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**Research article**

# The Impact of Untreated Sewage Wastes discharge on the Physico-chemical properties of Rivers in Port Harcourt Metropolis

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## Abstract

Chemical characteristics of water can affect aesthetic qualities such as how water looks, smells, and tastes. This can also affect its toxicity, whether or not the water is safe for use. Sampling of water from the study stations was done three times over a period of six months (June-November, 2013) using standard analytical methods. Results obtained show that there was decrease in dissolved oxygen, increase in total dissolved solids and a corresponding increase in electrical conductivity, increase in hardness, chloride and sulphate concentrations. The highest concentrations of BOD, TSS, TDS and Turbidity were 85.15 mg $l^{-1}$; 50.85 mg $l^{-1}$; 614 mg $l^{-1}$ and 48.9 NTU respectively were obtained at a point of effluent discharge into the water body**.** The study observed that the water samples from stations 1, 2 and 5 exhibited clear pollution tendencies which may be considered as deterioration of water quality.


**Keywords:** Sewage effluent, water quality, waste disposal, pollution, Ecosystem, health hazard, physico-chemical properties.

## INTRODUCTION

Rivers play a significant role as they serve not only the purpose of water supply for domestic, industrial, agricultural and power generation but also utilized for the purpose of sewage and industrial waste and therefore are put under tremendous pressure (Subin and Husna, 2013). In the last few decades, pressure has been increasing and greater emphasis is laid on the deterioration of the quality of rivers within the Niger Delta. This has rendered numerous water bodies in this area inaccessible, unwholesome and unable to sustain the teeming aquatic life associated with mangrove swamp ecosystems.

Most of the rivers have been unmindfully used for the disposal of domestic and industrial effluents far beyond their assimilative capacities and have been rendered grossly polluted (Baskaram and De Britto, 2010). Despite its importance, water is the most poorly managed resource in the world. The quality of water is getting vastly deteriorated mainly due to unscientific waste disposal; improper water management and carelessness towards the environment and this had led to the scarcity of potable water affecting human health (Agarrkar and Thombre, 2010). Chemical characteristics of water can affect aesthetic qualities such as how water looks, smells, and tastes. This can also affect its toxicity and whether or not the water is safe to use. Since the chemical quality of water is important to the health of humans as well as the plants and animals that live in and around streams, it is necessary to assess the chemical attributes of water.

People who live near the river area use the water from the river for domestic purposes. Unfortunately, there is no frequent and up to date monitoring and information providing facility on the quality of domestic sewage effluent discharged into the river and the quality of the water in the river for human use. Such information is important for the relevant authorities to take proper action in preventing pollution of the environment for the good health of the population. Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards to ensure that the water is potable and safe for drinking and other domestic purposes (Tebutt, 1983). However, several researches on water bodies point to the fact that there has been increased pollution with intensified environmental and public health hazards on the quality of water from the surface (streams, lakes, ponds, and rivers) due to the indiscriminate discharge of sewage effluents and other wastes into such bodies. It is in the light of these facts that the following chemical parameters are been determined for the water systems. The objective of this study is to assess the extent of various pollutants received by some rivers in Port Harcourt as affected by domestic sewage and solid wastes discharges to cause pollution.

## Materials and Method

### Sample containers

The containers used for sampling are made of materials that will not contaminate the samples by adding to or reducing the actual concentration of the sample. Samples collected were stored, to suit specific analytical procedures, for example,

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- Samples for the determination of Biochemical Oxygen Demand were stored in air-tight dark stoppered glass bottles. Turbulence and hence gas bubbles were avoided during collection, thereby ensuring smooth flow of the samples into the containers.

All the samples were ice-packed in coolers, from the field to the laboratory for analysis. Sample not immediately analyzed were refrigerated at $4^oC$. The samples were in good conditions at the point of analyzing them. After analysis, all residual samples were stored for a period of six (6) months under refrigeration conditions before content is eventually appropriately disposed of and containers thoroughly washed, cleaned and sterilized.

## Collection of Surface Water Samples

Sampling of water from the study area was done over a period of six months (June-November, 2013). The locations of the sampling sites were established using a Garmin 45 Ground Positioning System (GPS). The geographical locations, site elevations and types of samples collected from each sampling station are presented on Table 1.

**Table 1:** Surface water bodies sampled and their locations

| Stations | Surface Water Bodies | Sample Site Locations |
|---|---|---|
| Station 1 | Sewage Discharge point | N $04^0$ 47’ 31.74” E $006^0$ 57’ 10.68” |
| Station 2 | Discharge Creek junction | N $04^0$ 47’ 31.68” E $006^0$ 57’ 10.56” |
| Station 3 | Eagle Cement River | N $04^0$ 47’ 51.96” E $006^0$ 56’ 51.96” |
| Station 4 | Between Agip and Slaughter along Eagle Island river | N $04^0$ 45’ 41.76” E $006^0$ 58’ 27.48” |
| Station 5 | Ntawogba creek by Cherubim Road, Mile 3 | N $04^0$ 48’ 34.56” E$006^0$ 59’ 35.64” |

Surface water samples were collected using the method of Odokuma and Okpokwasili (1993). The collection was carried out using 4 litre plastic bottles previously sterilized with 70% alcohol 24 hours before the final collection. The bottles were rinsed 3 to 4 times with the water sample before the final collection. The water samples were collected from five different stations. Station 1 is the immediate point of discharge of the sewage wastes into the river along Iwofe-Rumuolemini (Plate 1) Station 2 is the discharge creek junction; Site 3 is along Eagle cement River; Station 4 is between Agip and Slaughter along Eagle Island river while Site 5 is Ntanwogba creek by Cherubim road, Mile 3 Diobu all in Port Harcourt. The sample from Station 1 served as the test sample while that from the other sites served as the control samples. To collect the water sample, base of the sterilized sample bottle was held with one hand, the bottle was plunged about 30cm below the water surface with the mouth of the sample bottles positioned in an opposite direction to water flow. The bottle was filled with water sample leaving a gap of about 2cm and covered immediately as described by Onyeagba and Umeham (2004). Collected samples were stored in a cooler containing ice cubes, and later transported to the laboratory at the Institute of Pollution Studies of the Rivers State University of Science and Technology, for analysis. At the laboratory, samples were stored in refrigerators at 4°C until analysis.

**Plate 1:** shows discharge of sewage materials into the water body.

**Plate 2:** Aquatic Microphytes threatening to take over the water body

## Analysis of waste water samples for physiochemical properties

Samples were analysed for the following physico-chemical parameters; hydrogen ion concentration, temperature, turbidity, total suspended solid, total dissolved solid, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and conductivity and other essential nutrients in water according to methods used by Adesemoye *et al* (2006). The pH value of the samples were determined with a pH meter (Unicam 9450, Orion model No. 91-02). Temperature was measured with mercury thermometer immediately after sample collection. Turbidity was determined with Milton Roy (USA) Spectronic 20D meter. Gravimetric method involving filtration and evaporation were used to measure total suspended solids and total dissolved solids. Methods recommended by APHA (1998) were followed for the measurement of BOD and COD. Wastewater sample was drawn into a 250 ml bottle, incubated in the dark for five days at 20$^{o}$C and at the end of five days, the final dissolved oxygen (DO) content was determined. Decrease in DO between the final DO reading and the initial DO reading was corrected for sample dilution and recorded as the BOD of the sample. The COD was estimated by determining equivalent amount of oxygen required to oxidize organic matter in the samples. Conductivity was determined using a conductivity meter (Metrohm 640, Switzerland). Salinity was measured by Mohr's methods, involving direct titration against standard silver nitrate, using potassium chromate as indicator.

