

Full Length Research Paper

Study of heavy metals pollution and physico-chemical assessment of water quality of River Owo, Agbara, Nigeria

Kuforiji Titilope Shakirat^{1*} and Ayandiran Tolulope Akinpelu²

¹Department of Zoology, Faculty of Science, Lagos State University (LASU), P.O. BOX LASU 001, Ojo, Lagos, Nigeria.

²Department of Pure and Applied Biology, Faculty of Science, Ladoko Akintola University of Technology, Ogbomosho, Oyo State, Nigeria.

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The various selected physicochemical and biological condition of freshwater bodies which receive varying number of outfalls of industrial and domestic effluents containing heavy metals of River Owo, Agbara Industrial Estate, a boundary town between Lagos and Ogun state, along Badagry Expressway in Nigeria, was assessed for five consecutive months. Four sampling points were chosen from the water body to reflect the effect of industrial effluent, domestic effluent and lotic habitats. Temperature, pH, salinity, total alkalinity, total hardness (TH), total settle-able solids (TSS), dissolved oxygen (DO), turbidity, biochemical oxygen demand (BOD), ammonia, phosphate, chloride level, sulphate, nitrate, cadmium, chromium, copper, iron, lead, manganese zinc, colour were analyzed monthly between November 2007 and March 2008 using standard methods and procedures. The ranges of these factors were found to be comparable to the recommended limit of the Lagos State Environment Protection Agency (LASEPA) 2001 and the Federal Environmental Protection Agency (FEPA) except for biochemical oxygen demand (BOD), ammonia, phosphate, cadmium, chromium, lead, copper and Iron which were found in higher concentrations at sampling point B (effluent discharge point) above LASEPA, FEPA and Freshwater limit. DO of the three sampling points A, C and D were between recommended limit but slightly low at point B (effluent discharge point), which is less than the recommended limit. The level of pollution is more pronounced at sampling point B due to the greater amount of BOD and the release of some heavy metals like cadmium, chromium and lead which greatly affect the water quality of the river. The study concludes that River Owo is slightly polluted while the pollution is as a result from the discharge of effluents by the companies, factory and materials from other anthropogenic sources.

Key words: Industrial and domestic effluent, biochemical physicochemical condition oxygen demand (BOD), heavy metals, monitoring, anthropogenic sources.

INTRODUCTION

Water serves as a significant utility in irrigation of agricultural lands, generation of hydro-electric power, municipal water supply, fishing, boating and body-contact recreation, communication as well as unending

domestic activities of man and animals. It also serves as a receptor of industrial waste, domestic waste and waste water resulting from other uses of water (Chapman, 1996; Rosemberg and Reish, 1993). Human developmental

*Corresponding author. E-mail: kuforijititilope@yahoo.com. Tel: +234.8035709260.

activities have led to increased population and waste generation, which in turn have contributed to the deterioration and degradation of the environment due to increased human population and increased waste generation (Thorne and Williams, 1997). The wastes find their way into the environment as gaseous, liquid or solid materials. They apparently have impacts on the environment and the flora and fauna in the receiving media.

Environmental deterioration is then a natural outcome of rapid population growth, agricultural practices, industrialization and urbanization of society (TERI, 2000). Industrial wastes are complex mixture of different contaminants or pollutants (Ajao, 1983; Oyewo, 1998). Just as these contaminants or pollutants are different so are their effects on the receiving environment and the biota. Most gaseous emissions lead to stratospheric ozone layer depletion, acid rain and photochemical smog (Warrick, 1988; Chiras, 1998). They are the major factors responsible for premature aging of the skin, skin cancer, cataracts and immune deficiencies by mutagenicity (Treshow and Anderson, 1989; Elsom, 1992). The industrial wastes released into the aquatic environment contain harmful chemicals such as heavy metals, oil, settle-able solids, nutrients and ammonia. These pollutants have various effects on the organisms in the receiving water body (McClugge, 1991). In addition, plants and animals inhabiting the water bodies are not spared as their normal functioning is affected by pollution and also alter their populations. Depletion of their numbers and species in diversity seems to be a major effect. This will go back to man as its insatiable assumption of freshwater resources remains unending. Thus, man may be facing a great physiological threat (Clark, 1994).

