IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 9, Issue 1 Ver. I (Jan. 2016), PP 01-06
www.iosrjournals.org

Determination of Eutrophication Indices of Surface Waters of Abuja- Nigeria

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Abstract: *This research work investigates the eutrophication status of the surface water of Abuja –Nigeria. Surface water samples were collected using 1000ml HDPE bottles and analyzed for a period of six months in five different sites. The concentration of nitrate nitrogen (NO_3-N), phosphorus (PO_4^{3-}) and the COD were analyzed using standard procedure. Temperature, pH, electrical conductivity (EC), and total dissolved solids (TDS) were measured in situ during sampling. The results show the BOD value ranged from 3.10 at Site 5 to 40.30 at Site 4 (Figure 1). Sites 1-4 had BOD greater than 5 mg/l in October and hence rich in organic waste and prone to eutrophication. The highest value of COD was recorded in Site 4 in with a value of 86.000 ± 0.000 while the lowest value of 8.000 ±1.000 was recorded at Site 5 which is a Dam. The nitrate level ranged from 0.400 ±0.100 at Site 5 to 7.70±0.100 mg/l at Site 3. Potassium concentration ranged from 0.220 ±0.000 at Site 5 to 10.98 ±0.000 at Site 3. The pH ranged from 3.0 to 6.4. The highest value of TDS was recorded in Site 1 with a value of 1222mg/l ± 0.00 while Site 5 recorded the lowest value of 86.20 ± 0.00 mg/l. The eutrophication indices monitored shows that eutrophication is at its early stage in the Abuja surface water.*
Keywords*: Eutrophication, BOD, water pollution, surface water, Abuja*

I. Introduction

Availability of freshwater is one of the most critical environmental issues in our contemporary society. The population and ecosystem depends on water whose availability and usage vary greatly due to climatic fluctuations and human induced changes which trigger eutrophication and consequently bring in drought and desertification. Eutrophication is the process whereby a confined water body ages with time due to accumulation of silt or organic matter (Ademoroti, 1996; Fred and Ann 1978). Eutrophication has the capacity to render surface waters extinct over time (Shoshana 2012). Nutrients run-off from agricultural farms and leaching of fertilizers are known to be notorious in the stimulation of algae growth (Lathrop, 1998) and hence, are factors in eutrophication. Other cause includes animal waste which is also transported in mobile rain water (Eckert, 1995; Gimba, 2011). Fertilizer, detergent, and food industries among others discharge a lot of waste which can find their ways into lakes, streams or rivers or even directly to the municipal sewer system (Weibel, 1970). These furnish the water bodies with excessive nutrients that could kick start eutrophication. It has been reported that the presence of nitrate in water bodies support eutrophication and that many surface water systems in Nigeria are eutrophic (Okibe 2005).

Abuja, Nigeria is one of the fastest growing cities in the world. Increasing population and developments projected that the pressure on existing water supplies will leap in geometrical proportions and the populace will soon become vulnerable. Urbanization alters the hydrology in watershed through changes in land cover and introduction of new water collection and conveyance systems (Schillings and Libra 2003). Prolonged urbanization activities have triggered eutrophication in various parts of Nigeria with solid particles clogging water ways and some rivers becoming shallow, moving towards extinction. This has also resulted in massive flooding in various states in year 2012. Abuja has no natural rivers but artificial dams, drainage systems and manmade reservoirs. This makes it imperative to look at the statues of the surface waters of Abuja periodically to provide analytically informed optimism in the fight against flood, drought and desertification phenomena. This research work investigates the eutrophication status of the surface water of Abuja –Nigeria..