## Results

## Physico-chemical Analysis

The pH values were in the range of 7.0 to 8.1As per BIS standard, the desirable range of pH for drinking water is 6.5 to 8.5 (fig.1)while temperature was 28.4 to 28.8$^{0}$C across the different stations sampled ( Fig. 2).

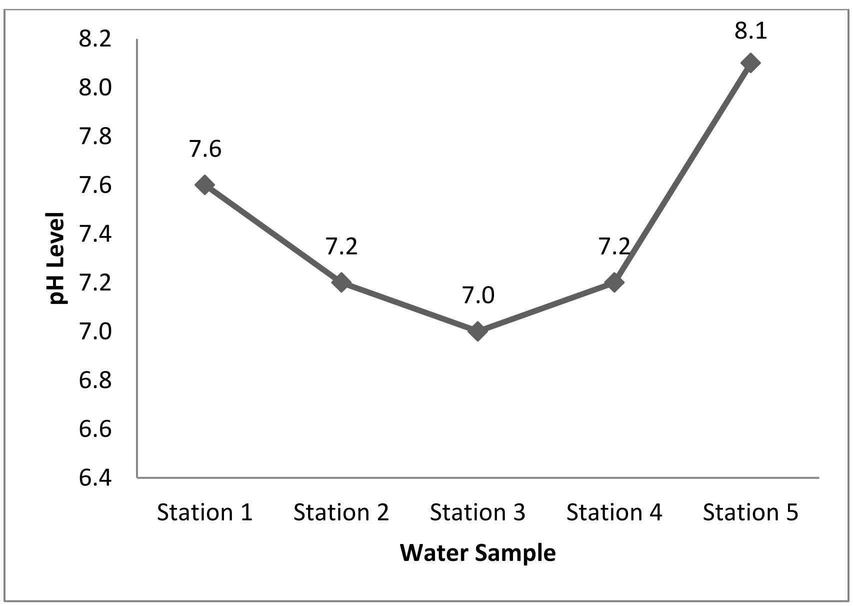


**Fig. 1:** Variation in the value of pH level at different stations

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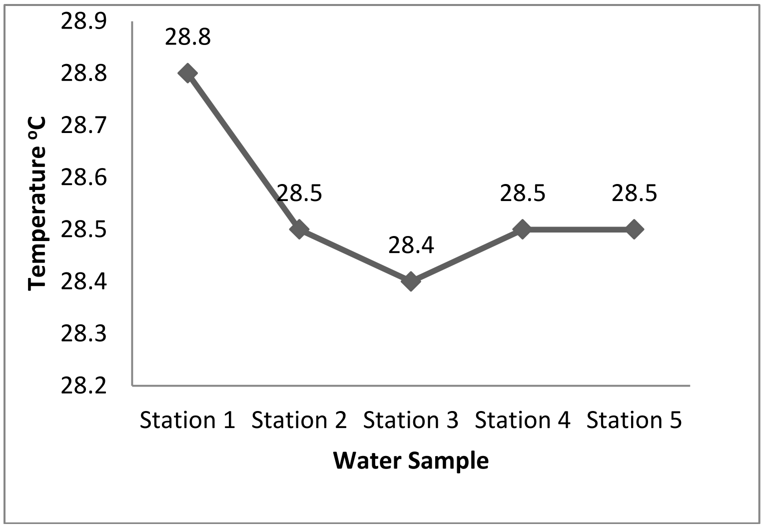


**Fig. 2:** Variation in the value of Temperature level at different stations

The highest EC value in the present study obtained in the water sample collected from station 5 (906 µS/cm) whereas the lowest value at station 4 (26.6 µS/cm) (fig. 3).

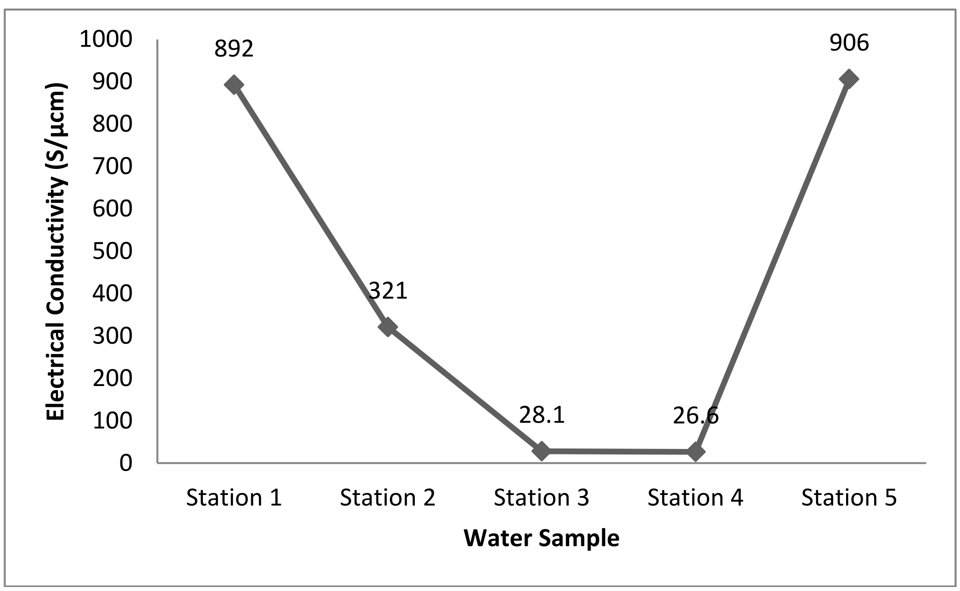


Fig. 3: Variation in the value of Electrical Conductivity level at different stations

Fig. 4 shows the Salinity values obtained for the different station with highest values recorded in stations 3 and 4 having 16.5% and 15.6%, respectively while lowest value was obtained for station 2 with 0.15%.

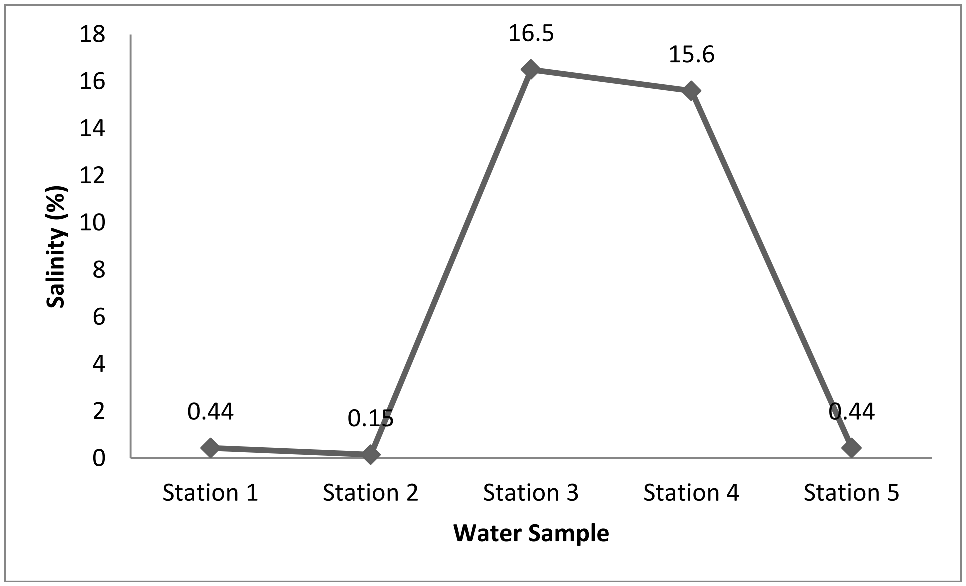


**Fig. 4:** Variation in the value of Salinity level at different stations

Fig. 5 shows the TDS values which had maximum values of 614mg/l and 626mg/l for stations 1 and 5 respectively. The desirable and maximum permissible limit prescribed by BIS in drinking water is 500mg/l and 2000mg/l respectively. Stations 1 and 5 exceed permissible limits while station 2 which had 209mg/l was within the permissible limit.

