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Influence of Human Activities on the Water Quality of Ogun River in Nigeria

Olalekan O. Ikotun, Oladipupo S. Olafusi, Habeeb A. Quadri, Oluwaseun A. Bolarinwa*

Civil Engineering Department, University of Ibadan, Ibadan, Nigeria

* E-mail of the corresponding author: bolarinwa.oluseun@yahoo.com

Abstract,

The quality of Ogun River in south-west, Nigeria was investigated by a field survey; covering the dry season and rainy season. Water samples were collected from seven sites (including an Abattoir, a market, residential community and a brewery); analysis of the physico-chemical parameters using standard methods and their environmental effects on the river were investigated. Generally, the value/degree of dissolved oxygen, phosphate, BOD, COD, pH, temperature, hardness from the sites during the rainy and dry seasons were compared with the World Health Organization (WHO) standards for domestic and commercial water. The traces of some hazardous physical and chemical impurities in the river were above the acceptable limits; and thereby pose a health risk to several rural communities who rely heavily on the river primarily as their source of domestic water. The study revealed a need for continuous pollution monitoring and management program of surface water in Nigeria.

Keywords: surface water, water quality, water pollution, field survey, physico-chemical analysis

1. Introduction

Water constitutes one of the most precious natural resources without which no form of livelihood is possible .Good quality water is needed to maintain ecological balance and for economic development activities, but scarcity of water is increasing, hence planning, monitoring and management of this natural resources should be undertaken.(Bamgbose and Arowolo,2007). Therefore quality and quantity of accessible water must be studied so as to make possible the concept of sustainable development. Rivers have become the focal point of much activity and primary candidates as a sink for waste from all kinds of human activities. (Agbede, 1991).Surface water pollution is a major problem beclouding most developing nations. The scarcity of clean water and pollution of fresh water has led to a situation in which one-fifth of urban dwellers in developing countries and three quarters of their rural dwelling population do not have access to reasonably safe water supplies (Lloyd and Helmer, 1992)

Freshwater bodies receiving effluents from point and non-point sources are usually characterized by higher than average biochemical oxygen demand (BOD) loadings and concentrations of major ions and trace metals (Ademoroti; 1982; Ogunfowokan and Fakankun; 1998). Although in the past, this problem was attributed mainly to industrial effluents, and therefore thought to be a concern of the industrialized countries, it is now a global issue as development and industrialization assume universal dimensions, and other types of effluents such as domestic and commercial effluents have been shown to cause as much pollution in freshwater bodies as industrial effluents. For instance, domestic and commercial effluents acidify receiving water bodies, making them lethal to fishes and other aquatic life. They also cause denaturation of key enzyme proteins in higher organisms and mineralize freshwater bodies, resulting in high concentrations of the major ions (Rowe and Abdel-Magid; 1995). Many of these ions have important health and environmental consequences. The source and nature of contamination however vary from one nation to another. Aside, very few percentage of the population in these nations has access to good and safe water while most surface water is either contaminated by industrial effluents or sewerage. The pollution can either be of point source or non-point source. Point sources of pollution occur when pollutants are emitted directly into the water body e.g., from industrial sewage or municipal waste water pipes. A non-point source delivers pollutants indirectly through environmental changes such as pollution from urban run-off (Bamgbose and Arowolo, 2007). Major known sources of water pollution are municipal, industrial and agricultural. The most polluting of them are sewage and industrial waste discharges into rivers. Industrial effluents mostly contain heavy metals, acids, hydrocarbons and atmospheric deposition (Aina and Adedipe, 1996). Agricultural run-off is another major water pollutant as it contains nitrogen compounds and phosphorus from fertilizers, pesticides, salts, poultry wastes and washes down. Also, the indiscriminate way of handling domestic waste sewage may lead to the pollution of underground sources of water supply such as wells. If sewage or partly treated sewage is directly discharged into surface water such as rivers, the water of such rivers get contaminated. It is well known that ineffective and insufficient waste management is one of the most pressing environmental problems facing many cities in developing world. (Coker et al, 2008). Therefore, for effective management of waste, there should be appropriate and affordable technique at the disposal of the community (Coker, et al., 2009)

