PHYSICOCHEMICAL PARAMETERS OF OGUN RIVER SAMPLED AT SELECTED POINTS DURING THE RAINY SEASON

Dedeke, G. A.*, Iwuchukwu, P. O.**, Oladosu, O. O.**, Aladesida, A. A.**, Afolabi, T. A.***, Bamgbola, A. A.*** and Ayanda, O. I.*

* Department of Biological Sciences, Covenant Univerity, Idiroko Road, Ota, Ogun State, NIGERIA. E-mails: gabriel.dedeke@covenantuniversity.edu.ng; opeyemi.ayand@ covenantuniversity.edu.ng
** Department of Pure and Applied Zoology, College of Biosciences, Federal University of Agriculture, Abeokuta, Ogun State, NIGERIA. E-mails: princewill.chukwu@gmail.com; williamsolaide48@gmail.com; aaladesida@gmail.com
*** Department of Chemistry, College of Physical Sciences, Federal University of Agriculture, Abeokuta, Ogun State, NIGERIA. E-mails: niyiafo@yahoo.com; bamgbolaaa@ funaab.edu.ng

ABSTRACT: The river system constitutes a major source of freshwater supply and no human or animal can survive without it on earth as it constantly replenishes the fluids lost through normal physiological activities like respiration. The study was designed to determine the physicochemical parameters of Ogun River at some selected points; Iberekodo, Ago Ika, Enugada, Sokori and Arakanga in Abeokuta. Sampling was conducted during the rainy season over a period of four months from May to August. Water and sediment samples were collected from the different points. The sediments were collected few distances away from the shore using a grappler. The pH and temperature of the river water was done in-situ using a digital pocket pH meter and mercury glass thermometer respectively. Total Dissolved Solids and Electrical conductivity was done in-situ using a digital pocket pH meter. Nitrate and phosphate was determined using H83200 multiparameter HANNA instrument. Dissolved Oxygen (DO) was determined using Winklers method. All sampling were replicated thrice. The pH and phosphate ranges obtained in this study were higher than all the standards; water temperature, TDS, BOD, Nitrate, and EC ranges were below the standards. The DO was within the standards with a higher upper limit. In conclusion, going by this study, though Ogun River was not heavily polluted compared to the standards of WHO and NESREA, fluctuation of the investigated parameters at the sampling sites could therefore be as result of constant dilution of the river by rainfall and on-going daily human activities at the sites.

KEY WORDS: Ogun River, physicochemical, rainy season, total dissolved solids

The River system constitutes a major source of freshwater supply and no human or animal can survive without it on earth as it constantly replenishes the fluids lost through normal physiological activities like respiration (Chinedu et al., 2011). Bamgbose and Arowolo (2007) reported that river system is needed to maintain ecological balance and for economic development. It is a system that is full of life and therefore serves as habitat for both living and non-living organisms (Murheka, 2011).

However, this valued resource is threatened as human population grows and the demand for more quality water for domestic purposes and economic activities increases (Okechukwu et al., 2012). Invariably, loads of dissolved and particulate

matter carried from different sources (Etim & Adie, 2012) introduce different kind of pollutants (such as heavy metal, persistent organic pollutant, dioxins etc) into it.

River Ogun is one of the main rivers in south western Nigeria with a total area of 22.4 km² (Oketola et al., 2013). The Ogun River flows through Abeokuta and serves as sources of water supply for agriculture, transportation, human consumption, various industrial activities and domestic purpose. This river constantly receives effluents from slaughterhouse, dye industries, galvanising industries and domestic wastewater which contribute to accumulation of pollution in the river and increase the level of pollutants {since heavy heavy metals are not the only pollutants introduced from the sourses mentioned} (Dimowo, 2013).

In the past, only industrial effluents are of major concern but researches have shown that human activities (such as sewage disposal, solid waste dump) and agricultural (fertilizers, pesticides) effluents can cause as much pollution in freshwater bodies. (Olalekan et al., 2012; Odukoya, 2000). Chemicals from agricultural activities enter freshwater bodies via aerial drift and runoffs after heavy rains while those from human activities mostly enter freshwater bodies via waste water treatment facilities (Basopo et al., 2014; Ghoochani et al., 2011; Danazumi & Bichi, 2010). The impact of these pollutants on aquatic ecosystem cause deleterious effects on aquatic life (Sankpal & Naikwade, 2012; Nyamangara et al., 2008).

Aquatic bodies being the final sink receives effluent from different sources and these chemical pollutants exert various biochemical effects on the wellbeing of aquatic biota. The pollutants interact additively, antagonistically or synergistically amongst themselves which affect their overall effect on the aquatic biota (Basopo et al., 2014). Pollutants such as heavy metals are highly reactive as reported by Anna (2011) and have the ability to disturb various cellular and metabolic processes (Inyang et al., 2010). Reactive oxygen species (ROS) whose roles are important in animal physiological activities is affected by these pollutants. There is therefore, the need to monitor the effects of chemical pollutants on aquatic ecosystem to safeguard its health.