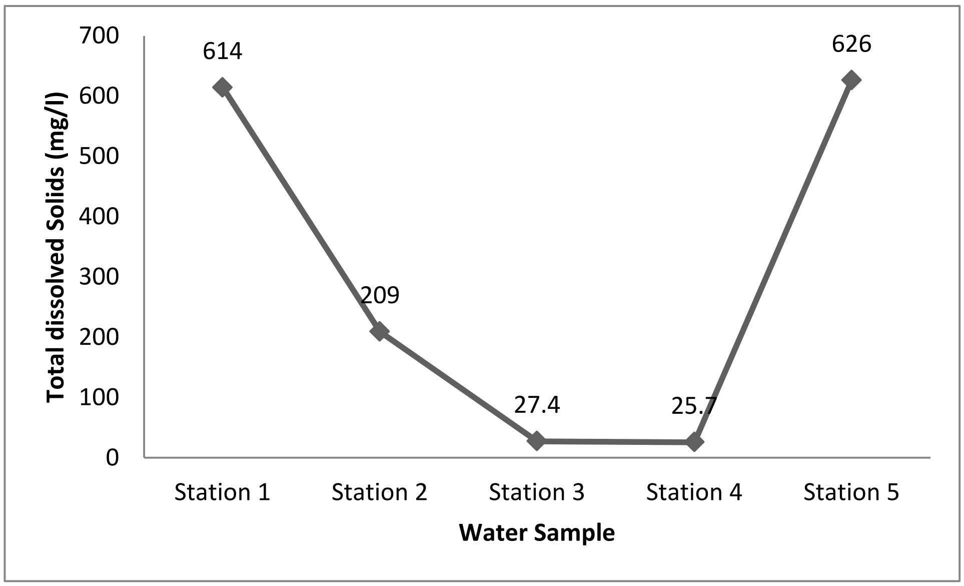


**Fig. 5:** Variation in the value of Total dissolved solids level at different station

Total Alkalinity values in the present study recorded in the range of 36mg/l to 180mg/l (fig 6).The desirable and maximum permissible limit of alkalinity in drinking water is 200mg/l and 600mg/l respectively. The water sample collected from the different stations exhibited the desirable values because they were below the limits.

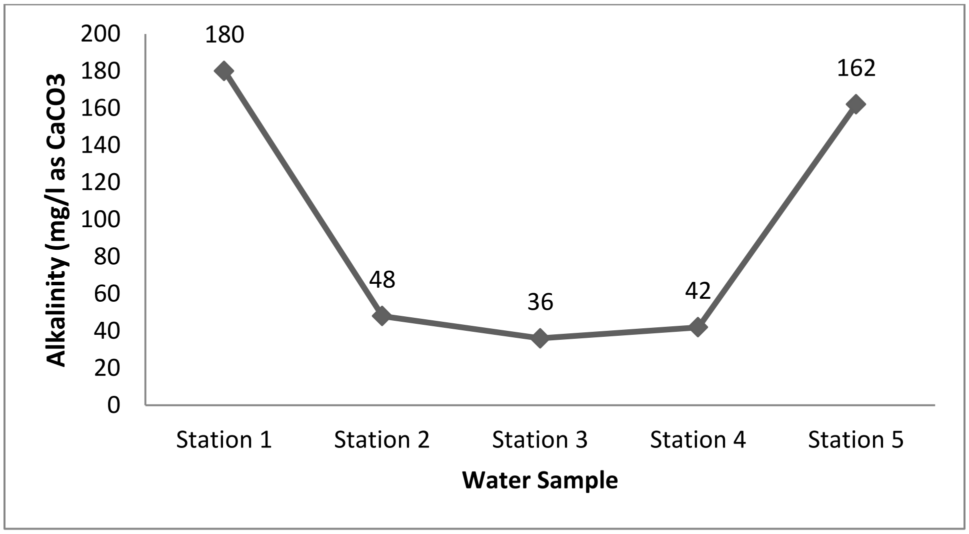


**Fig. 6:** Variation in the value of Alkalinity level at different stations

Figure 7 represents the result obtained for chloride in the water samples. For chloride, 250mg/l has been established as desirable limit and 1000mg/l as the maximum limit for chloride in drinking water (APHA, 1996). Stations 3 and 4 have chloride content exceeding the maximum limit and were 10324.6mg/l and 11016.2mg/l respectively.

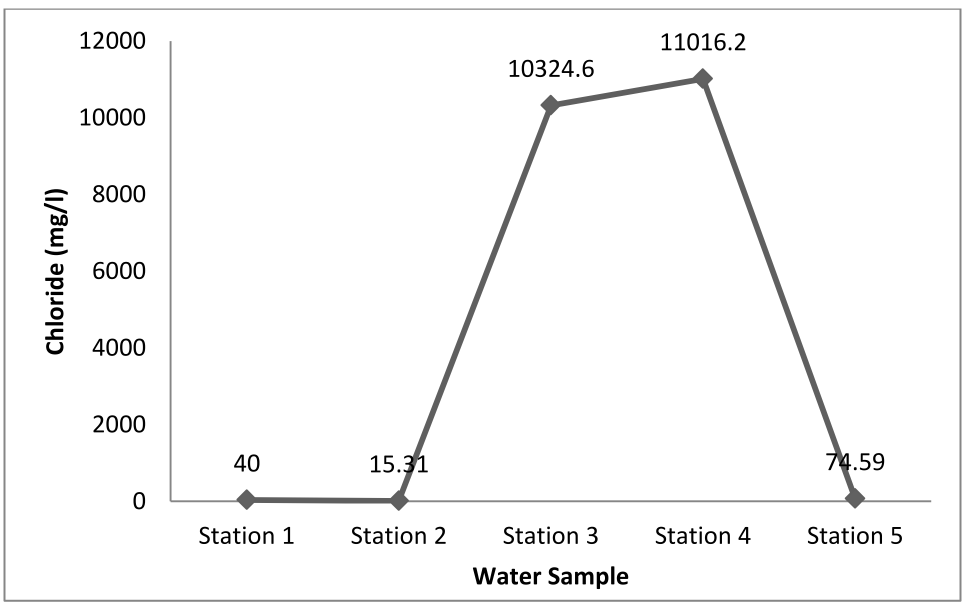


**Fig. 7:** Variation in the value of Chloride level at different stations

Fig. 8 shows the result obtained for sulphate in the water samples in the different stations. Sulphate varied from 1.0mg/l to 177.2mg/l which indicates to fall within the permissible limit.