2. Materials and Methods

2.1 Preamble:

Ogun River cuts across the South-Western Nigerian states (Ondo, Osun, Oyo, Ogun, and Lagos states) before discharging into the Atlantic Ocean through the Republic of Benin. Ogun State in Nigeria derived its name from the river. Ogun River is abstracted for water supplies in Ogun and Lagos States. The dwellers along the various points through which the river flows are seen using the untreated river for irrigation and domestic purposes (including drinking). The socio-economic and industrial activities of the society along the river have seriously changed the natural characteristics of the river. As faeces, domestic and industrial wastes are regularly emptied into it and along its banks leaving the river polluted. Study of physico-chemical characteristics of this river was conducted in order to access its quality and usefulness to human livelihood.

Water Sampling:

Sample collection is very important in water analysis. It is essential that all sampling procedures are adhered to in order to avoid contamination from sampling device. The first step for any test is to obtain reliable, representative sample. The need for careful sampling techniques varies according to the constituent being tested i.e. the bacteria and volatile organic elements is very sensitive to sample collection procedure while hardness and salts are fairly insensitive to sampling technique. Storage procedures before analyses and time between sampling and analyses are also very important. .Water samples for physico-chemical analysis were collected from seven sites (A, B, C, D, E, F and G) between 6.00am and 11am every sampling day along the river course. Samples were collected once a month from all sites for 4 months (January 2011 – April 2011). Therefore, a total of 4 water samples were collected from each sampling site, thereby resulting in a total of 28 water samples of Ogun River over a period of 4 months.

The following procedures were followed during sampling.

1. Plastic bottles with hard plastic screw caps were used for sample collection.
2. The sampling containers were properly cleaned before use and rinsed with water to be sampled before sampling
3. The water was skimmed to ensure debris does not enter the sample from the river before collecting the sample. The water was not allowed to make any contact with any object before running into the bottle. The sampling were done in the middle stream by dipping each sampling bottle at approximately 20 -30 cm below water surface (projecting the mouth of container upstream against flow direction), opening the bottle and allowing the container to fill up and be covered with its cap under water to preserve it from volatile compounds in the water and atmosphere contamination.
4. After collecting the samples, the containers were well labeled, stating the source and date of collection.

The samples were then taken to a Quality Control Laboratory immediately for physical and chemical analysis of the following parameters: Color, Odour, Conductivity, pH, Turbidity, Total solid, Total dissolved solid (TDS), Total Suspended solid, Acidity, Alkalinity, Total Hardness, Calcium Hardness, Magnesium Hardness, Chloride, Iron, zinc, Chloride Residual, Bacterial Count. Meanwhile, the samples were preserved by refrigeration before the commencement of the analysis. The Instruments used for the analysis are:

(i) Glass Thermometer: The temperature of water samples was measured on sites with portable mercury in glass thermometer (0-1100C) graduated at 0.10C interval. The glass bulb of the thermometer was dipped in the water body for few minutes and the reading was recorded.

(ii) Atomic Absorption Spectrophotometry (AAS): Atomic absorption spectrophotometer was used to determine concentration of calcium, chromium, iron, calcium, magnesium, zinc. The instrument was manufactured by Kenthe Technology (HK) CO., Limited, Hong Kong, China.

(iii) pH Meter: An electrically powered pH 211 microprocessor pH meter was used to determine the pH. The meter was standardized with buffer solution (4,7and 9) each time the measurements were made.

(iv) Optical Turbidimeter (Hach 2100A): Hach 2100A Turbidimeter was used to determine the turbidity. It is electric power operated. The instrument was standardized with Nephelometric Turbidity unit (NTU) cells (5, 10 and 100 NTU) each time the measurements were made. This instrument passes a beam of light upward through the sample where suspended particle scatter an amount of light proportional to the turbidity. A photomultiplier tube located at a 900 angle to the beam then converts the light energy to an electrical signal that is measured on the panel meter in NTUs.

(v) Electronic Balance: Mettler and Orion electronic weighing balance were used to weigh the powder broth, agar and other indicators used for preparation of laboratory reagent and solutions.