Different tools and scientific procedures are available for assessing water contaminants (Dissmeyer, 2000). Some of the parameters these procedure analyze include temperature, pH, turbidity, total suspended solids (TSS), total dissolved solids (TDS), total suspended solids (TSS), total organic carbon (TOC), and heavy metals. These parameters can affect the quality of water, if their values exceed concentrations of safe limits set by the World Health Organization (WHO) and other relevant regulatory agencies (WHO, 2011). As a result, ensuring the control of the quality of water is a topmost agenda in many parts of the world. The quality of water and its suitability for use are determined by its odor, colour, taste, and concentration of inorganic and organic and matters (Dissmeyer, 2000). When contaminants are present in water, the water quality is compromised and more importantly, human health.

Water quality and biota are vulnerable to anthropogenic activities and as stated by Etim & Adie (2012), there is the need to continually investigate the quality of water and condition of aquatic biota. Studies have shown that Ogun River is highly contaminated with various pollutants (Dimowo, 2013; Etim & Adie, 2012; Olalekan et al., 2012). The evaluation of risk factor associated with these pollutants is a major problem (Grara et al., 2012) and there is the need to demonstrate the relationship between exposure to pollutants and water quality.

This study was designed to determine the physicochemical parameters at some selected points of Ogun River.

MATERIALS AND METHODS

Study Area

The study was carried out in Abeokuta, Ogun State. Ogun River is a waterway in Nigeria that discharges into the Lagos Lagoon. The river rises in Oyo State near Shaki at coordinates 8°41′0″N and 3°28′0″E and flows through Ogun State into Lagos State (Ayoade et al., 2004). Five sites were chosen on the river namely Iberekodo, Ago Ika, Enugada, Off Pepsi Bus stop (Sokori) and Arakanga, all in Abeokuta, Ogun State. (Fig. 1).

Description of the Study Sites

Ago Ika site was located close to the FADAMA III supported ferry for transportation to Lafenwa. The vegetation around the banks is very dense. Residential houses, market and abattoir are very close to this site. The activities here includes: locust bean processing, bathing, washing of clothes and animal processing, refuse dumping, fishing and transportation by canoe. Farmland was observed at this sample site. **Enugada site** was located some few steps after the bridge connecting to Lafenwa. It is characterized by less dense vegetation. Residential houses are close to this site. Clothes washing, indiscriminate dumping of refuse as well as human defecating are some of the activities that takes place in this site. **Sokori site** was characterized by dense marshland. Residential houses, abattoir, mechanic workshop and farmland are close to this site. Water used in hides processing is washed into the river at this site. **Arakanga site** was located near Iberekodo. It is characterized by dense vegetation. Some residential houses were located nearby. No farmland and any other activities were noticed here. **Iberekodo site** was located immediately after Ogun State Water Works. The river was dammed at this site with spillway and high concrete dykes. The main activity at this site was fishing. There was no observable farmland nearby.

Sampling Procedures: Water samples were collected in polythene bottle of 750mL capacity which was thoroughly washed and rinsed with distil water. The bottles were emptied and rinsed with the water to be collected. The water was collected by lowering the polythene bottle beneath the water level as described by (Rice, 2012); thus, allowing water to flow into the bottle against water current of the river. Sediments samples were collected at various safe zones of the river with.

Determining Physico-Chemical Parameters of River Ogun

Physicochemical parameters such as pH, water temperature (°C), electrical conductivity (μS/cm) and total dissolved solid (mg/L) were measured *in-situ* with the use of HANNA Combo pH and EC multi meter Hi 98129 inserting the meter into a sample of water collected in a 25mL beaker.

Determining Nitrate (NO_3) and Phosphate (PO_3)

This was carried out in the chemical science department of College of Natural Science of the Federal University of Agriculture using the HI 83200 Multi parameter photometer HANNA Instrument. The following steps were used to carry out the process of determining nitrate and phosphate.

➢ 100mL of sample (coloured) was poured in a beaker

➢ A little quantity of decolourizing and de-odourizing charcoal was added to the sample and mixed thoroughly.
➢ Using a filter paper, a clean filtrate is filtered out.
➢ 10mL of the filtrate is carefully poured in to the cuvette of the instrument for zeroing for the required parameter (NO_3 or PO_3).
➢ After which the corresponding chemical is added to the filtrate in the cuvette and shaken thoroughly for the required amounts of time, before inserting into the cuvette space to obtain result.