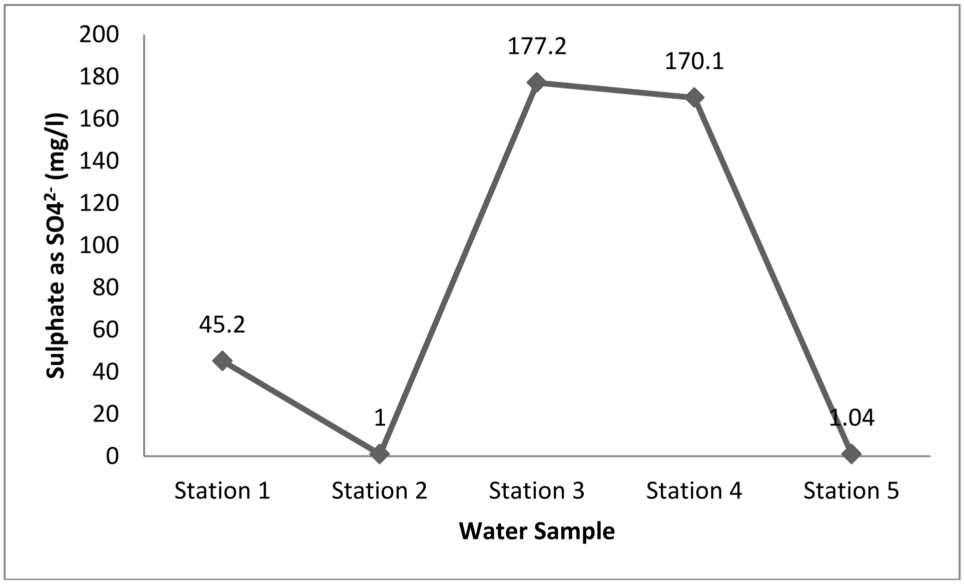


**Fig. 8:** Variation in the value of Sulphate level at different stations

The concentration of phosphate in water samples in the study varied from 0.05mg/l to 0.1mg/l (fig. 9). The highest phosphate value was observed at station 1(0.1mg/l). Nitrate level varied from 0.2mg/l to 0.94mg/l (fig. 10).

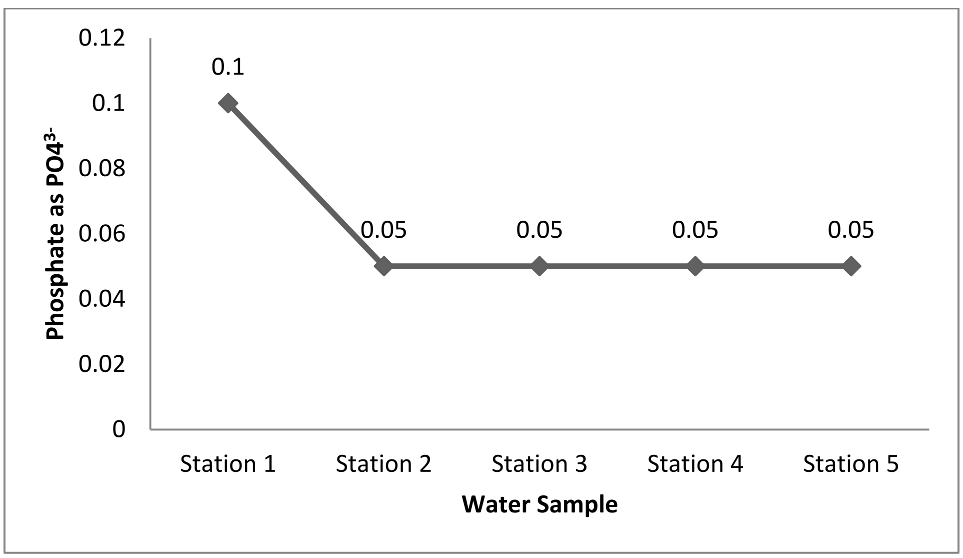


**Fig. 9:** Variation in the value of Phosphate level at different stations

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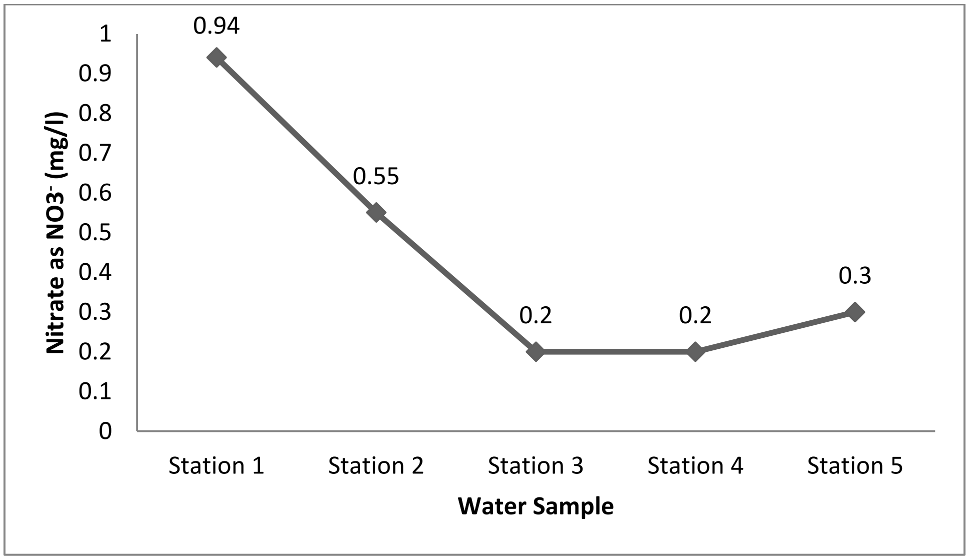


**Fig. 10:** Variation in the value of Nitrate level at different stations

Fig. 10 shows the result of nitrate levels in the water samples. The nitrate levels varied from 0.2mg/l to 0.55mg/l, which clearly indicates that the nitrate content in the water samples is within the desirable limit (APHA, 1996). Ammonia content varied from 0.42mg/l to 1.32mg/l in the water samples (fig. 11).

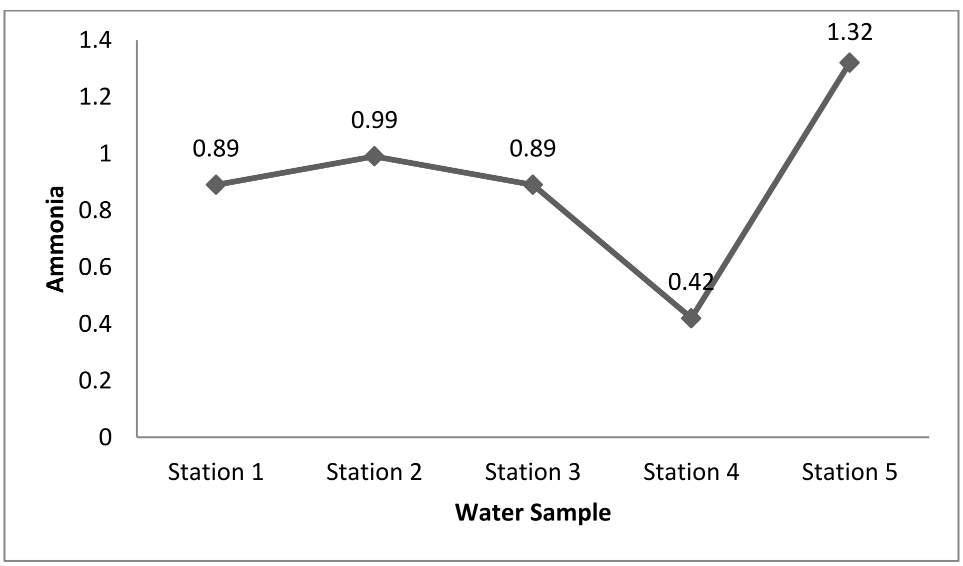


**Fig. 11.** Variation in the value of Ammonia level at different stations

Total hardness of water generally indicates the concentration of calcium and magnesium ions in water. Desirable and maximum permissible level of hardness in drinking water is 300mg/l (APHA, 1996). Total hardness of water samples varied from 40mg/l to 3648mg/l. The highest value was recorded at station 3 which was within the permissible limit.