(vi) Oven: Hot- air oven was used to dry glassware at uniform and adequate sterilizing temperature.

(vii) Autoclave: Analog Pressure Autoclave was used to sterilize the culture media prepared for cultivation of microbes for determining bacterial count and coliform count. This laboratory equipment is used to provide uniform temperature within the chambers up to and including the sterilizing temperature up to 1210c at 1 atmospheric pressure.

(viii) Incubator: Gallenkamp incubator was used for incubation at a uniform and constant temperature.

(ix) Colony Counter: Gallenkamp colony was used for quick and accurate counting of bacterial and mold colonies in Petri dishes.

(x) Water Bath: Evaporation to dryness was carried out on water samples with the use of water Bath of 12 porcelain basins capacity. Direct heat (from flame) can impair an experiment.

The Dissolved Oxygen (DO) contents of the water samples from the sampling points measured in mg/l were determined in the laboratory using the iodometric (Wrinkler's) method. The water samples collected in the bottles were fixed in the field by adding 1.0 ml of Winkler's solution 1 [Manganese (II) tetraoxosulphate (VI) Monohydrate - MnS04H20] and 1.0 ml of Winkler's solution II (Sodium Hydroxide and Sodium Iodide) using a 2.0 ml pipette. To dissolve the precipitate of Manganese II hydroxide farmed, 1.0 mL of concentrated tetraoxosulphate (VI) acid H2SO4 was added below the solution inside the reagent bottle using the pipette. In the laboratory, 20.0 mL of the fixed water samples from each of the four stations were respectively pipette into 250 mL flat bottom conical flasks and 0.0125 m standardized disodium trioxosulphate (IV) (Na2S2O3) solution was titrated against each, using 2.0 mL of 1.0% starch solution as indicator. The point at which the blue color first disappeared indicated the end point of each titration. The titration was repeated thrice for each station and the average titer was determined. From the average titer values obtained for each station, the dissolved oxygen concentration was calculated in mg/l using the formula

02 mg/l = t x 101.6

20 ml of water sample

Where t = titer or volume of thiosulphate used.

101.6 = constant.

Other instruments and apparatus used in the laboratory for physico-chemical analysis are: Stoppered flasks, Burettes, Pipettes, Test tubes and Nessler tubes, Conical flask, Measuring cylinder, Porcelain basin (100ml capacity), Desiccators, Beakers, Lovibond comparator and discs, Sampling bottles, Glass Petri dishes, Fermentation bottles with Durham tubes.

2.2 Site Description:

The descriptions of the sampling sites are as in table 1 and as discussed below;

Site A- was a water course around an abattoir as shown on figures 1 and 2. The slaughters dispose their effluent into the river without any form of treatment and the slaughter cows washed with the same water. Wastes from slaughter cows usually contain fat, hair, manure and undigested food. There is agricultural practice along the river side; Birds also feed along the stream. Residents along the river course dump their waste and defecate into the river as most of the houses have no toilet facilities.

Site B- was a water course around a market. Thousands of people visit it daily to buy, sell or transact other businesses. Major items of trade include clothing, vegetables, fruits, livestock (live and dressed), foodstuffs and plastics. Engineering activities were also evident with about two motorcycle mechanics, ironsmiths and/or welding workshops observed in the market. Other activities such as tailoring, shoe making, watch repairing, fruit and grain grinding also take place, and each of these activities gives rise to different types of waste. The major types of solid waste generated in the market include fresh vegetable matter, plastic bags, animal dung, decaying foodstuff, metal scraps and clothing materials. Wastewaters usually come from the operations of grinding, washing of various items, activities of meat sellers, and repair of motorcycles. These wastes are disposed of indiscriminately into the drainage channels from where they flow into the river. It was observed that while the solid wastes in the channels were freely transported downstream during the rainy season, they block the channels mostly during the dry season.

Site C- was a municipal area; highly polluted with domestic waste. The river is used as dump site. There is a car wash at the river bank.

Site D- was a water course around a brewery. Though the industry is non-functional; but resident of the area use the river as a dump site, they defecate into the river as most of the houses are without toilets and summer algae was seen during rainy season.