II. Materials And Methods

Study Area and sampling sites

The study area is located in the North central region of Nigeria and lies between Latitude 9^{o}03.471'N and Longitude 7^{o}29.7048'E. Abuja is 476m above sea level. It is one of the fastest growing cities of the world and highly urbanized. Five sites were selected for analysis, considering the interconnectivity of water channels at strategic points and the availability of water flow throughout the year. Site 1 is located in suburban area of Abuja where the main sources of pollutants are agricultural waste and domestic effluents. It serves as a washing site for the inhabitants of that area. Site 2 is located in another suburban area with a water velocity relatively higher than Site 1. It serves as a source of domestic water to many and is in close contact with farmlands. The geography of the area can easily permit agricultural runoff into the water during heavy down pour. Site 3 collects effluents from a densely populated area and is characterized by greenish appearance and offensive odour. This area is a bee hive of economic activity and the water flow allows fine granules of sandy and silt soils ranging from 0.002-2mm to accumulate at the bottom of the channels. Site 4 collects pollutants from different zones in Wuse and the major sources are domestic waste and improper sewage disposal. Site 5 is a dam is located in Kado Estate built on 7th May 2007. It serves as a relaxation center and free from indiscriminate discharge of pollutants.

Sample analysis:

Surface water samples were collected monthly from October 2013 to March 2014. A total of 240 samples were collected and analyzed. Water from about 10 cm below the water surface was collected using 1000ml HDPE bottles. The dark BOD bottles (300 ml) were used to collect sample for BOD analysis. Collected samples were preserved in cool box during sampling and transported to the laboratory for analysis. The concentration of nitrate nitrogen (NO_3-N), total phosphorus (PO_4^{3-}) and the COD were analyzed using standard procedure (APHA, 2005). Potassium was analyzed using flame photometer. Regarding BOD determination, the first DO reading was taken just after collecting the samples and the second one was taken after 5 days preservation in incubator at 20^{o}C. Parameters such as temperature, pH, electrical conductivity (EC), and total dissolved solids (TDS) were measured in situ during sampling.

III. Results And Discussions

Biochemical oxygen demand (BOD) is the amount of oxygen required by bacteria for breaking down to simpler substances, the decomposable organic matter present in any water, waste water or treated effluent. BOD value is a pointer to the level of eutrophication in a water body. The BOD value ranged from 3.10 at Site 5 to 40.30 at Site 4 (Figure 1). The fluctuation in the value with months of analysis is attributed to change in velocities of water flow. Similar patterns were observed at all other Sites (Figure 1). Only site 5 recorded a low value of 3.1mg/L BOD in October probably because it is a dam with legislation restricting human activities. Sites 1-4 had BOD greater than 5 mg/l in October and hence rich in organic waste and prone to eutrophication. Samples of water with BOD values greater or equal to 10 mg/l are said to be very bad with heavy biodegradable waste deposits. Research by Taiwo *et al.,* (2012) reported BOD values as high as 534mg/l and 1352.3 mg/l in two different sites in Lagos and 4374 mg/l in Port Harcourt, 300 mg/l in Kaduna. Taiwo *et al.,* (2012) reported that investigation into eutrophication of water body should not be limited to water assessment for consumption but also in relation to its agricultural, industrial, recreational, commercial uses and its ability to sustain aquatic life. The highest value of BOD in this research was 40.300mg/l. This is a pointer to the fact that organic load of Abuja surface water is far lower compared to literature and that eutrophication is at its very early stage. Lagos and Port Harcourt have greater concentration of chemical industries and are relatively denser in population than Abuja. The BOD values of Abuja surface water shows that it can sustain life and that it is fit for agricultural, industrial, recreational, and commercial uses.