Dissolved Oxygen (DO) (mg/L) and Biological Oxygen Demand (BOD) (mL^{-1}) Assay

Analysis to reveal quantity of oxygen present in a sample of water at the time of sampling was carried out in the Water Resource Management Department of the College of Environmental Management of the federal University of Agriculture, Abeokuta. To determine the level of DO and BOD the standard alkaline azide modification of Winkler's method was employed.

➢ Water samples were collected in a 300mL polythene bottle.
➢ 2mL of both Manganesse sulphate ($MnSO_4$) and alkali iodide reagent were added to the sample.
➢ The mixture was mixed by inverting the bottle a number of times, after which mixture was allowed to settle until a clear supernatant was obtained.
➢ 2mL of concentrated hydrogen tetraoxosulphate VI acid was added. Gentle mixing by inverting the bottle to allow complete dissolution of mixture. A golden brown colour was obtained after proper dissolution is done.
➢ 200mL of the sample was poured into a 250mL conical flask
➢ 0.025M sodium thiosulphate ($Na_2S_2O_3$. $5H_2O$) was titrated to sample, titration was done a drop- wise form till a pale straw colour is observed.
➢ 2mL of starch solution was added, thus the ensuing colour turns blue, titration was continued by adding $Na_2S_2O_3$. $5H_2O$ in a drop- wise form till the blue colour disappears and a clear solution is obtained. (Note: the starch was used as an indicator).
➢ Initial and final readings were recorded.

DO (mL^{-1}) was calculated as: $\dfrac{(final - initial)*0.025*8000}{200}$

Note: BOD analysis was carried out after the samples were stored after five days in the dark.

RESULTS

Displayed in Table 1 is the coordinates of the sampling sites on Ogun River over the period of four months; they all fell within 3°14′20.73″E and 7°11′20.85″N.

Physicochemical parameters of water samples

The mean concentrations of physicochemical parameters at each sampling site are presented in Table 2.

The mean concentration of temperature across the sampling sites ranged from 28.00 °C to 29.15 °C. The least value was observed at Iberekodo and the highest

value recorded at Ago Ika. There was no significant difference (p>0.05) in the temperature recorded from all the sampling sites.

The hydrogen ion concentration (pH) mean ranged from 7.42 and 7.60. The lowest value was recorded at Sokori while the highest pH was recorded at Arakanga and Ago Ika. Ago Ika and Enugada had the same value of 7.58. There was no significant difference (p>0.05) in the pH recorded from all the sampling sites. All the sites were observed to be slightly alkaline.

The mean concentration of Total Dissolved Solid (TDS) across the sampling sites ranged from 56.50 mg/L to 85.23 mg/L. The least concentration was observed at Enugada while the highest concentration was recorded at Ago Ika. Significant difference (p<0.05) was observed between Sokori and other sampling sites.

Nitrate mean concentration ranged from 6.82 mg/L to 12.81 mg/L. The highest was recorded at Sokori while the lowest was observed at Ago Ika. Significant difference (p<0.05) was observed across the sampling sites.

Water samples collected at Ago Ika had the highest concentration (1.50 mg/L) of phosphate while the least average concentration was recorded in water samples collected at Arakanga. There was no significant difference (p>0.05) in phosphate level of samples collected from all the sampling sites.

Dissolved Oxygen (DO) ranged from 5.51 mg/L to 7.11 mg/L with the lowest values recorded in water samples collected at Enugada and highest values recorded in water samples collected at Arakanga. There was no significant difference (p>0.05) observed from all the sampling sites.

Lowest BOD (3.32 mg/L) values was recorded in water samples collected at Ago Ika and Sokori while highest value (4.71 mg/L) recorded in water samples collected at Arakanga. There was no significant difference (p>0.05) in all the sampling sites.

Average value of Electrical conductivity (EC) obtained ranged from 135.75 μmho/cm to 168.25 μmho/cm with the lowest values recorded in water samples collected at Ago Ika and highest values recorded in water samples collected at Sokori. There was no significant difference (p>0.05) in all the sampling sites.

The comparison of the ranges of physicochemical parameters in this study with selected water quality standards was shown in Table 3. The pH and phosphate ranges obtained in this study were higher than all the standards; water temperature, TDS, BOD, Nitrate, and EC ranges were below the standards. The DO was within the standards with a higher upper limit.

Trend of Physicochemical parameters of water samples during study period

The trend of physicochemical parameters of water samples during the study period are presented in Figures 2 to 9.

Ago Ika, Enugada and Sokori showed a slight increase in temperature from May to June, a decrease from June to July and a slight increase in the month of August. In Arakanga, temperature decreased from May to July and later increase in August. Iberekodo showed an increase from May to June which later decreased from June to August. June had the highest value for temperature while July had the least value.