Site E- was a water course around a water works; with car wash and mechanic workshop along the river bank. The river is also used as a dump site by the resident of the area.

Site F- was a municipal area. Highly polluted with domestic waste as shown in figure 3

Site G- was another municipal area. Residents of the village use the river as their source of drinking water. This point is free from point of pollution. It has aquatic life and fish farming is practiced there.

3. Results and Discussions

3.1 Field survey:

The field survey conducted revealed the following;

i. Source of water supply: Underground wells serves domestic purposes (including drinking) for Ninety six percent (96%) of the people around the river; and irrigation purposes for their farmers. Due to the untreated state of the wells, it poses health hazard to the dwellers as polluted water may eventually find its way to the ground water.
ii. Drainage system: Most of the houses along the river course channel their wastewater drainages towards the river. During rainfall, dust particles, domestic waste, animal dropping and surface run-off is washed into the river.
iii. Sanitation program: The rural dwellers around the river banks organize environmental cleaning and sanitation programs mostly on Saturdays.
iv. Solid waste disposal: There is no organized waste disposal system in the areas, hence most of the people use the river course and open dump as refuse depots. In areas where industry is located, industrial wastes are dumped directly into the river. At sites ‘C’ and ‘F’, the river courses have been silted up by refuse, and debris.
v. Livestock management: Goats, pigs and poultry birds are the common livestock in the area. They are free range; they therefore roam about the streets. Their faeces litter the streets and are washed into the river through the surface runoff during rainfall.
vi. Toilet facility: Very few houses around the river course use modern toilet facilities. Pit latrine is mostly used. Some of the dwellers interviewed agreed that the most prevalent practice is an early morning or evening walk to a secluded open area to defecate.

3. 2 Physico-chemical parameters:

The results for the various physico-chemical parameters determined in the water samples from each sampling site along Ogun River are presented in Tables 1 and 2. The analysis of the samples was carried out in the Quality Control Laboratory of Abeokuta Main Water works Scheme, Arakonga, Iberekodo, Abeokuta, Ogun State, Nigeria.

i. Temperature: The temperature of water sample ranged from 30.83-31.7^{0}C during the dry season and 23.7-29.5^{0}C during the rainy season. There were little variations in temperature between sites and the two seasons.

ii. pH: The pH value of all water samples ranged from 6.5-7.5 during the dry season and 7.18-7.7 during the rainy season. Generally, the pH values fall within the WHO standard of 6.5–8.5 (World Health Organization, 1984). There was no significant difference between the pH values for the two seasons.

iii. Dissolved Oxygen (DO): The dissolved oxygen ranged from 3.9–6.55mg/l for the dry season and 4.1–7.7 mg/l for the rainy season. DO was lower during the dry season compared to the rainy season. The DO values obtained at all sites were generally above the acceptable limit of ≤ 4 mg/l set by the Nigerian Federal Ministry of Environment as the permissible level for surface water quality for public supplies except for site 'G' during the dry season.

iv. Turbidity: The values of turbidity obtained in the study ranged from 4.9-20.95NTU during the dry season and 5.5 – 19.05 NTU for the rainy season. The turbidity values obtained at all sites during both seasons except site 'G' were higher than the WHO standard of 5 NTU (World Health Organization, 1984). However the turbidity values were generally lower during the dry season as against the rainy season. The increase in values during the dry season could be attributed to surface runoff and erosion carrying soil/silt and partially dissolved or undissolved organic matters (Morokov, 1987).

v. Total Suspended Solids: The result obtained for all sites ranged from 62.5-107.5mg/l for the dry season and 52.9 – 106.5mg/l for the rainy season. All the TDS result obtained fall within the WHO standard of 500mg/l (World Health Organization, 1984).

vi. Chloride: The chloride ion content of Ogun River ranged from 29.3-104.5mg/l for dry season and from 31-101mg/l for rainy season. Chloride values were generally higher during dry season. The chloride values obtained from all sites during the two seasons are below the WHO standard of 250mg/l (World Health Organization, 1984).