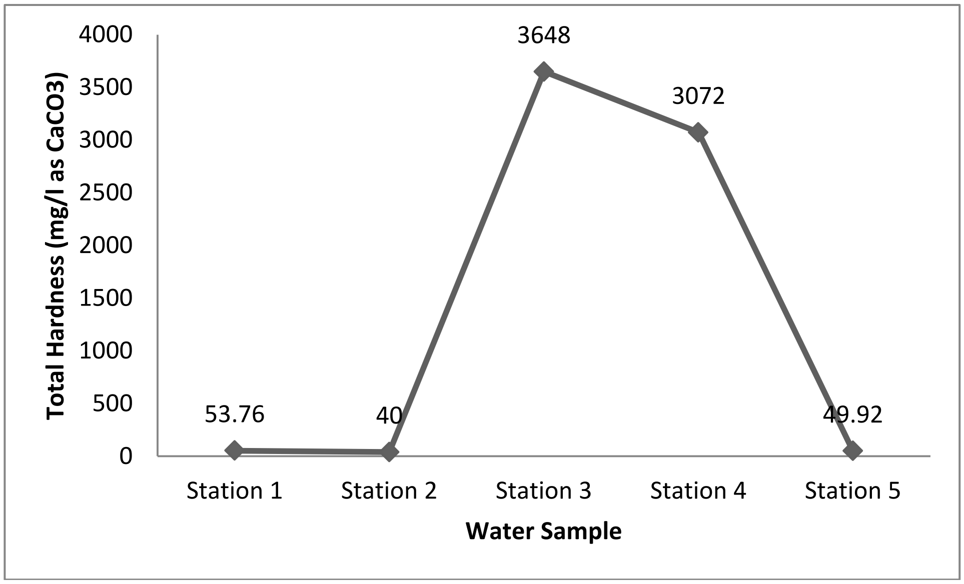


**Fig. 12:** Variation in the value of Total Hardness level at different stations

Figs. 13 and 14 represent results obtained for calcium and magnesium respectively. Calcium (Ca) and magnesium (Mg) content of water sample vary at different stations fluctuated in the range of 25.3 mg/l to 1305.6 mg/l

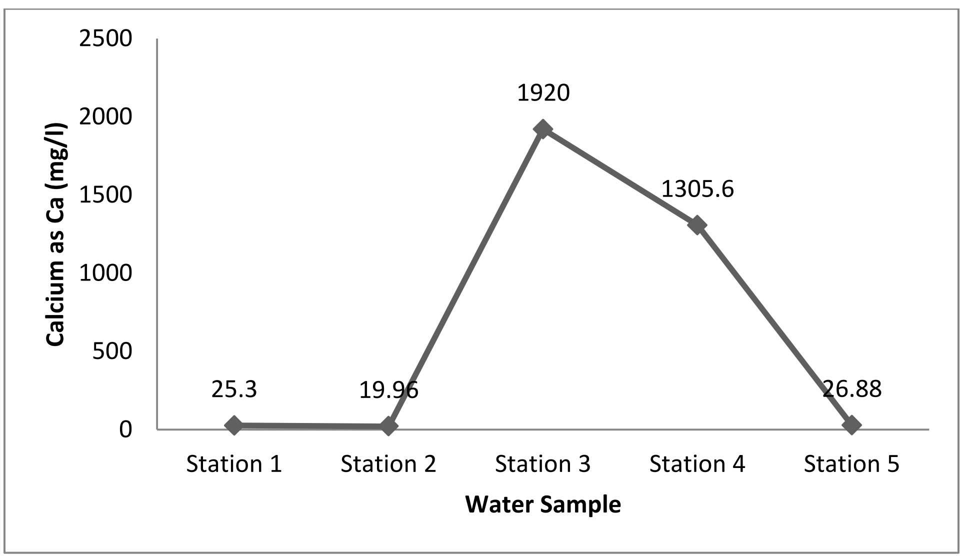


**Fig. 13:** Variation in the value of Calcium level at different stations

and 20.04mg/l to 1766.4 mg/l respectively. Desirable and maximum permissible content of Ca and Mg in drinking water are 75mg/l and 200mg/l and 30mg/l and 100mg/l respectively (BIS, 1992). The study shows that Ca content at stations 3 and 4 are within the desirable limit. Mg content exceeded the desirable limit (fig 14).

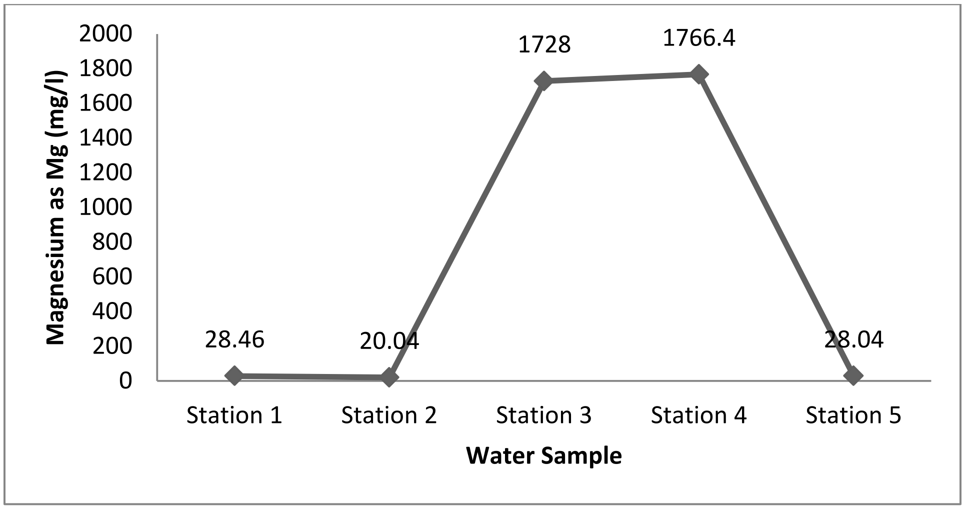


**Fig.14:** Variation in the value of Magnesium level at different stations

Figure 15 represents the BOD levels in all the different stations. BOD values of water sample in the present study varied from 0 mg/l to 85.15 mg/l. The water samples from station 2, 3 and 4 exhibited higher values of BOD compared to stations 1 and 5. Higher BOD value at station 2 (85.15 mg/l), station 3 (75.6mg/l) and station 4(85.14 mg/l) clearly indicate pollution.