Ago Ika, Iberekodo and Sokori revealed the same trend in pH as shown in Figure 3. A slight decrease from May to June which later increased from June to August. A similar trend was observed in Enugada but a decrease was noticed between July and August. Arakanga showed an increase from May to August.

TDS data revealed an increase from May to June, decrease from June to July and an increase between July and August in Enugada, Arakanga and Sokori. In Ago Ika, there was an increase from May to July and a decrease in August. Iberekodo showed a decrease from May to July and stabilized between July and August.

The nitrate level of Arakanga and Sokori increased betweenMay and June, decreased from June to July and increased in August. In Enugada and Iberekodo, nitrate levels decreased from May to June, slightly increased from June to July and decreased from July to August. In Ago Ika, it increased from May to July and decreased in August (Fig. 5).

The phosphate levels across the months is shown in Figure 6. It was revealed that In Arakanga and Ago Ika , there was a decrease in phosphate levels between May and August while in Enugada, there was a slight increase from July to August.

Dissolved Oxygen (DO) values across the months is shown in Figure 7. In Sokori and Ago Ika, there was a decrease between May and June, an increase from June to July and later, a decrease in August. In Enugada and Arakanga, dissolved oxygen decreased between May and June and increased from June to August.

Result for Biological Oxygen Demand (BOD) is shown in Figure 8. This parameter decreased between May and June in all the sampling sites except at Iberekodo. In Sokori and Iberekodo, it decreased between June and July while there was increase at Enugada, Arakanga and Ago Ika. In Enugada, Sokori and Ago Ika, Biological Oxygen Demand was observed to increase between July and August while in Iberekodo and Arakanga, it decreased.

Electrical Conductivity as shown in Figure 9 increased increased from May to July in Ago Ika and Arakanga then decreased from July to August while in Iberekodo, Sokori and Enugada it increased from July to August.

DISCUSSION

The importance of monitoring the levels of physico-chemical parameters in the aquatic ecosystem, in order to ensure they are within the range recommended by regulating bodies cannot be overemphasized. Temperature is an important biologically significant factor which plays an important role in the metabolic activities of organism (Murhekar, 2011). The maximum value for temperature fell within the permissible limits of WHO (2011) and NESREA (2011) in (Table 7). The temperature from this present study is similar to that obtained by Etim and Adie (2012) and Murhekar (2011) who reported temperature range of 27.00 - 33.70 ^{o}C and 26.00-29.00 ^{o}C on Ogun River and Akot surface water respectively. The temperature difference of any aquatic habitat is affected by weather and the extent of direct exposure to sunlight. Also, biodegradation of organic matter that enter the water may increase heat (Nwanko et al., 2014). The natural and anthropogenic inference in the river course may be responsible for the temperature variation across the months.

All the water samples from the sampling sites were slightly alkaline, however, they fell within the maximum permissible limit of WHO (2011) and NESREA (2011). The pH values obtained in this study were similar to that reported by Olalekan et al. (2012) and Alani et al. (2014) for Ogun River (7.18-7.70 and 7.00-7.89 respectively). Caustic soda from soaps and detergents from washed materials may have been the cause of increased pH (Ekhaise & Anyasi, 2005). Variation in pH values across the months could be due to the dissolution of CO_2 by rain water

(Ali et al., 2013). The observed slightly acidic nature at Iberekodo in May could be due to existence of compounds like chloride of iron or aluminium, which hydrolyze in excess water to produce solution which may have affected the pH (Akubugwo & Duru, 2011).

TDS result obtained from this study (Table 4) fell below the permissible standard limit of WHO (2011) and NESREA (2011). These findings are not in line with Pandey and Tiwari (2009) who reported TDS values that ranged from 145 to 245 mg/L of ground water. TDS values from this study are comparable with that of Akubugwo and Duru (2011) who reported TDS`range of 49.00 mg/L to 70.00 mg/L on Otamiri River. The observed TDS in this study could be due to the presence of large number of organic salts as carbonate, bicarbonate, sodium, potassium and calcium that flow into the river (Farombi et al., 2014).

Though the mean values for nitrate (6.82 mg/L to 12.81 mg/L) were found to be above the expected concentration range of 0.1 mg/L for natural unpolluted waters, it was found to be below the permissible limit of WHO (50 mg/L). The level of nitrate observed in this study is in line with the findings of Ali et al. (2013) on *Lymnaea luteola*. The higher concentration of nitrate observed at Sokori and Iberekodo might have been due to human activities such as agricultural activities near the river, discharge of domestic sewage and other organic waste materials. The mean values for nitrate was observed to be below the maximum permissible limit of 50 mg/L by the WHO (2011).

