all the pollutants. The correlation coefficient of all the parameters is shown in Table 6.

Although river purify itself through the process of dilution and mixing, sorption and sedimentation in physical processes, solubility, acid-base and redox reactions, digestion, respiration and photosynthesis in biological processes, it is never restored back to its pristine freshness[15] due to the type of pollution, the type and quantity of the biomass, the river profile, the geometry of the biotop, pH, temperature, depth and availability of dissolved oxygen and also, trace metals which are not usually eliminated from the aquatic ecosystem by natural processes, in contrast to most organic pollutants[15]. Thus, they tend to accumulate in bottom sediment from where they may be released into water by various processes of remobilization and in changing form especially during mining can move up the biologic chain, thereby reaching human beings where they produce chronic and acute ailments[8].

Increased levels of nitrogen and phosphorus were observed around the cattle market and the N: P ratio was calculated and found to be around 91%. This will have a negative impact on the water, since phosphorus concentration in excess of 0.015 mg L^{-1} and nitrogen concentration of about 0.3 mg L^{-1} are sufficient to cause algal bloom[16]. Phosphorus is the limiting nutrient in fresh water aquatic systems and it functions as the growth-limiting factor because is usually present in very low concentration. Excessive concentrations of phosphorus can quickly cause extensive growth of aquatic plants and algal blooms. Concentration of phosphate was higher than that of nitrate in most points around the cattle market. Atmospheric nitrogen also rains down into streams, lakes, rivers and coastal waters and the increased nitrogen then contributes to the algae blooms that deprive fish and other aquatic organisms of oxygen[17]. Thus, high nitrogen and phosphorus in water leads to algal bloom and eventually, eutrophication, which is excessive enrichment of water body with nutrients whose consequences are detrimental to the life forms in the water.

Excessive algae and plant growth can lead to depletion of the dissolved oxygen, which adversely affects many organisms population and can cause fish kills. Excessive plant growth can increase the pH of the water because plants and algae remove dissolved carbon dioxide from the water during photosynthesis, thus altering the carbonic acid-carbonate balance. High nutrient concentrations also interfere with recreation and aesthetic enjoyment of water resources by causing reduced water clarity, odours and blooms of toxic and nontoxic organisms[12].

Based on some parameters indicative of gross organic pollution as used in the classification of surface water quality (Table 7), the water at this point can be classified as Class III, which is surface water that is slightly polluted. The pollutants may be mainly from the cattle market, followed by the run-off from the busy express road, agricultural and other discharges into the water.

It's classification also showed that it can best be used for livestock watering since the concentration of total dissolved solids, sulphate and nitrate were within the permissible limits for this purpose. High N: P ratio makes it to be excellent for irrigation purpose. High levels of suspended solids and total dissolved solids with low level of dissolved oxygen make it less useful for industrial purposes, freshwater aquatic life and recreation. The upper limit of Cu recommended for livestock, irrigation and freshwater species are 0.5, 0.2 and 0.005 mg L^{-1}, respectively[23]. The water cannot be used for freshwater species since the concentration of Cu is more than what can be tolerated by freshwater species.

CONCLUSIONS

Ogun river around the cattle market, Isheri, along Ibadan-Lagos express road is presently being overstressed by pollution loads mainly from the cattle market and the pollutants can be said to be from the cattle waste, feeds, slaughter houses and run-off from the busy express road etc. Hence the water around the market is presently been polluted. This needs to be checked since accumulation of the pollutants over time will have detrimental effects on the Lagos lagoon, which is the final sink.