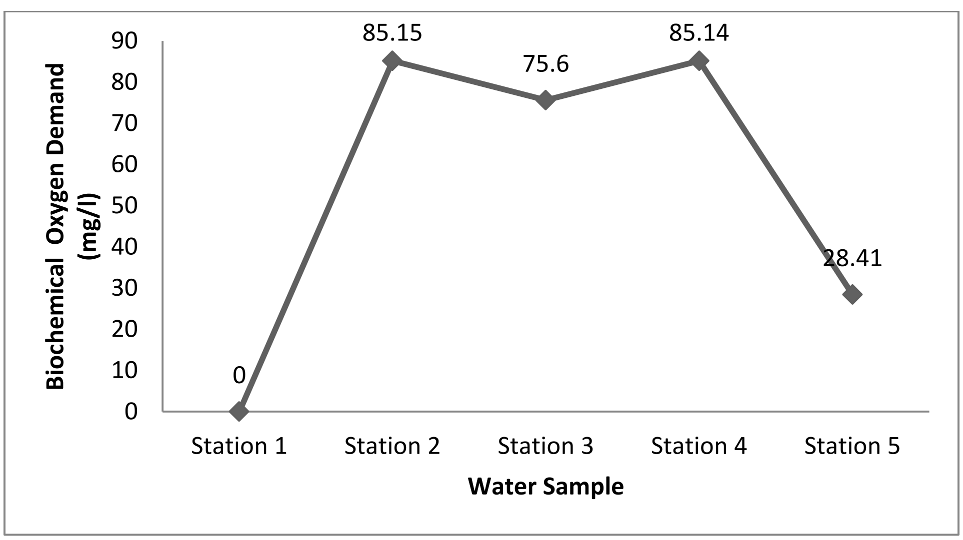


**Fig. 15:** Variation in the value of Biochemical oxygen demand level at different stations

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Dissolved oxygen levels in the present study vary from 3.65mg/l to 9.74 mg/l. Among the water samples analyzed, the lowest DO level was noticed in station 1, followed by station 4 and then by station 3 and this was 0 mg/l, 3.65mg/l and 4.87mg/l respectively (Figure 16). All these values are not desirable.

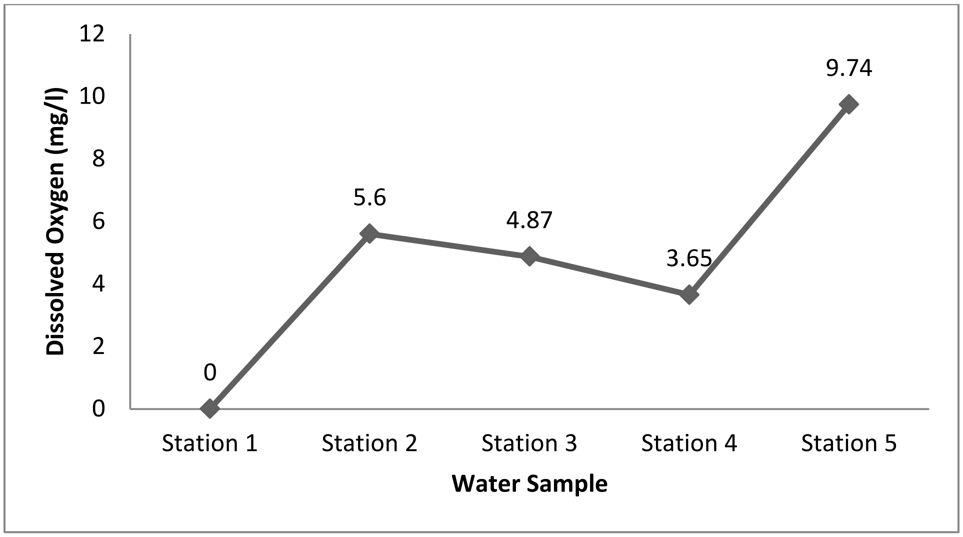


**Fig.16:** Variation in the value of Dissolved oxygen level at different stations

In the present study, the highest TSS value was obtained in water sample collected from station 1 with an average of 50.85 mg/l. This was followed by 46.85mg/l, 45.3mg/l and 40.8mg/l at stations 2, station 4 and station 5 respectively (fig 17) while in fig 18 turbidity values were high at stations1 (ie the immediate water body receiving the raw sewage effluent) with 48.9 NTU and station 4, had 39.45 NTU where abattoir activities are in operation and wastes are discharged into water body close by.

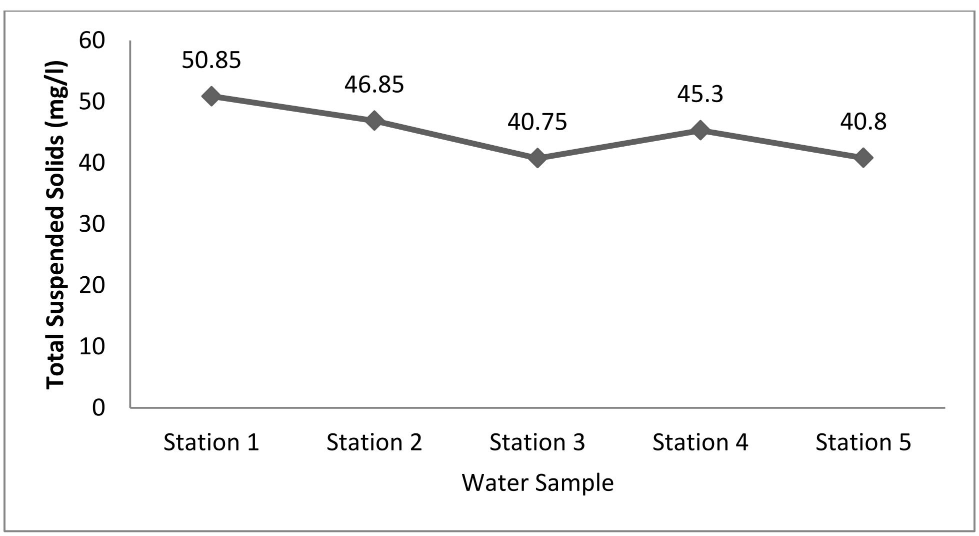


**Fig. 17:** Variation in the value of Total Suspended Solids at different stations

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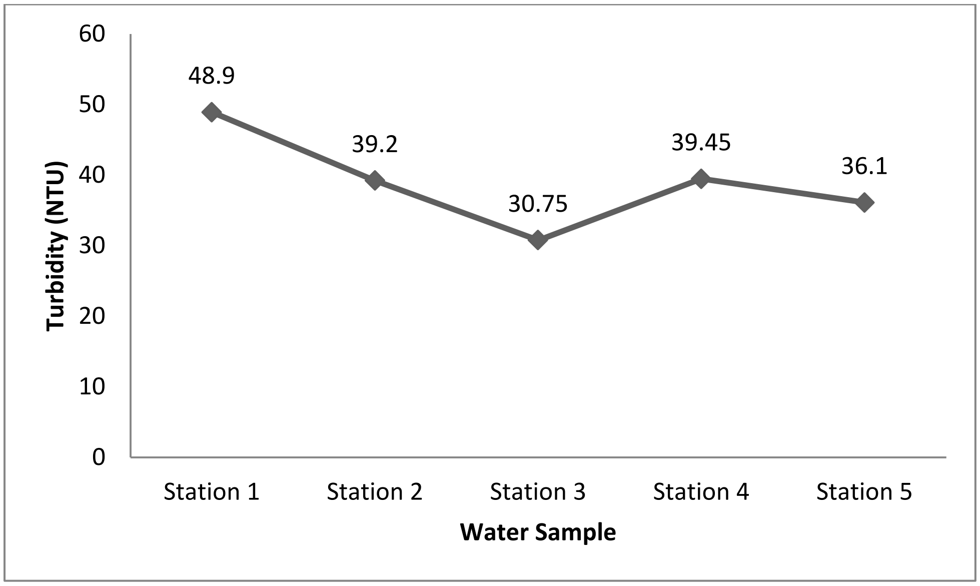


**Fig.18:** Variation in the value of Turbidity at different stations

## DISCUSSION

pH is important in water quality assessment as it influences many biological and chemical processes within a water body (Chapman, 1996). The pH values were alkaline with little variations among the study stations. The mean values fell within the WHO acceptable limits of 6.5 - 8.5. The high pH value at station 5 is probably due to the direct disposal of refuse into the water body and also to sea water intrusion. However, most of the sampled sites had pH values slightly higher than natural background level of 7 for tropical surface water. Water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion which can adversely affect the growth and development of aquatic life (Bolawa and Gbenle, 2012). As pH affects the unit processes in water treatment that contribute to the removal of harmful organisms, it could be argued that pH has an indirect effect on health (Aramini *et al*., 2009). It is a known fact that variations in pH affect chemical and biological processes in water and low pH increases the availability of metals and other toxins for intake by aquatic life. On the other hand, the slightly high alkaline pH values recorded at the study stations would tend to decrease the availability of metals and other toxins for intake by aquatic life as well as plants. The high pH may be due to the presence of other pollutants introduced into the water. As most of the study sites are located near waste dumpsites in the metropolis.