Aquatic pollution by heavy metals is very prominent in industrialized and mining areas and these metals are released or leached to the water bodies (Garbarino et al., 1995; INECAR, 2000). Some heavy metals has bio-importance as trace elements but the toxic effluents of many of them on aquatic organism accumulating in their body are of great concern since they apply to the group of metals and sediments (metalloids) that are associated with contamination, potential toxicity or ecotoxicity with atomic number greater than 4 g/cm or five times or more, greater than water (Garbarino et al., 1995; Hawkes, 1997). Therefore, the accurate determinations of water quality using the physico-chemical parameters and heavy metals pollution are of ultimately important for controlling their pollution, this study aims at providing additional information to existing data on water quality assessment of this water body.

MATERIALS AND METHODS

Agbara industrial estate, the study area

Agbara industrial estate is located between latitude 3°00' and 3°15'

and longitude 6°15' and 6°30'. It is approximately 31 km West of Lagos on the Badagry Expressway. It is first privately developed new town in Nigeria. It covers an area of 454 ha, which consists of industrial, commercial and private housing areas in a place that previously was only a forest. Clubs, shopping complexes, schools and medical facilities were incorporated in the master plan (Agbara Estate Limited, 1982).

Sampling sites

Four experimental (sampling) sites were chosen; upstream and downstream of effluent discharge outfall.

Sampling site A (pre-effluent discharge)

The site was located approximately 1 to 2 km upstream of the effluent entry point into River Owo. The water depth varied between 3.5 m close to the bank and 10.5 m at the centre. The speed of water-flow was sluggish.

Sampling site B (effluent discharge point)

This is the effluent discharge point into River Owo. It had a depth of between 3.8 m at the bank and 10.2 m at the centre. The flow of water was sluggish.

Sampling site C (effluent entry point)

This represented the lagoon site, the entry point of the River Owo into Olooge Lagoon. The water depth varied between 2.0 m at the bank and 4.5 m at the centre.

Sampling site D (Lagoon)

This represented the Ologe Lagoon with depth varied between 3.0 m at bank and 5.2 m at the centre.

The effluent and water temperatures were measured *in-situ* by dipping a thermometer bulb into the water for about 2 to 3 min and were recorded in degree Celsius; pH was determined using Griffin pH meter (model 40) and Hach test kit (Jenson and Avery, 1989). The following factors selected as water quality parameters were measured using the methods described for each factors as follows. Dissolved oxygen (DO) was determined by Azide modification of the Winkler method; Salinity was determined by use of salinometer TSI (model 33); turbidity was measured using formalin photometer set at a wavelength of 450 nm; total alkalinity (TA), total hardness (TH), carbon dioxide were determined by titration method (APHA, 1995); total settle-able solids (TSS) was measured by gravimetric method (APHA, 1995); biochemical oxygen demand (BOD) was measured using aluminum potassium sulphate (AlKSO₄) method. Nitrate, phosphate, sulphate and ammonia were determined separately by use of Hach's spectrophotometer set at the wavelength of 450 nm for sulphate, 500 nm for nitrate, 700 nm for phosphate and 620 nm for ammonia (APHA, 1995).

Water and effluent samples for heavy metal analysis was acidified using few drops of concentrated sulphuric acid to bring the pH between 2 to 3. Twenty-five milliliter of each sample was then filtered and the amount of heavy metal in each sample was determined using Atomic Absorption Spectrophotometer (AAS), (APHA, 1995). The heavy metal analysis was carried out at the University of Lagos, Chemistry Department Laboratory and the Mobil oil plc laboratory at Apapa in Lagos.

RESULTS

Nature of sampling points

The physical appearances of sampling points A, B and D were similar with a bluish green colour while sampling point C appeared different from sampling point A, B and D with a darkish green colour.

Physicochemical parameters

The physicochemical properties of River Owo at the four sampling points A, B, C and D for five consecutive months are shown in Figures 1 to 18. The values of the results were compared with standard values of LASEPA (2001) and FEPA (1991) for environmental pollution control in Nigeria. The determination of the physicochemical parameters of the sampled sites was carried out from the month of November, 2007 to March, 2008.

DISCUSSION

The physicochemical properties of River Owo at the sampling points A, C and D shows that all the parameters measure for five consecutive months were within the Federal Environmental Protection Agency (FEPA, 1991) and Lagos State Environmental Protection Agency (LASEPA, 2001) regulatory limits but slightly higher at sampling point B as a result of the effluent discharge point. The pH values of the four sampling points were ranged between 6.4 and 7.7 for the month of November (2007) to March (2008). There was no significant difference between the four sampling points and all are within FEPA and LASEPA permissible limit of 6.0 to 9.0. The result compares with findings of Ogunlaja and Ogunlaja (2007) and Uzoekwe and Oghosanine (2011). This authors found that the pH of the surface water in their environment (Ubeji creek, Warri and southern Nigeria) ranged between 6.5 and 8.5 and are within the Federal Ministry of Environment Nigeria (FMEnv.) recommended limit both nationally and internationally.