vii. Nitrate: The most highly oxidized form of nitrogen compounds is commonly present in surface and groundwater; because it is the by-product of the aerobic decomposition of organic nitrogenous matter. Unpolluted natural waters usually contain negligible quantum of nitrate. In this study, the nitrate concentrations of Ogun River ranged from 0.82-3.91mg/l for the dry season and from 0.66-3.3mg/l. for the rainy season. The nitrate value obtained in all sites fall within the WHO standard of 10mg/l (World Health Organization 1984).

viii. Phosphate: phosphate content of Ogun River ranged from 0.4-0.95mg/l during the dry season and from 0.19-2.0mg/l for the rainy season. The results obtained were above Nigerian Federal Ministry of Environment maximum permissible value of 0.05mg/l. Generally, the phosphate values obtained were higher during the rainy season as against the rainy season. The high phosphate values obtained from the investigation could be attributed to the phosphorus in runoff from domestic, municipal and agricultural wastes (non-point source) flowing into the river as well as washing along the riverside with detergent (Correl, 1998).

ix. Iron: The concentration of iron in Ogun River ranged from 0.12-1.79mg/l for the dry season and from 0.16-2.3mg/l in the rainy season. The values obtained from all sites during the two seasons were higher than WHO standard of 0.3mg/l except for Site 'G' that fell below the range. Generally, there was increased iron content during the rainy season compared to the dry season. Anthropogenic sources of iron urbanized and environment are largely due to corrosion of iron and steel structure in buildings, dumpsites and vehicles.

x. Manganese: This ranged from 0.0-0.02mg/l during the dry season and from 0.0-1.0mg/l in the rainy season. Generally, the values obtained during the dry season were higher than WHO standard of 0.1mg/l. During the dry season, Ogun River is in influent condition, so the river flow is maintained by groundwater discharge. Usually, there is a direct hydraulic connection between the river system and the upper portion of the shallow aquifers. As cessation of rainfall starts in the month of November, the river discharges starts to decrease but sustained by base flow as groundwater discharge. The low flow condition in the river by December makes the water level in Ogun River to drop to a level that the rocky bottom is exposed.

It can be concluded that point sources of pollution are responsible for the pollution of Ogun River during the dry season. The results obtained in the study also suggest that some of the measured pollutants have localized impacts which get diluted downstream. Other pollutant (turbidity, pH,) appeared cumulative during the rainy season. While rainfall may dilute and weaken the effects of point source pollution, it also increases the contribution of non-point source or diffuse pollution through land runoff from agricultural fields and leachates from refuse dumps. Ogun River develops summer algal growth in most section of the river. The result of the analyses for most parameters did not show the expected trends in water quality from upstream to downstream sites on the river along the 7 sampling sites. It is expected that the concentration of most parameters downstream should be higher than midstream or upstream. This is not the case in this study. This clearly confirms that the main source of contamination Ogun River is point source pollution. Nevertheless, non-point source such as diffuse pollution from agriculture, urbanization, logging, construction etc. add to contamination of the river.

4. Conclusion

The result of the study conducted on Ogun River to determine its quality and pollution profile over 4 months spread across two seasons; clearly shows highly polluted water. The results of this study indicate that Ogun River is polluted along the river course and poses a health risk to several rural communities who rely on the river primarily as their source of domestic water. The study showed a need for a continuous pollution monitoring program of surface waters in Nigeria. Also, the appropriate government agencies concerned with environmental matters in Nigeria should evolve measure to check the indiscriminate dumping of human waste and solid waste into the rivers.

However, In order to have effective control of water pollution and quality management, the following preventive methods are suggested:

- ✓ The administration of water pollution control and management should be given a seat in the front row and remain in the hands of state or central government
- ✓ Scientific techniques should be adopted for the environmental control of catchment areas, rivers or stream.
- ✓ Environmentally and economical sustainable technological options, which can be efficiently operated and maintained, should be considered for waste management
- ✓ Industrial and community sanitation along with control and treatment of human and industrial waste are necessary to reduce water pollution. More than 95% of urban sewage is released into the near water way or field due to inadequate or lack of treatment plants in developing countries. More sewage water treatment plants should be installed in cities belts. The treated water can be reused. The best approach is to practice waste reduction in different sectors of human activity and to prevent pollution at the source itself. The industries which have tried to reduce waste by recycling materials or redesigning production processes and products have found that such measures actually save money.
- ✓ There is need for sustained cooperation among all the 'waste stakeholders' (government, waste manager and waste generator) in implementing a safe and reliable method both in domestic and industrial waste management strategy, not only in legislation and policy formation but also particularly in monitoring and enforcement.
- ✓ Waste dump sites should be located far away from river bodies
- ✓ Environmental education at various levels, schools, markets, religious centers and industry should be encouraged.