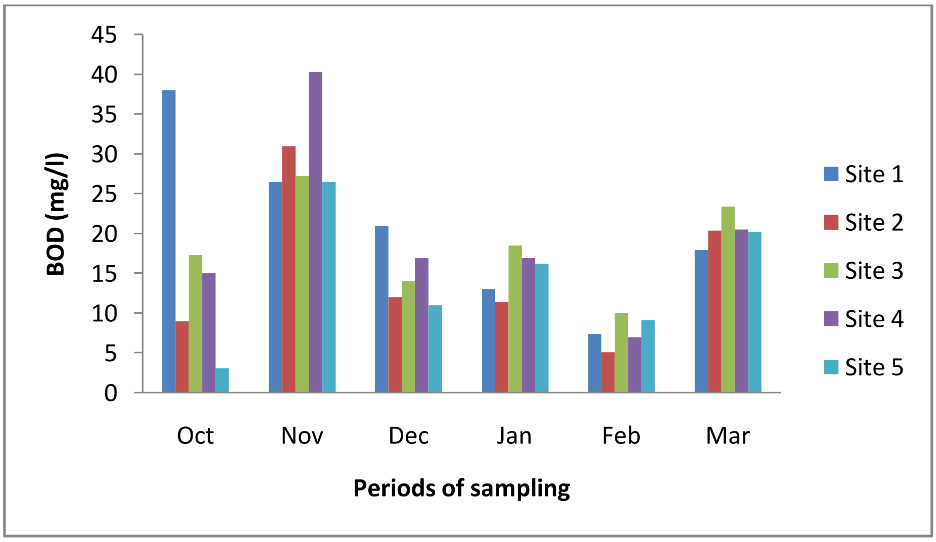

Figure 1: the BOD levels of studied sites within the period of study.

Figure 2 shows the Chemical oxygen demand (COD) during the period of study. COD is the amount of oxygen required for complete oxidation to carbon (IV) oxide and water of organic matter present in a sample of water, waste water or effluent. The highest value of COD was recorded in Site 4 in the month of October with a value of 86.000 ± 0.000 while the lowest value of 8.000 ±1.000 in October at Site 5 which is a Dam. Figure 2 shows irregular trends in the value of COD in all the sites suggesting that the major sources of waste may be due to anthropogenic activities with irregular discharges of waste with time. Taiwo *et al.*, (2012) recorded high values of 850 mg/l and 2253 mg/l for COD in two sites in Lagos and 1800 mg/l in Kaduna. The research shows a low COD compared with report in literature (Taiwo *et al*., 2012).

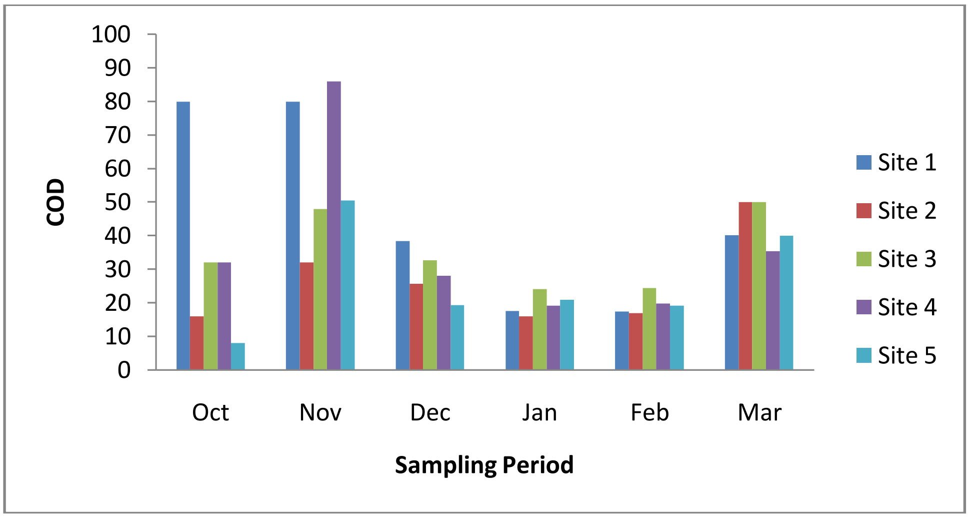

Figure 2: The COD values of the study sites

The variations in nitrate concentrations at the various sites are shown in Figure 3. Site 1 shows a diminishing value from 3.520 ± 0.106 in October to 0.967 ± 0.058 mg/l in March whereas Site 2 shows an increase from October to March. The nitrate nitrogen content varied aberrantly throughout the study period especially at Sites 3 and 4. The irregular pattern of nitrate concentration could be due to differences in pattern of rainfall with months and variation in the magnitude of farming activities at the different months. It may also be due to differences in bacteria conditions which participate in the natural nitrogen cycle producing nitrate for plant metabolism. The nitrate level ranged from 0.400 ±0.100 at Site 5 to 7.70±0.100 mg/l at Site 3. Nitrate concentration is a major determinant of eutrophication profile. Akin-Oriola (2003) reported very low values of nitrate in the range of 0.00-0.40mg/l with an average of 0.16±0.04mg/l for Ibadan in Western part of Nigeria.