The temperature at the time of study ranged from 25.70 to 28.60°C for sampling points A, C and D. The observed higher temperature at the sampling point B (effluent discharge point) might be due to fresh effluent from the industries, homes, hospitals etc., and these values pose no threat to the homeostatic balance of the receiving water and were in agreement with the report of Jaji et al. (2007). Turbidity at the effluent discharge point ranged (48.52 to 75.20) NTU and for other sampling points (point A, C and D) ranged between 22.60 to 43.20 NTU. There were significant differences in values obtained at the effluent discharge point, in compare with other sampling points A, C and D. The turbidity values obtained for all

the locations were higher than WHO standard limit of 5 NTU (WHO, 2004). Excessive turbidity in water can cause problem for water purification process such as flocculation and filtration which may increase treatment cost. High turbid waters are associated with microbial contamination (DWAF, 1998). Again turbidity causes decrease in photosynthesis process since turbidity precludes deep penetration of light in water (Muoghalu and Omocho, 2000). Ultimately, the water receiving bodies disqualified as source of water for domestic use in the community.

The dissolved oxygen (DO) concentration of the effluent discharge point A was ranged between 0.3 to 0.7 mg/L and was observed to be lower than other sampling points A, C and D (4.4 to 6.6 mg/L) as compared with FEPA regulatory limit. The lower value at the discharge point could be attributed to the presence of degradable organic matter. Decrease in DO concentration could be attributed to breakdown of organic matter by aerobic microbes. The Oxygen required for this process is taken from the surrounding water thus diminishing its total oxygen content. Odukuma and Okpokwasili (1993) reported that it may be partially due to the displacement of dissolve oxygen by dissolved solids within the effluent.

Biological oxygen demand (BOD)

BOD test is useful in determining the relative waste loading and its higher degree therefore indicates the presence of large amount of organic pollutant and relatively higher level of microbial activities with consequent depletion of oxygen content. The value measured at sampling point B (effluent discharge point) was 333.2 to 524.2 mg/L and this was higher than 4.2 to 24.20 mg/L for the remaining sampling point A, C and D. The four sampling points A, B, C and D has low salinity might be due to the presence of calcium and magnesium ions (Boyd, 1979). There is no significant different between salinity range of the four sampling point of 0.025 to 1.280 mg/L. With regard to total hardness, no distinctly defined levels of what constitute a hard or soft water supply. The general accepted classification for hardness of water is 75 to 150 mg/L of CaCO₃ for soft and 150 mg/L and above for hard water (Deat, 2000). There was significant difference between the point of effluent discharge (119 to 133 mg/L) and values measured for sampling points A, C and D (27.6 to 55.6 mg/L).

Muoghalu and Omocho (2000) observed that when waste are heavily laden with pollutant and dissolved solids gain access to water bodies, they need large dose of oxygen for decomposition. The value of nutrients (total phosphate, nitrate, sulphate, ammonia) differs significantly between bodies. Unpolluted water usually contain only minute amount of nitrate (Jaji et al., 2007). Nitrate is a very important nutrient was observed to have been slightly high among the four sampling points with

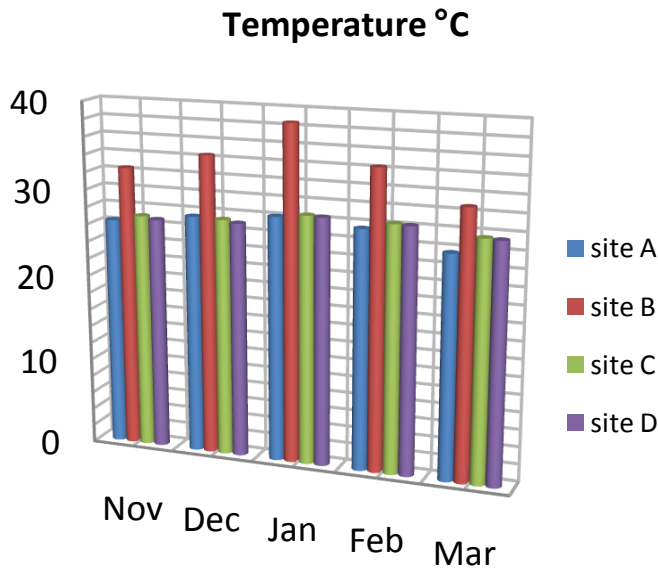


Figure 1. The effect of temperature at the four sampling points in River Owo for five consecutive months.