REFERENCES

1. Kakulu, S.E. and O. Osibanjo, 1992. Pollution studies of Nigerian Rivers: Trace metal levels of surface waters in the Niger Delta area. Intl. J. Environ. Studies, 4: 287-292.
2. Oluwande, P.A., M.K.C. Sridhar, A.O. Bammeke and A.O. Okubadejo, 1993. Pollution levels in some Nigerian Rivers. Water Res., 17: 957-963.
3. Mombeshora, C., O. Osibanjo and S.O. Ajayi, 1981. Pollution studies on Nigerian River: The onset of Lead pollution of surface waters in Ibadan. Environ. Intl., 9: 81-84.
4. Mombeshora, C., S.O. Ajayi and O. Osibanjo, 1981. Pollution studies on Nigeria Rivers: Toxic heavy metal status of surface waters in Ibadan city. Environ. Intl., 5: 49-53.
5. Udousoro, I.I., 1997. Physico-chemical quality assessment of Ogun River and the environmental impact on the Lagos Lagoon. Ph.D Thesis, University of Ibadan, Ibadan, Nigeria, pp: 101-150.
6. Fishbein, L., 1981. Sources, transport and alterations of metal compounds: An Overview I. As, Be, Cd, Cr and Ni. Environ. Health Perspectives, 40: 43-64.
7. Lee, R.E. Jr. and P.V. Duffield, 1979. Sources of Environmentally Important Metals in the Atmosphere. In: T.H. Risby (Eds.) Ultratrace Metal Analysis in Biological Sciences and Environment. (American Chemical Society Washington D.C.), 172: 146-168.
8. Forstner, U. and G.T.W. Wittmann, 1983. Metal Pollution in the Aquatic Environment. 2nd Edn., Springler-verlag. New York, pp: 4-68.
9. Olajire, A.A. and F.E. Imeokparia, 2000. A study of the water quality of the osun river: Metal monitoring and geochemistry. Bull. Chem. Soc. Ethiop., 14: 1-8.
10. Miner, J.R. and T.L. Willrich, 1970. Pollution characteristics of animal wastes. In: Agriculture Practices and Water Quality, pp: 231-240.
11. Korte, F., 1977. Potential Impact of Petroleum Products on the Environment. (UNEP/ ISS.5/5), 2: 475-480.
12. Radojevic, M. and N.V. Bashkin, 1999. Practical Environmental Analysis. Royal Society of Chemistry, pp: 25-150.
13. APHA, 1992. Standard methods for the examination of water and wastewater. American Public Health Association. 18th Edn., New York.
14. Michael, T.J., 1950. Phenoldisulphonic acid method for determining nitrates in water. Anal. Chem., 22: 1020-1022.
15. Ellis, K.V., G. White and A.E. Warn, 1989. Surface Water Pollution and its Control. Macmilllan Press Limited, pp: 20-35.
16. Hawke, H.A., 1962. River Pollution II. Causes and Effects. Klein, L. (Eds.). Buterworths, London, pp: 311-315.
17. Schiffman, S., 1995. Effects of the livestock industry on the environment. Environ. Health Perspectives, 102: 1096-1099.
18. FEPA, 1988. Present water quality status in Nigeria. Federal Environmental Protection Agency, Lagos, pp: 35-41.
19. Report of the Committee on Water Quality Criteria, 1968. Federal Water Pollution Administration, USA, Washington D.C., pp: 25.
20. WHO, 1971. International Standard for Drinking Water. 2nd Edn., World Health Organization, Geneva.

21. Vivian, C.M.G. and K.S. Massie, 1977. Trace metals in waters and sediments of the River Tawe, South Wales in relation to local sources. Environ. Pollu., 14: 47-61.
22. Biney, C., A.T. Amuzu, D. Calamari, N. Kaba and I.L. Mbome *et al.*, 1994. Review of Heavy Metals. In: Calamari D. and H. Naeve (Eds.). Review of Pollution in the African Aquatic Environment, pp: 4-68.
23. Environment Canada, 1979. Water Quality Source Book. A Guide to Water Quality Parameters. In: Mcneely, R.N., V.P. Neimanis and L. Dwyer (Eds.). Inland Waters Directorate, Water Quality Branch. Ottawa. Canada, pp: 88.