Temperature affects sediment and microbial growth among other characteristics of water and it is also a known fact that the rate at which chemical reactions occur increase with increasing temperature and the rate of biochemical reactions usually double for every 10.0°C rise in temperature. Physically, less oxygen can dissolve in warm water than in cold water. This is because increased temperature decreases the solubility of gases in water. Increased temperature increases respiration leading to increased oxygen consumption and increased decomposition of organic matter (Pierce *et al*., 1998). It is for these reasons that the temperatures of the water samples were determined for the river systems.  Since water temperature affects the concentration of biological, physical, and chemical constituents of water, the relatively high temperatures recorded would speed up the decomposition of organic matter in the water. Hence, population of bacteria and phytoplankton would double in warm weather in a very short time (Chapman, 1996).

Turbidity is a term that refers to the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through water, therefore, turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic matter, plankton and other microscopic organisms. The high turbidity value could be due to the siting of the wastes dumpsites close to the water bodies. It could also be due to indiscriminate disposal of waste into the water bodies. Plate 1 shows discharge of sewage materials disposed off into the water body at Iwofe. Another possible cause of high turbidity values may be due to the siltation of the Rivers and lagoons within the area. Siltation of these rivers and the lagoon is one of the problems arising from the cultivation along the banks of the rivers and the lagoon. Because of the rural setting of Iwofe people in Rivers state, most of the farms are situated very close to the banks of these water bodies and cultivation of the banks is intense especially during the dry season, when there is water scarcity. This therefore results in erosion. According to the EPA, (2002), turbidity values between 0.0 - 5.0 NTU show no visible turbidity, no adverse aesthetic effects and no significant risk of infectious disease transmission. Values > 10 NTU have severe aesthetic effects and the water carries an associated risk of diseases due to infectious agents and chemicals absorbed onto particulate matter (EPA, 2002).

Suspended solids consist of materials originating from the surface of the catchment area, eroded from river banks or lake shores and suspended from the bed of the water body (Chapman, 1996). Suspended solids include tiny particles of silts and clays, living organisms such as zooplankton, phytoplankton and bacterioplankton and dead particulate organic matter (Davis and Day, 1998). The suspended solids values recorded were generally high. The extremely high values recorded at all the sampling locations could be due to the large quantity of decomposing matter as all the sites have dumpsites located near them. At Iwofe, as evidenced in Plate 2**,** aquatic microphytes are threatening to take over the water body. According to Lester and Birkett, (1999), suspended solid values of less than 25 mg/l have no harmful effect on fisheries. One direct effect of suspended solids is the influence on the turbidity of the receiving water body. This in turn reduces the amount of light that can penetrate the water and therefore will tend to reduce photosynthesis. Moreover, this could affect the recreational use of the water body. Suspended solids may also exhibit an effect if they settle out of suspension. Deposition of solids can change the characteristics of the riverbed, which will in turn affect plant and animal growth and fish breeding. Suspended solids generally cause damage to fish gills affecting their oxygen consumption and ultimately causing death at high concentrations.

The amount of oxygen dissolved in water depends on the rate of aeration from the atmosphere, temperature, air pressure and salinity. While the actual amount of oxygen that can be dissolved in water depends on the relative rates of respiration by all organisms and of photosynthesis by plants, oxygen levels are actually low where organic matter accumulates because aerobic decomposers require oxygen.

The DO values recorded at the locations compared with the natural background level of 7.0 mg/l were generally low. This low values give an indication of pollution at all the sampling stations especially at stations1 and 4. The major possible causes of the pollution would include contamination by leachates from the wastes dumpsites and indiscriminate defaecation and dumping of refuse along the banks and into the water bodies. The influence of other human activities such as farming at the river banks, fishing, washing and bathing in the river cannot be ruled out. According to Cunningham and Saigo, (1999), the addition of certain organic materials to water stimulates oxygen consumption by decomposers. The dissolved oxygen falls as decomposers metabolize waste materials. The optimal DO concentration for growth of fisheries is 5.00 - 8.00 mg/l. The sites that fell within this range are stations 2 and 5 where some kind of fishing is done. All the other sites except station 5 which fell in the range lethal for tilapia had concentration for which growth of tilapia will be impaired (EPA, 2002).

Biochemical Oxygen Demand (BOD) is used as an index for determining the amount of decomposing organic materials as well as the rate of biological activities in water. This is because oxygen is required for respiration by microorganisms involved in the decomposition of organic materials (Nartey *et al*., 2012). Thus high concentration of BOD indicates the presence of organic effluent and hence oxygen- requiring microorganisms. Indiscriminate defaecation and refuse disposal was observed at all the sampling stations. The slightly high BOD values may be attributed to the discharge of organic waste into water bodies resulting in the uptake of DO in the oxidative breakdown of these wastes (Akuffo, 1998). The nearness of the sampling locations to sewage /refuse wastes dumpsites is a factor promoting the loading of the water bodies with organic matter hence the high BOD values may be attributed to the percolation of waste water loaded with biodegradable compounds ( Pitchammal, 2009), which might be the result of untreated sewage, solid and industrial waste discharge respectively into each station (Milovanovic, 2007). The implication of high BOD in surface water could also mean that the oxygen present in the water will be used for decomposition of the pollutants, and thus, is not available for aquatic life anymore. The natural background level for freshwater ranges from 1.0 to 3.0 mg/l. The BOD of a river must generally not exceed 4.0 mg/l. This would reduce DO from saturating to 5.0 - 6.0 mg/l which is still capable of supporting aquatic life (Nartey *et al*., 2012).

Nitrogen which usually exists in water bodies as nitrate is a key ingredient in fertilizers. It generally becomes a pollutant in saltwater or brackish estuarine systems where nitrogen is a limiting nutrient. Excess amounts of bioavailable nitrogen in marine systems lead to eutrophication and algae blooms. The presence of nitrate observed in the study may be the result of waste being disposed off at the dumpsites. Thus, contamination of the water bodies with chemicals from the dumpsites is very likely to occur. This is because wastes from agro- based Industries which may contain nitrates are not segregated before disposal and are likely to find their way into the river systems in runoffs or leachate emanating from the dumpsites. It could also be attributed to run-offs from farms along the banks of the rivers which may contain organic fertilizers. Nitrates are the most common form of nitrogen found in natural waters with enough dissolved oxygen. The natural background levels of nitrate may come from rocks, land drainage and plant and animal matter. Extremely high concentration of nitrate is toxic. However, the values recorded for all the sampling stations do not exceed the WHO limit value of 10.0 mg/l (WHO, 2009). Invariably, nitrate is seldom abundant in natural surface water because it is incorporated into cells and chemically reduced by microbes and converted into atmospheric nitrogen (Chapman, 1996). This phenomenon may account for the low concentration of nitrate in surface waters particularly in the sampling stations.