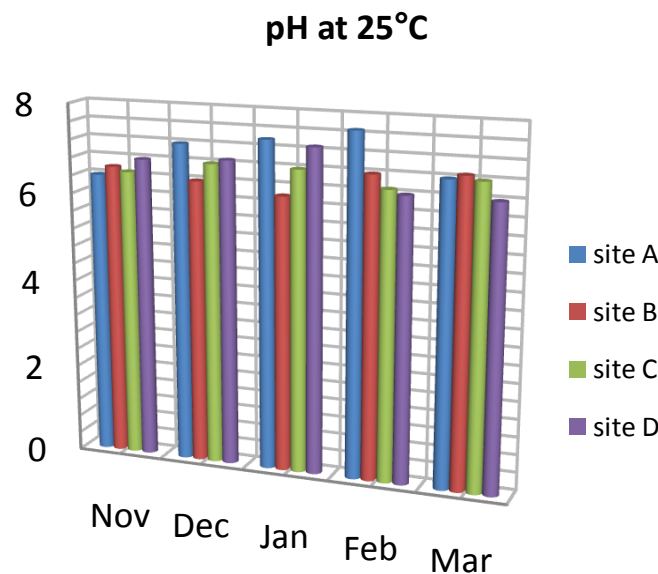


Figure 2. The effect of pH at the four sampling points in River Owo for five consecutive months.

the range 2.3 to 6.84 mg/L. It was observed that the locations were slightly polluted. Elevated levels in nitrate have been reported to exhibit delayed reactions to light and sound stimuli (Robillard et al., 2003a, b) and can cause methemoglobinemia (Fatoki et al, 2008). Phosphate was also found to be low in all the sampling points. However, phosphate are essential nutrients to plants life, but when found in excess quantities (point B), stimulates excessive plant growth such as algae bloom (Igbiosa and Oko, 2009).

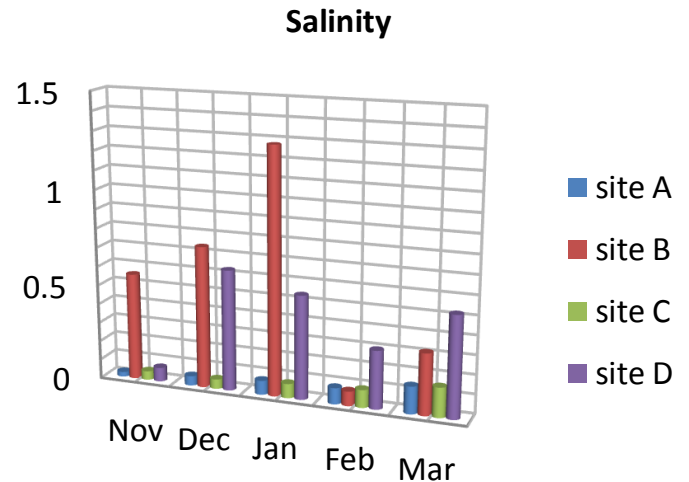


Figure 3. The effect of salinity at the four sampling points in River Owo for five consecutive months.

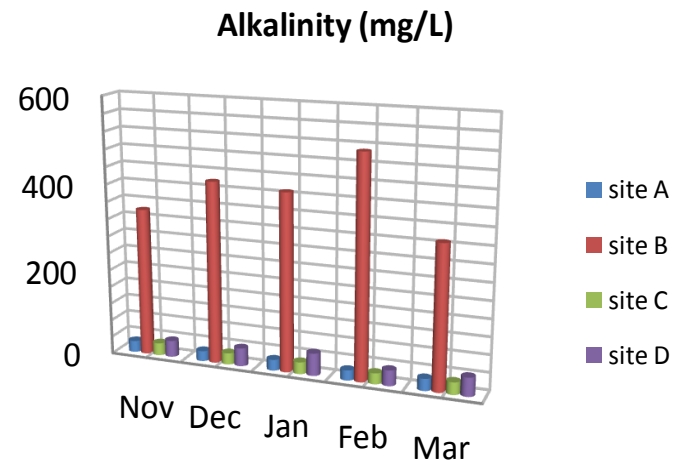


Figure 4. The effect of alkalinity at the four sampling points in River Owo for five consecutive months.