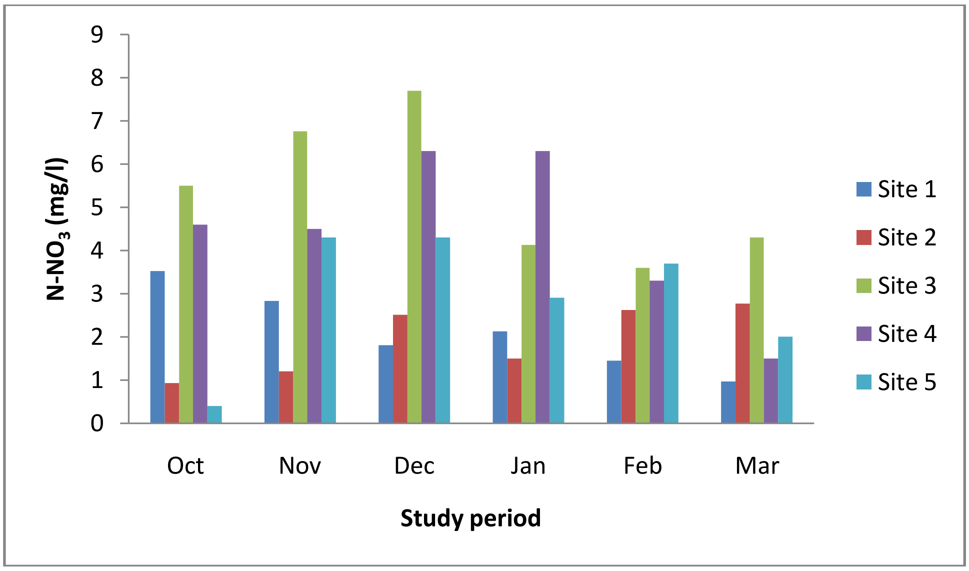

Figure 3: The variation of nitrate concentration within the study period

The phosphate level of the study area is shown in Figure 4. Only Site 1 shows a progressive increase in phosphate concentrations from October (3.600 ± 0.000) to March (13.300 ± 0.100 mg/l). However, the results from Sites 2 to 5 show varying concentration of phosphate. Phosphorus, the most vital nutrient effecting productivity of natural water, fluctuated between 3.60 mg/l to 13.30 mg/l. This may be due to irregular release of phosphate from sediments or bacteria oxidation of phosphorous compounds and perturbation from human activities through waste disposal. Pinto-Coelho (1998) reported that phosphorus, nitrogen and chlorophyll are widely used to monitor the progress of eutrophication in aquatic ecosystem.