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First Author (Olalekan Opeyemi Ikotun), holds a B.Tech (Hons) and MSc degrees in civil engineering from Ladoke Akintola University of Technology, Ogbomoso, Nigeria and University of Ibadan, Ibadan, Nigeria respectively. He is currently working on his Doctoral Degree and he has a number of publications in both local and international journals.

Second Author (Oladipupo Stephen Olafusi), holds a B.Tech (Hons) and MSc degrees in civil engineering from Ladoke Akintola University of Technology, Ogbomoso, Nigeria and University of Ibadan, Ibadan, Nigeria respectively. He is currently working on his Doctoral Degree and he has a number of publications in both local and international journals.

Third Author (Habeeb Adedeji Quadri), holds a B.Tech (Hons) and MSc degrees in civil engineering from Ladoke Akintola University of Technology, Ogbomoso, Nigeria and University of Ibadan, Ibadan, Nigeria respectively. He has a number of publications in both local and international journals.

Fourth Author (Oluwaseun Ayoola Bolarinwa), holds a B.Tech (Hons) and MSc degrees in civil engineering from Ladoke Akintola University of Technology, Ogbomoso, Nigeria and University of Ibadan, Ibadan, Nigeria respectively.

Table 1. Sample Location

SITE	LOCATION	GPS LOCATION	ELEVATION	AREA DESCRIPTION
A	LAFENWA	N07^{0}08.932^{I} E003^{0}19.598^{I}	47m	Abattoir
B	LAFENWA	N07^{0}09.196^{I} E003^{0}19.659^{I}	34m	Market
C	AKINOLUGBADE	N07^{0}08.869^{I} E003^{0}19.685^{I}	40m	Municipal Area
D	LAFENWA	N07^{0}08.963^{I} E003^{0}19.437^{I}	42m	Brewery
E	WATERWORKS	N07^{0}11.401^{I} E003^{0}20.375^{I}	33m	Residential/Commercial Area
F	ISABO	N07^{0}09.030^{I} E003^{0}20.793^{I}	67m	Municipal Area
G	ORBADA	N07^{0}3.344^{I} E003^{0}16.164^{I}	24m	Residential Village

All location in Ogun state, Nigeria

Table 2: Physico-chemical analysis of water samples collected from Ogun River during the dry season (January –February, 2011)

	SITES						
Parameters	A	B	C	D	E	F	G
Temperature	31.3	31.7	30.85	30.3	31.5	30.7	30.5
pH value	6.5	7.1	7.1	7.5	7.3	7.4	7.3
Dissolved Oxygen	6.5	6.0	5.6	6.4	6.0	5.6	3.9
Conductivity	239	159.5	236.6	166.7	275	190.5	186
Color	30	17.5	10	15	12.5	12.5	12.5
Odour	Objectionable						
Turbidity	20.9	9.9	6.6	6.9	11.8	7.1	4.9
Total Solid	235	167.5	197.5	135.1	223.3	202.3	193
Total Suspended	121	87.7	104.8	62.5	98.4	100.1	107.5
Total dissolved solid	114	79.8	92.7	72.7	124.9	102.2	86
Acidity	0.35	0.1	0.1	0.1	0.1	0.15	0.1
Total Hardness	63	40	31	27	36	34	28
Calcium Hardness	41	27	21	19	44.5	24	14.5
Magnesium Hardness	22	20	18	9.5	25.5	19	13.5
Chloride	104.5	80	68.4	52.5	29.3	93.5	63
Iron	1.79	1.21	1.21	0.33	0.23	0.95	0.12
Nitrate	3.91	1.71	1.61	0.82	3.32	2.15	1.35
Sulphate	5.86	5.55	4.86	3.15	3.88	5.05	3.0
Chromium	0.07	0.04	0.02	0.03	0.02	0.02	0.01
Manganese	Nil	Nil	Nil	0.02	Nil	0.08	0.02
Copper	0.085	0.055	0.04	0.06	0.095	0.035	0.01
Phosphate	0.95	0.81	0.7	0.69	0.74	0.75	0.4
Chloride Residual	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Bacterial count /100ml	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
E-coli (24hrs)	>160	>160	>160	>160	>160	>160	116