Heavy metal concentrations in water samples measured were slightly high for the four sampling locations but higher at sampling point B. Generally, higher level of iron, copper, lead, cadmium and chromium were observed at sampling point B ($Fe > Cu > Cr > Pb > Cd$) which as a result of effluent discharge point. Lead exposure has been associated with hypochromic anaemia with basophilic stippling of erythrocytes (Emory et al., 2001). Cadmium is highly toxic and accumulates in the body and eventually causes effects such as disturbances in calcium homeostasis and metabolism (Emory et al., 2001). Most chromium compounds are carcinogenic, long exposure may cause kidney, liver and nerve damage (Aremu et al., 2000). Generally, high level of metals may also be attributed to the discharge of effluents by the companies, factory, materials and other relevant occupational fields (steel making, welding, cutting, glass

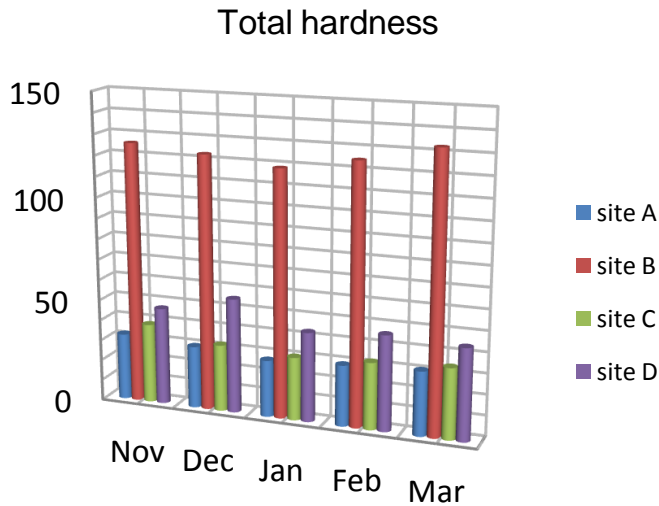


Figure 5. The effect of total hardness at the four sampling points in River Owo for five consecutive months.

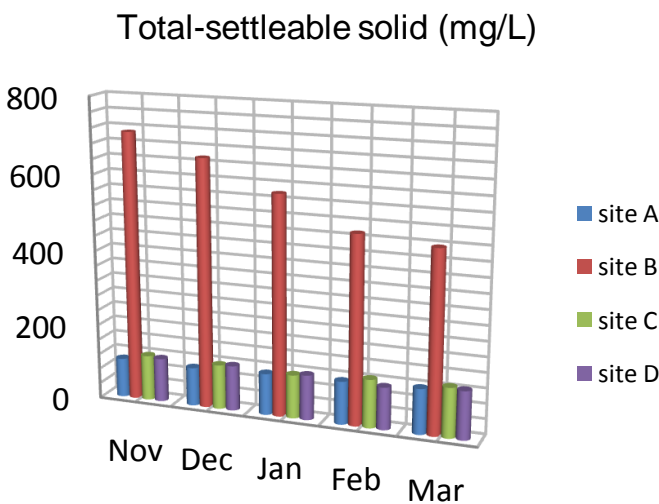


Figure 6. The effect of total-settle-able solid at the four sampling points in River Owo for five consecutive months.

and ceramic production etc.) (Vilia-Elena, 2006). The level of pollution is more pronounced at sampling point B due to the greater amount of biochemical oxygen demand (BOD) and the release of some heavy metals like cadmium, chromium and lead which greatly affect the water quality of the river.

RECOMMENDATIONS AND CONCLUSION

Metallic pollution which was noticed to be a threat to the water quality of River Owo should be arrested at the nick of time by the regulatory agencies to encourage and

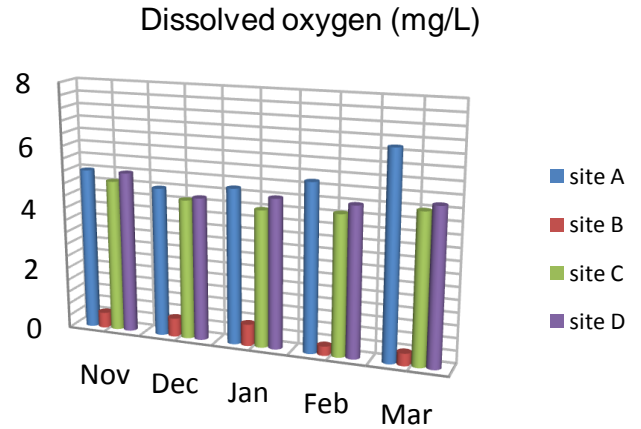


Figure 7. The effect of dissolved oxygen at the four sampling points in River Owo for five consecutive months.