The element phosphorus is necessary for plant and animal growth. This study is in agreement with the study of Okechukwu et al. (2012) and Olalekan et al. (2012) who reported phosphate concentration ranges of 0.61-1.06 mg/L and 0.19 mg/L to 2.00 mg/L respectively in Ogun River. The result obtained in this study (0.56mg/L to 1.50 mg/L) is far above the permissible standard limit of NESREA (2011) (0.05), an indication that theriver is polluted. The high phosphate values obtained from the study could be attributed to the phosphorus in runoffs from domestic, municipal, agricultural and laundry wastes flonwing into the river (Olalekan et al., 2012). The higher phosphate concentration observed at Ago Ika area of Ogun River may be attributed to direct disposal of laundry wastes into the river. The report of Himangshu et al. (2012) pointed out that detergents and soap contents of laundry wastes give rise to high amount of phosphate in the aquatic environment.

Dissolved oxygen is very crucial for survival of aquatic organisms and it is also used to evaluate the degree of freshness of a river (Fakayode, 2005). The DO from this study fell below the 6 mg/L recommended for unpolluted water except in Arakanga. As DO levels in water drops below 5 mg/L, aquatic life is put under stress and the lower the concentration, the greater the stress. Common practice of waste dumping (domestic and industrial) and agricultural activities along the bank of the river could support depletion of oxygen. The DO values (5.51 mg/L to 7.71 mg/L) obtained in this study agrees with the report of Umunnakwe *et al.* (2011) for Nworie River.

Biological oxygen demand (BOD) is a standard water treatment test for the presence of organic pollutants and directly shows the presence of degradable organic matter by microbial metabolism (Akubugwo & Duru, 2011). The BOD values recorded in this study were lower than the recommended WHO standard (6 mg/L). Adakole et al. (2002) categorized BOD water values as unpolluted (BOD<1.0 mg/L), moderately polluted (BOD<10.0 mg/L) and heavily polluted (BOD>10.0 mg/L). The BOD values were high probably due to discharge of domestic wastes especially defecation activities and poorly executed agricultural activities near the river banks which was observed during survey of study sites

(Kolawole et al., 2011). BOD values decreased in all in June except at Iberekodo, this could be as aresult of massive amount of waste flowing into the river after rainfall. The result of this study is in line with the findings of Agbaire and Obi (2009) who reported BOD range of 2.9-5.8 mg/L on Ethiope River.

Electrical Conductivity is an indicator of how salt- free, ion-free or impurities free a water sample is (Aktar et al., 2010). Conductivity values depends on the total concentration of ionized substances and the temperature of the water, during rainy season more dissolved solids and ions are introduced into aquatic environment from municipal run off, this could be the reason for higher conductivity values across the months (Farombi et al., 2014). The fluctuation in the values of conductivity could be due to variations in the rate of decomposition of organic matter and dilution from the enormous amount of rainfall and cleansing of the flooded water (Adeosun et al., 2014).

CONCLUSION AND RECOMMENDATION

Though Ogun River is not heavily polluted when compared to WHO standards since almost all the physicochemical index pollution were not affected. Fluctuation of the investigated parameters at the sampling sites could therefore be as result of the observed on-going daily human activities at the sites.

LITERATURE CITED

Adakole, J. A., Balogun, J. K. & Lawal, F. A. 2002. Water Quality Impacts Assessment Associated with an Urban Stream in Zaria, Nigeria. Nigerian Society of Experimental Biology Journal, 2 (3): 195-203.

Adeosun, F. I., Akin-Obasola, B. J., Jegede, T., Oyekanmi, F. B. & Kayode, J. O. 2014. Physical and Chemical Parameters of Lower Ogun River Akomoje, Ogun State, Nigeria. Fisheries and aquaculture Journal, 5: 1.

Agbaire, P. O. & Obi, C. G. J. 2009. Seasonal Variations of Some Physico-Chemical Properties of River Ethiope Water in Abraka, Nigeria. Applied Science of Environmental Management, 13 (1): 55-57.

Aktar, I. S., Ogundele, F. O. & Soladoye, O. 2010. Characterisation by factor analysis of chemical facies water in the coastal plain sand aquifers of Lagos, S.W, Nigeria. International Journal Academic Research, 5: 256-260.

Akubugwo, E. I. & Duru, M. K. C. 2011. Human activities and water quality: A case study of Otamiri River, Owerri, Imo State, Nigeria. Global Research Journal of Science, 1: 48-53.

Alani, R., Alo, B. & Ukoakonam, F. 2014. Preliminary investigation of the state of pollution of Ogun River at Kara abattoir, near Berger, Lagos. International Journal Environment Science Toxicology, 2 (2): 11-23.

Ali, M. Z., Adelanwa, M. A. & Tanimu, Y. 2013. Physico-Chemical Characteristics and Phytoplankton Abundance of the Lower Niger River, Kogi State, Nigeria. Journal of Environmental Science, Toxicology and Food Technology, 2 (4): 31-37.