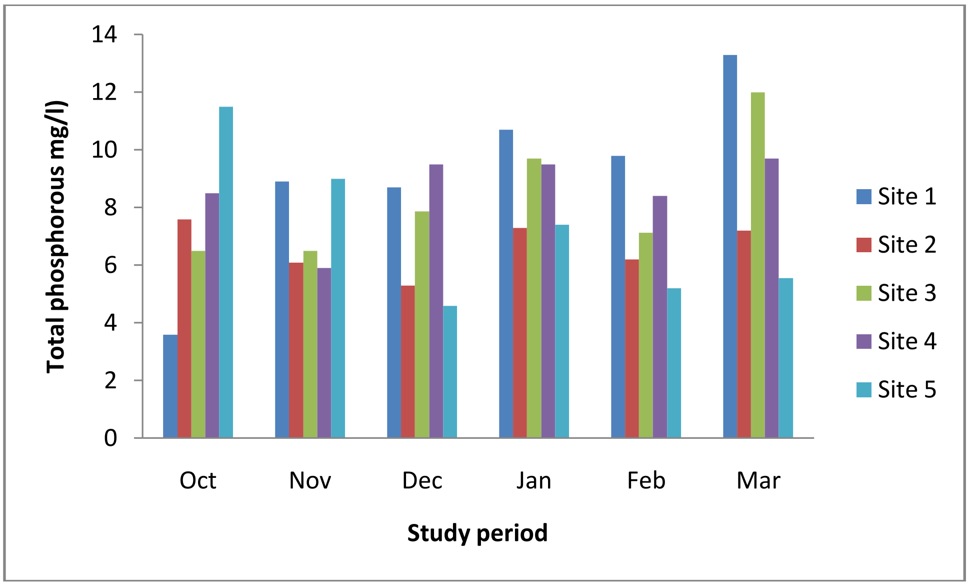

Figure 4: The variation of phosphorous concentration within the study period

Potassium concentration ranged from 0.220 ±0.000 at Site 5 to 10.98 ±0.000 mg/l at Site 3 as shown in Figure 5. The potassium level was very low in the month of January with almost a general decrease from October to January. This may be due to the reduction in the use of the popular NPK fertilizers as the year approached the dry season and hence reduction in farming activities. A rapid leap in potassium concentration was again noticed from February to March in all sites suggesting that potassium might have been introduced by resumption of cultivation usually by irrigation along the water bodies.

The conductivity was exceptionally high at Site 1 by October but generally between 100 and 200 µs/cm (Figure 6). Generally, as the water becomes less in volume or move with slow uniform velocity; most of the ions in solution migrate to the bottom leading to a reduced concentration on the top surface water. Anake *et al.*, (2013) reported that conductivity is often used as a surrogate for TDS and that a conductivity of 1400 µs/cm is equivalent to 1000µg/L of dissolved solid.