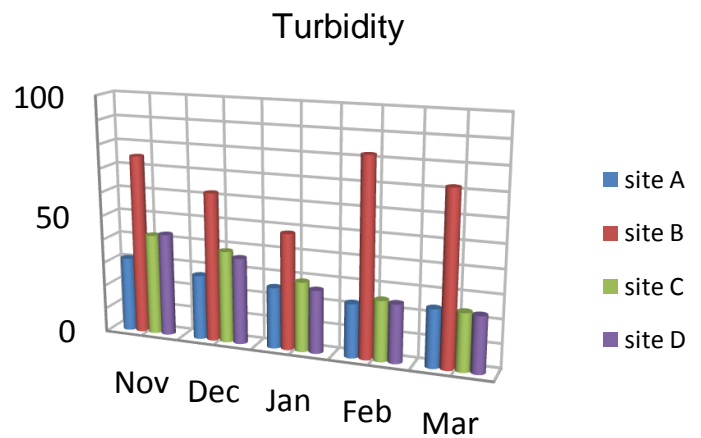


Figure 8. The effect of turbidity at the four sampling points in River Owo for five consecutive months.

Biochemical oxygen demand (BOD) (mg/L)

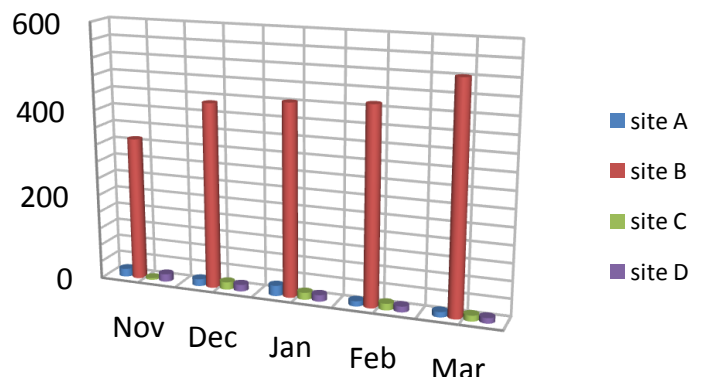


Figure 9. The effect of biochemical oxygen demand (BOD) at the four sampling points in River Owo for five consecutive months.

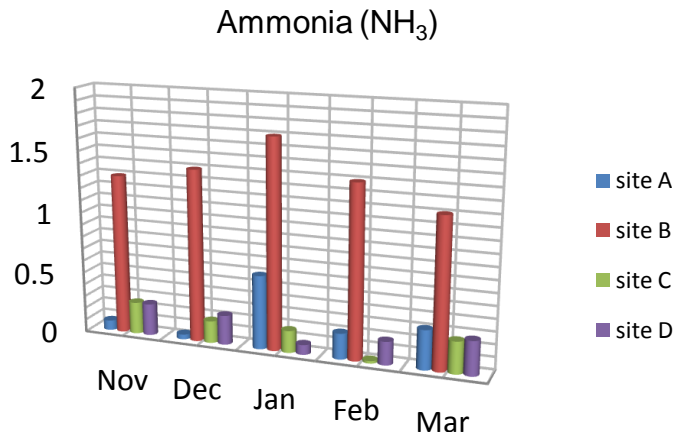


Figure 10. The effect of ammonia at the four sampling points in River Owo for five consecutive months.

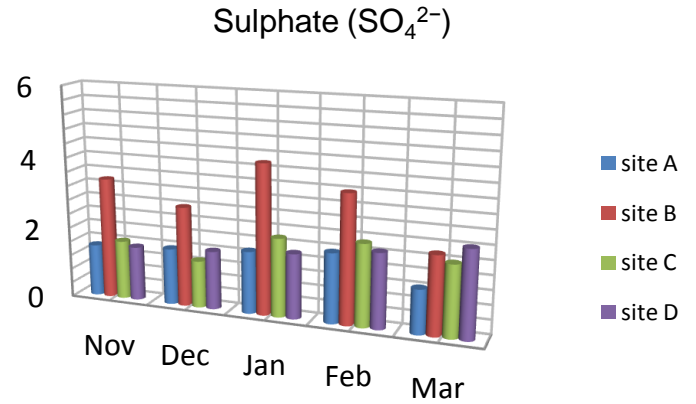


Figure 13. The effect of sulphate at the four sampling points in River Owo for five consecutive months.