Anna, J., Piotr, K., Skora, K. & Jacek, N. 2011. Bioaccumulation of metals in tissues of marine animals, part II. Metal concentration in Animal tissues. Pollution Journal of Accruement, 20 (5): 1127-1146.

Ayoade, A. A., Sowunmi, A. A. & Nwachukwu, H. I. 2004. Gill asymmetry in Labeo ogunensis from Ogun River, Southwest Nigeria. Revised Biology Tropical, 52 (1): 171-175.

Bamgbose, O. O. & Arowolo, T. A. 2007. Water quality assessment of Ogun River, South west Nigeria. Environmental monitoring and assessment, 2: 473-478.

Basopo, N., Mumbamarwo, L. T., Mnkandla, D. & Yogeshkumar, S. N. 2014. Pollutant mixtures as stressors of selected enzyme activities of the aquatic snail, *Helisoma duryi.* Journal of Environment Chemistry and Toxicology, 6 (4): 27-37.

Chinedu, S. N., Nwinyi, O. C., Adetayo, Y. O. & Eze, V. N. 2011. Assessment of water quality in canaanland, Ota, Southwest Nigeria. Agriculture Biology Journal, 2 (4): 577-583.

Danazumi, S. & Bichi, M. H. 2010. Industrial pollution and implication on source of water supply in Kano, Nigeria. International Journal Engineering Technology, 10 (3): 464-469.

Dimowo, B. O. 2013. Assessment of some physico-chemical parameters of River Ogun (Abeokuta, Ogun state, Southwestern Nigeria) in comparison with National and International standard. International Journal of Aquaculture, 3 (15): 79-84.

Ekhaise, F. O. & Anyasi, C. C. (2005). Influence of breweries effluent discharge on the microbiological and physicochemical quality of Ikpoba River, Nigeria. African Journal of Biotechnology, 4 (10): 1062-1065.

Etim, E. U. & Adie, G. U. 2012. Assessment of Qualities of Surface Water, Sediments and Aquatic Fish from Selected Major Rivers in South-Western Nigeria. Research Journal of Environmental and Earth Sciences, 4 (12): 1045-1051.

Fakayode, S. O. 2005. Impact Assessment of Industrial Effluent on Water Quality of the Receiving ALaro River in Ibadan, Nigeria. Ajeam-Ragee, 10: 1-13.

Farombi, A. G., Adebayo, O. R., Olagunju, E. O. & Oyekanmi, A. M. 2014. Variation in abiotic conditions of water quality of River Osun, Osun State, Nigeria. African Journal of Environmental Science and Technology, 8 (5): 283-288.

Farombi, E., O., Adelowo, O., A. & Ajimoko, Y., R. 2007. Biomarkers of oxidative stress and heavy metal levels as indicator of environmental pollution in African catfish (*Clarias gariepinus*) from Nigeria Ogun River. International Journal of Environmental Research and Public Health, 4: 158-165.

Ghoochani, M., Shekoohiyan, S., Mahri, A. H., Haibati, B. & Norouzi, M. 2011. Determination of detergent in Tehran ground and surface water. Journal of Agricultiure and Environnmental Science, 10 (3): 464-469.

Grara, N., Atailia, A., Boucenna, M., Berrebbah, H. & Djebar, M. R. 2012. Toxicity of metal dust from Annaba steel complex (Eastern Algeria) on the morpho physiological parameters of the snail (*Helsix aspersa*). Advances in Environmental Biology, 6 (2): 605-611.

Himangshu, S. M., Amrita, D. & Ashis, K. N. 2012. Study of some physicochemical water quality parameters of Karola River, west Bengal. An attempt to estimate pollution status. International Journal of Environment and Protection, 2 (8): 16-22.

Inyang, I. R., daka, E. R. & Ogemba, E. N. 2010. Changes in electrolyte activities Clarias gariepinus exposed to diazinon. Journal Tropical Biology Environmental Sciences, 7: 198-200.

Kolawole, O. M., Kolawole T. A., Albert, B. O. & Okoh, A. I. 2011. Assessment of Water Quality in Asa River (Nigeria) and Its Indigenous *Clarias gariepinus* Fish. International Journal of Environmental Research and Public Health, 8: 4332-4352.

Murhekar, G. H. 2011. Determination of Physico-Chemical parameters of Surface Water Samples in and around Akot City. International Journal Research Chemistry and Environment, 1 (2): 183-187.

Nigeria Environmental Standard and Regulatory Enforcement Agency (NESREA). 2011. Guidlelines and Standards for environmental pollution control in Nigeria, Abuja, Nigeria.

Nwanko, C., Mohammed, A., Ikyereve, R. E. & Dawari, B. 2014. The impact of human water exploitation on physicochemical characteristic of Mmubete River in the Niger Delta, Nigeria. International.Journal Science Technology, 3 (5): 292-297.