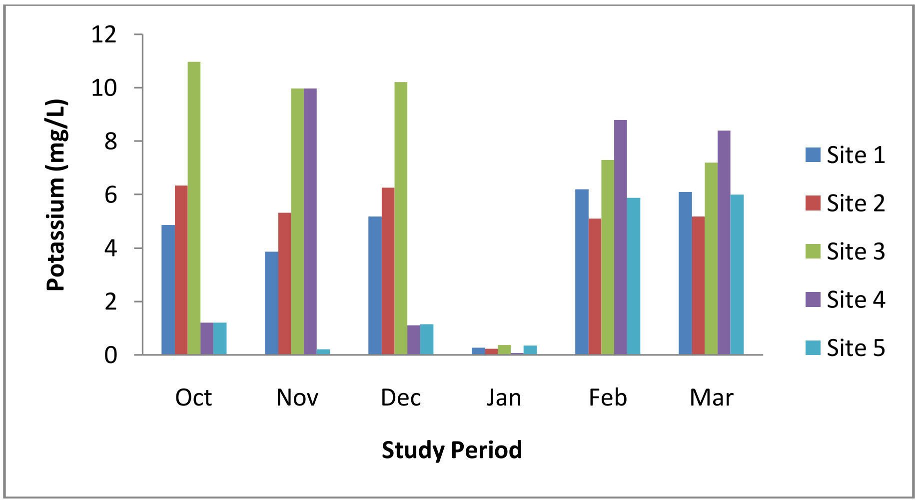

Figure 5: The concentration of potassium at the study sites

The conductivities reported by Anake *et al.*, (2013) varied from 116 µs/cm to 396 µs/cm for surface waters and 36.5 µs/cm to 98.2 µs/cm for portable water. Standard Organization of Nigeria (SON) permissible limits for unpolluted water was fixed at 1000 µs/cm Anake *et al.*, (2013). The conductivity was above 2000 µs/cm at Site 1 implying high level of pollution. However, the values were less than a 1000 µs/cm at the subsequent months of analysis. Moshood (2008) observed higher conductivity during rainy season which he attributed to increased in concentration of cations such as magnesium and sulphate while utilization of these salts by planktons and macrophytes produce reduction in conductivity. Moshood (2008) observed in Kwara State of Nigeria that 80.40µs/cm-178.80µs/cm would support diverse species of organism. In this research work, the values of conductivities obtained were far higher than 80.40µs/cm-178.80µs/cm so there is limitation placed on the survival of certain organisms in Abuja aquatic environment.

The highest values of TDS of the four sites were recorded in Site 1 in the month of October with a value of 1222mg/l ± 0.00 while Site 5 recorded its lowest value of 86.20 ± 0.00 in the month of October. This high value of total dissolved solid in the month of October could be due to higher rainfall pattern compared to other months and hence higher water volume and consequently higher entropy in the solid particles making them to dissolve better in the water samples. Moshood (2008) adduced that settling of dissolved salts coupled with uptake of ions may be responsible for lower TDS in dry season as observed in this research.

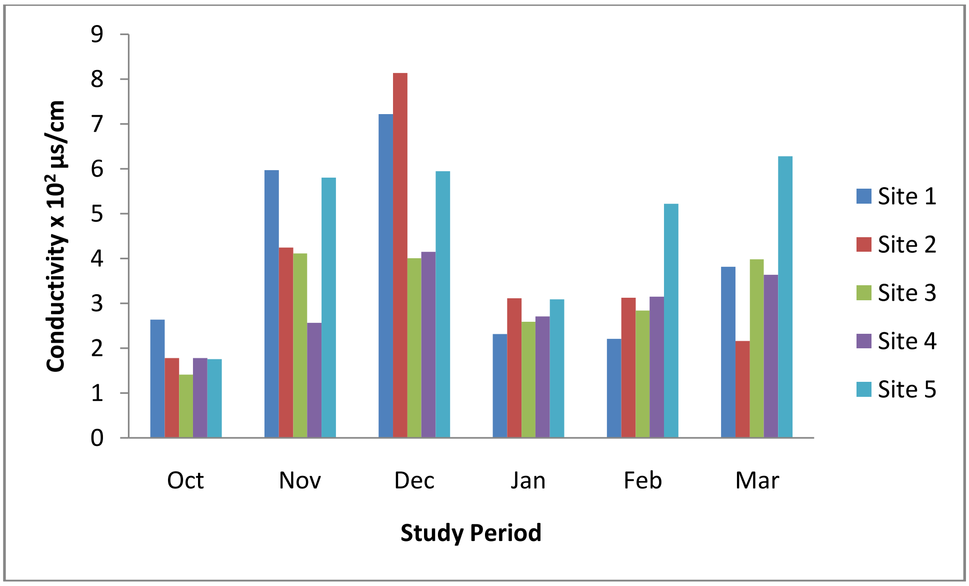

Figure 6: Conductivity values of the different sites

All the sites showed increase in pH value from October to March suggesting that there was a decreasing trend in anthropogenic activities such as fertilizer application to farms. Anake *et al.*, (2013) reported that low level of pH could be attributed to presence of excess CO_2 and SO_2 caused by microbial activities. The pH ranged from 3.0 to 6.4 as shown in Figure 8.