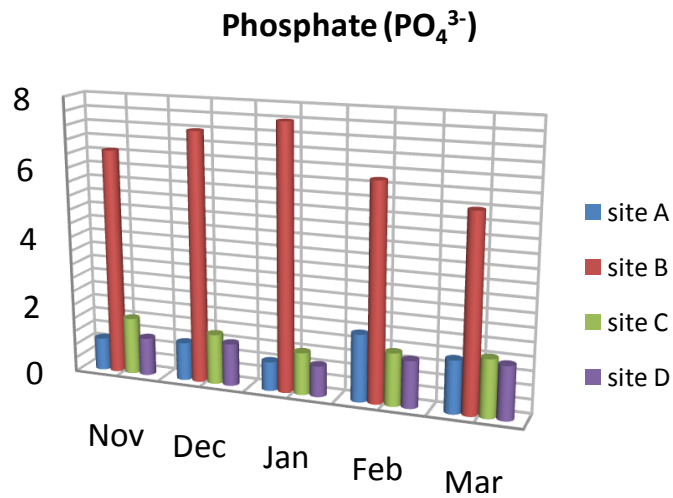


Figure 11. The effect of phosphate at the four sampling points in River Owo for five consecutive months.

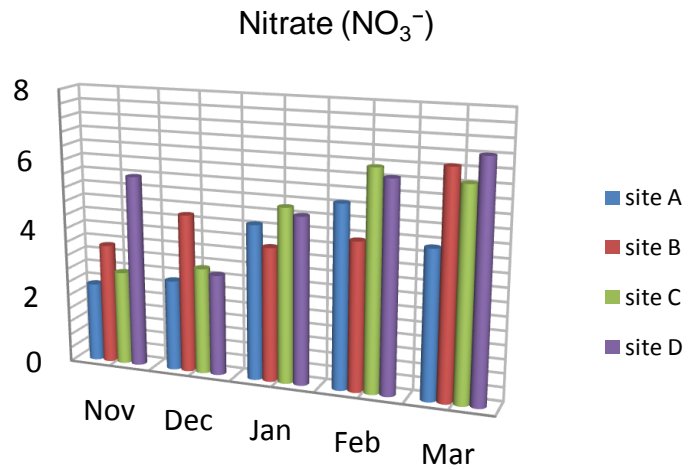


Figure 14. The effect of nitrate at the four sampling points in River Owo for five consecutive months.

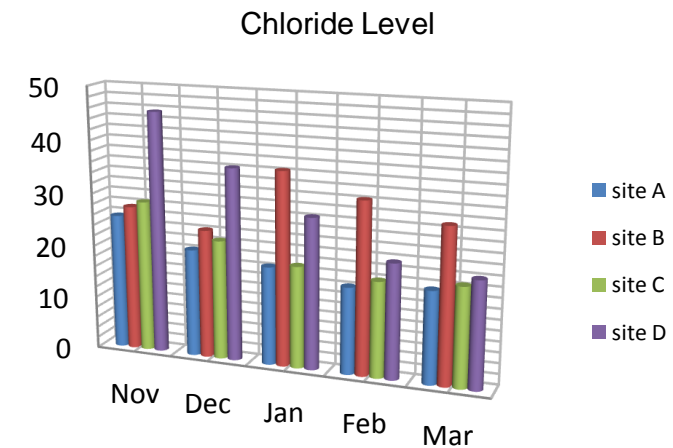


Figure 12. The effect of chloride at the four sampling points in River Owo for five consecutive months.

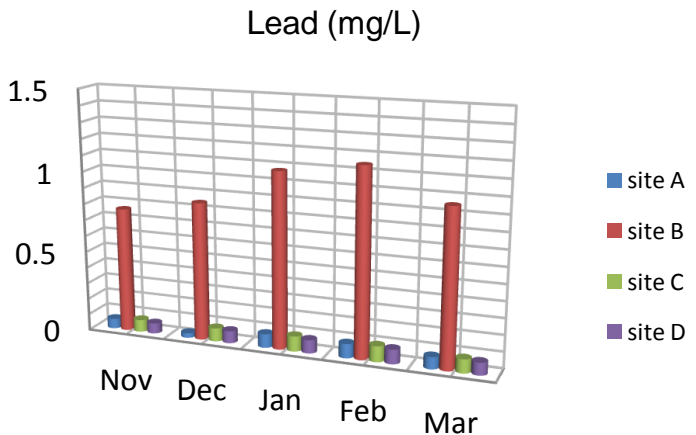


Figure 15. The effect of lead at the four sampling points in River Owo for five consecutive months.