Nyamangara, J., Bangira, C., Taruvinga, T., Masina, C., Nyemba, A. & Ndlovu, D. 2008. Effects of sewage and industrial effluent on the concentration of Zn, Cu, Pb and Cd in water and sediments along waterfalls stream and lower Mukuvisi River in Harare, Zimbabwe. Physis and Chemistry Earth, 33: 708-713.

Odukoya, O. O. 2000. Pollution trend in Ogun River, Abeokuta, Nigeria. Nigeria Journal of science, 34 (2): 183-186.

Okechukwu, M. E., Ogwo, V., Onuegbu C. U. & Mbajiorgu C. C. 2012. Water Quality Evaluation of Spring Waters in Nsukka, Nigeria. Special Publication of the Nigerian Association of Hydrological Sciences, pp. 224-230.

Oketola, A. A., Adekolurejo, S. M. & Osibanjo, O. 2013. Water quality assessment of Ogun River using multivariate statistical techniques. Journal Environmental Pollution, 4: 466-479.

Olalekan, O. I., Oladipupo, S. O., Habeeb, A. Q. & Oluwaseun, A. B. 2012. Influence of Human activities on the water quality of Ogun River in Nigeria. Civil and environmnental research, 2 (9): 36-48.

Pandey, S. K. & Tiwari, S. 2009. Physicochemical analysis of ground water of selected area of Ghazipur city- A case study. Nature Science, 7 (1): 17-20.

Samir, M. S. & Shaker, I. M. 2008. Assessment of heavy metals pollution in water and sediments and their effect on Oreochromis niloticus in the Northern Delta lakes, Egypt. Abbassa International Journal Aquaculture, (1B): 475-490.

Sankpal, S. T. & Naikwade, P. V. 2012. Heavy metal concentration in effluent discharge of pharmaceutical industries. Science Research Reporter, 2 (1): 88-90.

Umunnakwe, J. E., Nnaji, A. O. & Ejimmaduekwu, P. I. 2011. Preliminary Assessment of Some Physicochemical Parameters During Dredging of Nworie River, Owerri. Pakistan Journal of Nutrition, 10 (3): 269-273.

USEPA. 1999. National recommended water quality criteria-Correlation: EPA 822/Z-99-001. United State Environmental Protection Agency, Washington DC.

WHO. 2011. World Health Organisation, Guidelines for Drinking Water-Quality (4th Edition), Geneva, Switzerland.

Zhoua, Q., Zhanga, J., Fua, J., Shia, J. & Jiang, G. 2008. Biomonitoring: An appealing tool for assessment of metal pollution in the aquatic ecosystem. Analytica Chemical Acta, 6 (6): 135-150.
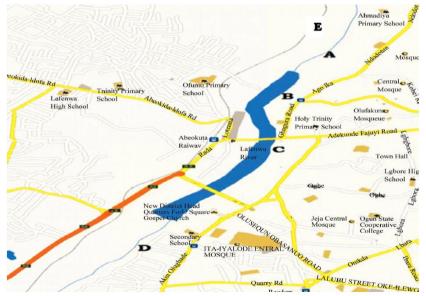
Figure 1. Map of Ogun River showing sampling sites
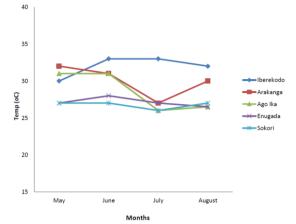Legend: A-Iberekodo; B-Ago Ika; C-Enugada; D-Sokori and E-Arakanga

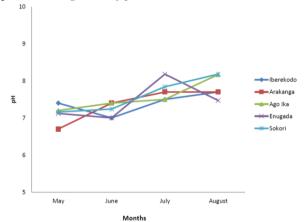Figure 2. Temperature during the study period.
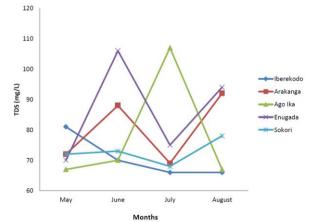

Figure 3. pH during the study period.

Figure 4. Total Dissolved Solids during the study period.
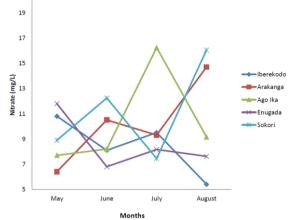
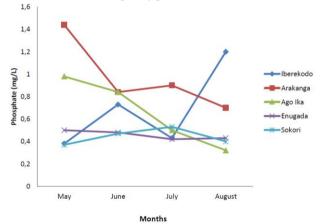Figure 5. Nitrate concentration during study period.