All results in mg/l (except electrical conductivity in µs/cm, temperature in 0C and turbidity is in NTU)

TNTC implies too numerous to count

Table 3: Result of physico-chemical analysis of water collected from Ogun River for rainy season (March – April, 2011)

	SITES						
Parameters	A	B	C	D	E	F	G
Temperature	26.4	23.7	24.5	25.6	27.3	27.4	29.5
pH value	7.49	7.52	7.6	7.5	7.7	7.35	7.18
Milli volt	Nil	4.35	-10.95	0.5	-1.15	-11.1	27.3
Dissolved oxygen	7.30	7.21	7.38	7.39	7.15	7.71	4.1
Conductivity	226.5	109.4	100.75	179.7	220.9	184	70
Color	20	17.5	15	20	20	20	12.5
Odour	Objectionable						
Turbidity	19.05	8.54	7.96	12.13	16.95	5.55	3.9
Total solid	205.3	183.05	207.9	150	169.9	214.0	108.48
Total suspended	106.5	54.4	60.15	61.55	63.85	52.9	59.05
Total dissolved solid	98.8	128.65	147.75	88.45	106	161.1	49.4
Acidity	0.2	0.1	0.15	0.1	Nil	0.1	0.2
Alkalinity	Nil	Nil	Nil	Nil	0.1	Nil	Nil
Total hardness	77	68	78.5	48.5	61	70.5	20
Calcium hardness	44.5	41	59.5	22	30.5	46.5	13.5
Magnesium hardness	34	41	14.5	25.5	26	22	5.5
Chloride	99	66	101	68.5	86.5	86	31
Iron	2.26	1.02	0.90	0.91	2.3	1.85	0.16
Nitrate	3.3	0.66	3.25	2.89	2.55	3.0	1.15
Sulphate	4	2	4.2	3.5	2.85	3.6	2.5
Chromium	0.07	0.05	0.04	0.5	0.41	0.06	0.03
Manganese	0.1	0.10	0.39	0.39	0.08	0.39	0.06
Copper	0.41	0.29	0.54	0.61	0.31	0.11	0.05
Phosphate	0.82	0.74	0.45	0.79	0.38	0.32	0.20
Chloride residual	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Bacterial count /100ml	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
E-coli (24hrs)	>160	>160	>160	>160	>160	>160	140

Result in mg/l except electrical conductivity in µs/cm, temperature in 0C and turbidity in NTU

TNTC implies Too Numerous To Count

Table 4. World Health Organization Drinking Water Standards

Parameter	Highest Desirable Level	Maximum Permissible Level
Total solid	500	1500
Color (pt co)	5	50
Taste	Unobjectionable	_
Odour	Unobjectionable	_
Turbidity (NTU)	5	25
Chloride	200	600
Iron	0.1	1
Manganese	0.05	0.5
Copper	0.05	1.5
Zinc	5	15
Calcium	75	200
Magnesium	30	150
Sulphate	200	400
Total hardness (CaCO3)	100	500
Nitrate	45	500
Ammonium	_	_
pH (unit)	7- 8	Min 6.5 Max 9.2

Source: WHO (1971)

Concentration in mg/l except where noted

Figure 1. Slaughtering of cow in Abeokuta abattoir

Figure 2. Washing parts of slaughtered Cow in Ogun river

Figure 3. Isabo site in Abeokuta, Ogun State

Figure 4. Collection of Sample on Isabo site in Abeokuta, Ogun state