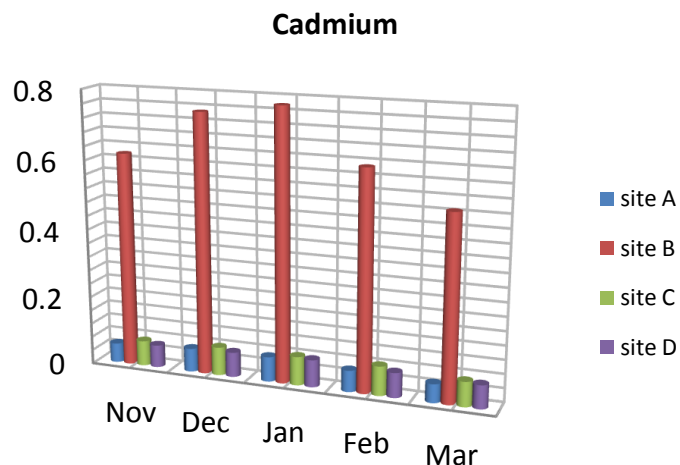


Figure 16. The effect of cadmium at the four sampling points in River Owo for five consecutive months.

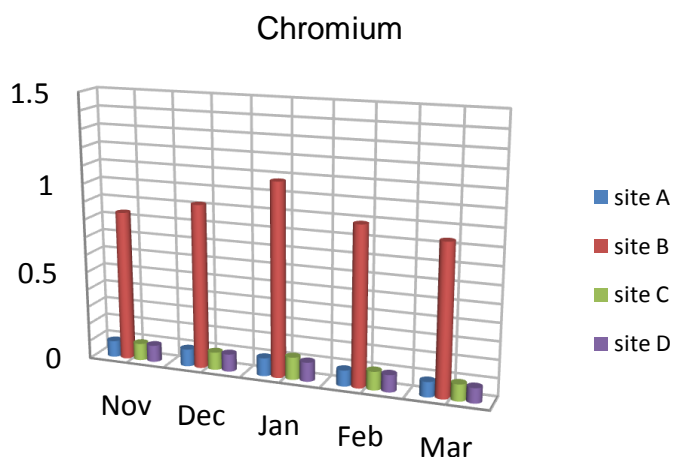


Figure 17. The effect of chromium at the four sampling points in River Owo for five consecutive months.

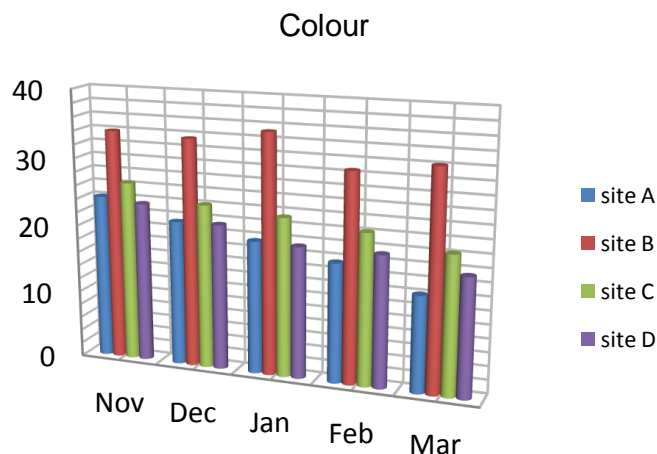


Figure 18. The effect of colour at the four sampling points in River Owo for five consecutive months.

compelled manufacturing industries/companies to treat their effluents before discharging into receiving water bodies. Also, the water quality of River Owo should be continuously monitored so that the level of pollution will be known and also to determine if the water is safe for agricultural practices. The Federal Ministry of Environment and its parastatal like Federal Environmental Protection Agency (FEPA) and other state owned and nongovernmental organizations like Lagos State Environmental Protection Agency (LASEPA), World Health Organization (WHO), should try and prevent discharge and channeling of waste into the water bodies such as River Owo in order to prevent pollution of the water.

In addition to these, manufacturing industries/companies should be encouraged and compelled by the regulatory agencies to treat their effluents before discharging into receiving water bodies. Also, the water quality of River Owo should be continuously monitored so that the level of pollution will be known and also to determine if the water is safe for agricultural practices and other benthic macro-invertebrates to live in to avoid the eradication of useful benthic macro-invertebrates.

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