Water containing high Calcium is not suitable for washing, bathing and in boilers. It causes concretion in the body and may cause intestinal diseases and stone formation. Higher concentration of Mg can cause hardness of water and exerts a cathartic and diuretic action (APHA, 1996). Total hardness causes incrustations in distribution systems and excessive soap consumption (Coleman, 1976). The higher content of chloride in stations 3 and 4 can be attributed to the heavy discharge of sewage waste (Pettyjohn, 1972), effluents from chemical industries (Little, 1971) and leaches from solid waste dumping, sea water intrusion etc (NRCC, 1977). Higher concentration of chloride in water can impart undesirable taste, may cause corrosion in the distribution system and may harm growing plants (McConnell, 1972).

The phosphate concentrations were relatively high compared with the natural background level of 0.02 mg/l. The high concentration may be due to the effect of seepage from the dumpsites into the water bodies. It can also be attributed to domestic waste water and agricultural run-offs. A high phosphate concentration is an indication of pollution. Phosphorus is also an essential nutrient and can exist in water in both dissolved and particulate forms. It is vital to the production of living organisms in the aquatic environment. High phosphate concentration is responsible for the eutrophication of a water body as phosphorus is a limiting nutrient for algae growth. All polyphosphates are eventually hydrolysed to produce the ortho form and the rate of hydrolysis is increased by temperature, decreased pH and bacterial enzyme action (WHO, 2004).

Conclusion

It was evident from the study that water quality in the river outlets was severely impaired by the raw wastes discharged from different sources at stations 1, 2 and 5. The decrease in dissolved oxygen, increase in total dissolved solids and a corresponding increase in electrical conductivity, turbidity, BOD, increase in hardness, chloride and sulphate concentrations proved considerable deterioration of water quality. These compounds can threaten the health of both humans and aquatic species while being resistant to environmental breakdown, thus allowing them to persist in the environment. The sources of these pollutants into these water bodies are through runoffs from the municipal dump sites and could also be attributed to indiscriminate defaecation and refuse disposal which had contributed to elevated levels of the pollutants. Also, dumping and farming along the banks of these water bodies had led to eroded materials accumulating in them.

## References

[1] Adesemoye, A.O., Opere, B.O. and Makinde, S.C.O. (2006). Microbial content of abattoir waste water and its contaminated soil in Lagos, Nigeria. Afr. J. Biotechnol. 5(20): 1963-1968.

[2] Agarrkar, VS and Thombre BS (2005). Status of Drinking Water quality in Schools in Buldhana District of Maharashtra, Nature Environment and Pollution Technology, 4(1), 495-499

[3] Akuffo, SB (1998). "Pollution Control in a Developing Country: A Case Study of the Situation in Ghana," 2nd Edition, Ghana Universities Press, Legon.

[4] American Public Health Association (APHA)(1996). Standard Methods of Examination of Water and Wastewater, 19th ed., American Public Health Association, Washington DC.

[5] American Public Health Association (APHA)(1998). "Standard Methods for the Examination of Water and Waste Water," 20th Edition, APHA, Washington DC.

[6] Aramini, JM; McLean, M; Wilson, J; Holt, J; Copes, R; Allen, B and Sears W (2009). Drinking water Quality and Health Care Utilization for Gastrointestinal Illness in Greater Vancouver, Environmental and Workplace Health Reports and Publications,

[7] Baskaran, P P and De Britto, AJ(2010). Impact of industrial effluents and sewage on river Thamirabarani and its concerns, Bioresearch Bulletin, 16(1): 16-18

[8] BIS (1992). Indian Standard Specification for drinking water, IS10500, Bureau of Indian Standards, New Delhi.

[9] Bolawa, OE and Gbenle, GO (2012). Analysis of industrial impact on physiochemical parameters and heavy metal concentrations in waters of river Majidun, Molatori and Ibeshe around Ikorodu in Lagos, Nigeria, Journal of Environmental Science and Water Resources, 1(2), 34–38

[10] Chapman, D (1996). "Water Quality Assessment. A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring," 2nd Editon, E&FN Spon, New York.

[11] Coleman R.L (1976). Potential public health aspects of trace elements and drinking water quality, Ann. Okla. Acad. Sci.,5, 57.

[12] Cunningham, WP and Saigo, BW(1999). "Environmental Science: A GlobalConcern," 5th Edition, McGraw-Hill Publishers, Boston.

[13] Davis, BR and Day, JA (1998). "Vanishing Waters," University of Cape Town Press and Juta Press, Cape Town, 1998

[14] EPA (2002). "Ghana Landfills Guidelines", Accra, 2002.

[15] Little, AD (1971). Inorganic Chemical Pollution of Freshwater, U.S. Environmental Protection Agency, Washington, DC.,

[16] McConnell, HH and Lewis, J (1972). Add salt to taste. Environment, 14, 38

[17] Milovanovic, M (2007). Water quality assessment and determination of pollution sources along the Axios/Vardar River, Southeastern Europe Desalination, 213, 159–173

[18] Nartey, VK; Hayford, EK and Ametsi, SK (2012). Assessment of the Impact of Solid Waste Dumpsites on some surface water systems in the Accra Metropolitan Area, Ghana. Journal of Water Resource and Protection 4:605-61

[19] NRCC(1977).The Effects of Alkali Halides in the Canadian Environment, NRCC No. 15019, Associate Committee on Scientific Criteria for Environmental Quality, Ottawa

[20] Odokuma, L.O. and Okpokwasili, G.C. (1993). Seasonal influences on inorganic anion monitoring of the New Calabar River, Nigeria. Environ. Manage. 17(4): 491-496.

[21] Onyeagba, R.A. and Umeham, S.N. (2004). Analytical Methods in Water Microbiology. In: Onyeagba, R.A. (ed.). Laboratory Guide for Microbiology. 1st ed. Crystal Publishers Okigwe, Nigeria. Pp. 178-191.

[22] Pierce, JJ; Weiner, RF and Vesihind, AP (1998).“Environ- mental Pollution and Control,” 4th Edition, Butterworth- Heinemann Press, Boston

[23] Pitchammal, V; Subramanian, G; Ramadevi, P and Ramanathan, R (2009). The study of water quality at Madurai,Tamilnadu, India, Nature Environment and PollutionTechnology, 8(2), 355-358.

[24] Sadar M.J (1996). Understanding turbidity science, Technical Information Series, Booklet II. Hach Co., Loveland, Co.,

[25] Subin, MP and Husna AH (2013). An Assessment on the Impact of Waste Discharge on Water Quality of Priyar River Lets in Certain Selected Sites in the Northern Part of Ernakulum District in Kerala, India. International Research Journal of Environment Sciences 2(6): 76-84

[26] Tebutt THY (1983). Principles of Quality Control, Pergamon, England, 235

[27] WHO (2004). “Environmental Chemistry,” 2nd Edition, WH Freeman and Co., New York, 2004

[28] WHO (2009). “Guidelines for Drinking-Water Quality, Volume 1: Recommendations. Geneva: WHO,” http://www.who.int/water_sanitation_health/dwq/GDWQ2004web.pdf