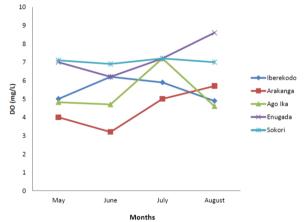Figure 6. Phosphate concentration during study period.

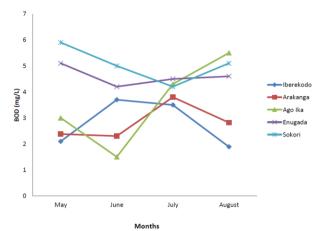Figure 7. Dissolved Oxygen during study period.

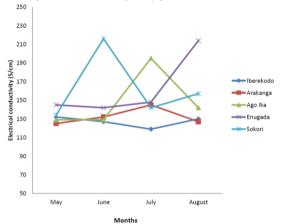Figure 8. Biological Oxygen Demand during study period.

Figure 9. Electrical Conductivity during study period.

Table 1. Co-ordinates of the sampling sites.

Month/sample site	Iberekodo	Arakanga	Ago Ika	Enugada	Sokori
May	7°11′20.85″N and 3°19′54.85″E	7°11′08.13″N and 3°14′20.73″E	7°09′43.85″N and 3°19′43.89″E	7°09′18.03″N and 3°19′45.88″E	7°08′55.95″N and 3°19′32.04″E
June	7°11′19.64″N and 3°19′54.02″E	7°11′08.11″N and 3°20′00.77″E	7°09′43.54″N and 3°19′45.17″E	7°09′22.83″N and 3°19′44.53″E	7°08′56.27″N and 3°19′32.62″E
July	7°11′17.73″N and 3°19′54.41″E	7°11′08.13″N and 3°20′00.64″E	7°09′43.63″N and 3°19′45.16″E	7°09′22.93″N and 3°19′44.53″E	7°08′56.27″N and 3°19′32.62″E
August	7°11′17.74″N and 3°19′54.45″E	7°11′08.18″N and 3°20′00.19″E	7°09′43.57″N and 3°19′46.89″E	7°09′22.93″N and 3°19′44.54″E	7°08′56.35″N and 3°19′32.79″E

Table 2. Mean physico-chemical parameters at the selected sites along Ogun River.

Physicochemical parameters	Sites				
	Iberekodo (control)	Arakanga	Ago-Ika	Enugada	Sokori
Temperature (^{0}C)	28.00±2.87^a	28.56±2.98 ^{a}	28.75±3.15 ^{a}	29.15±2.74 ^{a}	28.13±2.17 ^{a}
pH	7.49±0.72^a	7.60±0.61^a	7.58±0.68^a	7.58±0.69^a	7.42±0.02^a
TDS (mgL^{-1})	74.03±13.82^b	70.00±2.94^b	85.23±22.53^b	56.50±33.21^a	76.20±21.86^b
NO$_3^-$ (mgL^{-1})	11.00±2.29^b	8.84±0.54^a	6.82±1.03^a	9.70±4.31^b	12.81±3.56^b
PO$_4^-$ (mgL^{-1})	0.86±1.02^a	0.58±0.30^a	1.50±1.40^a	0.81±0.48^a	0.56±0.19^a
DO (mgL^{-1})	5.80±1.22^a	7.71±1.22^a	5.89±1.32^a	5.51±1.90^a	5.81±1.39^a
BOD (mgL^{-1})	4.71±1.14^a	4.11±1.13^a	3.32±1.10^a	3.37±1.71^a	3.32±1.31^a
EC (μmho/cm)	137.00±8.12^a	137.00±8.12^a	135.75±7.23^a	139.75±15.26^a	168.25±42.57^a

Mean values in the same row having the same superscript are not significantly different (p>0.05)

Table 3. Selected water quality standard guidelines.

PARAMETER	USEPA(1999)	WHO(2011)	NESREA(2011)	This Study
pH	6.50-8.50	6.50-9.50	6.50-9.00	7.42-7.60
Water temperature (^{o}C)	-	40	< 40	28.00-28.75
TDS (mg/L)	500	1000	2000	56.50-85.23
DO (mg/L)	-	≥ 4	≥ 6	5.51-7.71
BOD (mg/L)	-	6	6	3.32-4.71
Nitrate (mg/L)	-	50	40	6.82-12.81
Phosphate (mg/L)	-	0.5	0.05	0.56-1.50
EC (μmho/cm)		1000	500	135.75-168.25

Note: USEPA - United States Environmental Protection Agency, WHO - World Health Organization and NESREA - Nigeria Environmental Standards and Regulations Enforcement Agency.

Plate 1. Pictures of the sampling sites: A- D. A (Enugada), B (Sokori), C (Ago Ika) and (D) Iberekodo sampling site of River Ogun.