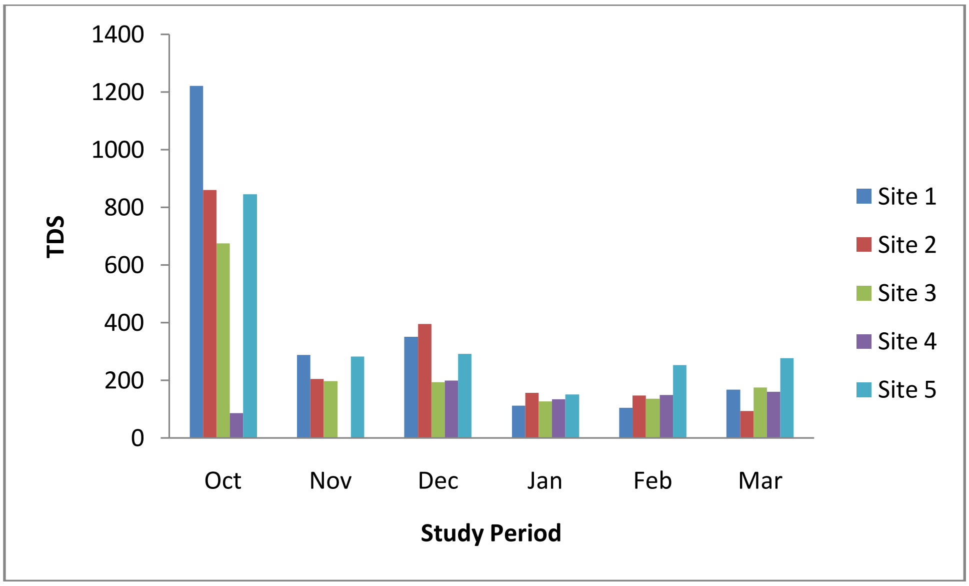

Figure 7: TDS values of the different sites

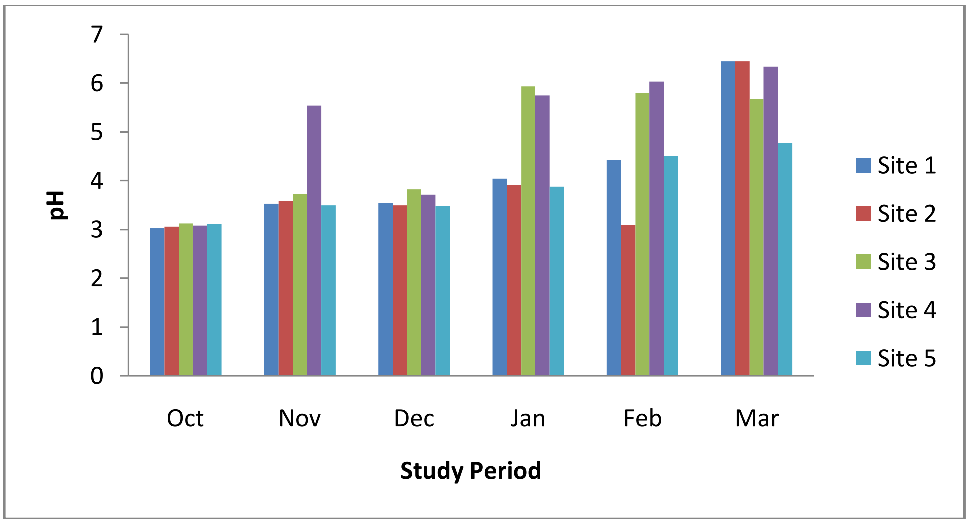

Figure 8: Variation of pH with sites

IV. Conclusions

Phosphorus, nitrogen and potassium are widely used to monitor the progress of eutrophication in aquatic ecosystem. The eutrophiction indices obtained from the research work shows low level of eutrophication of the Abuja surface water**.** The BOD values of Abuja surface water shows that it can sustain life and that it is fit for agricultural, industrial, recreational, and commercial uses. Farming activities influence to a large extent the concentration of nitrate nitrogen, phosphate and potassium in the studied sites. Variation in the level of phosphorous with sites may be due to irregular release of phosphate from sediments or bacteria oxidation of phosphorous compounds and perturbation from human activities through waste disposal. The values of conductivities obtained indicate there is limitation placed on the survival of certain organisms in the Abuja aquatic environment. All the sites showed increase in pH value from October to March suggesting that there was a decreasing trend in anthropogenic activities such as fertilizer application to farms. Overall it can be concluded that eutrophication is at its rudimentary stage in the Abuja surface waters.

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