Physicochemical Characteristics of a Tropical Seasonal Water Body: Ikoro Stream, Edo State, Nigeria

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ABSTRACT: The objective of this paper is to evaluate the physicochemical characteristics of a tropical seasonal water body- Ikoro stream, Edo State, Nigeria using standard methods. The results obtained from the physical and chemical analyses showed that the range of values were: 23ºC - 30ºC for air temperature, 22ºC - 29ºC for water temperature, 1.28NTU - 14.48NTU for turbidity, 1mg/l - 10mg/l for total dissolved solid, 4.01 - 6.43 for pH, 2.3µScm^{-1} - 21.7µScm^{-1} for conductivity, 4.00mg/l - 13.00mg/l for dissolved oxygen, 0.005mg/l - 0.227mg/l for Sulphate, 0.004mg/l - 0.047mg/l for nitrate, 0.05mg/l - 0.15mg/l for phosphate, 0.49mg/l - 2.43mg/l for magnesium, 2.41mg/l - 8.02mg/l for calcium, 0.19mg/l - 8.71mg/l for ammonium, 14.3mg/l - 22.3mg/l for chloride, 1.33mg/l - 2.57mg/l for sodium, 0.76mg/l - 1.46mg/l for potassium, 10.18mg/l - 26.88mg/l for silicate, 18.30mg/l - 42.70mg/l for total alkalinity 2.90mg/l - 9.64mg/l for total hardness. The parameters fluctuated in all three stations throughout the period of study while only turbidity showed a seasonal pattern of increasing trend from dry season to rainy season. The stream had low nutrients level but high ammonium in one of the stations which clearly exceeded the WHO guideline for drinking water.

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Limnology is the study of the structural and functional interrelationship of organisms of inland water as they are affected by their dynamic physical, chemical and biotic environment (Wetzel, 2001). It is an interdisciplinary field with major components contributed by biological, geological, physical and chemical sciences in order to study inland waters as a complex ecological system (Wetzel, 2000). Inland waters bodies can be classified as either lotic (flowing water) or lentic (standing waters). Lotic habitats include rivers, streams and brooks while lentic habitats include lakes, ponds and marshes. The major difference between them is the persistent flow of water in a lotic ecosystem. These water bodies are essential to humans not only for drinking but also, for transportation, fishing, agriculture, energy production, industry and waste disposal (Carpenter *et. al.* 2011). Limnological studies involving the study of the physical and chemical characteristics of Rivers and lakes have been of great importance in recent times. Water bodies vary in their biological, chemical and physical characteristics. Biologically water bodies vary in terms of biomass, population numbers and growth (Lorenzen and Enberg 2002).Chemically, they vary in dissolved oxygen, total hardness, conductivity pH, total alkalinity, chlorophyll a, organic matter and nutrients (Mwamburi *et al*. 2020), physically, they vary in terms of temperature, colour, turbidity, rainfall, light intensity, transparency, solar radiation and solids (Wetzel and Likens 2000). Physical and chemical factors provide a frame work of a running water community in which organisms in their favoured ecological niches occupy (Wetzel and Likens, 2000). The physical and chemical environment is important in monitoring the changes in any water body. Such information explains the aging process of a river or

lake and enables comparison with other water bodies. Hence, the objective of this paper is to evaluate the physicochemical characteristics of a tropical seasonal water body- Ikoro stream, Edo State, Nigeria.

MATERIALS AND METHODS

Description of study area: Ikoro Stream is located at Ikoro village in Ovia North East Local Government Area of Edo State. It is a tributary of River Osse and it lies between latitude 5^0 25 E and 5^0 30 and longitude 6^0 15 N and 6^0 19 N. There are two main seasons in the study area. These are the dry season, which starts in November, and last up to April (it is often accompanied by dry, dusty harmattan winds from December to January) and the rainy season which starts in May and ends in October or November.

Collection of samples: The sampling was carried from three sampling stations on monthly intervals for a period of eight months that covered both dry and wet season. Water samples for physical and chemical parameters were collected in sterile plastic containers.

Physicochemical Analysis: Air and water temperatures were measured *in situ* using mercury in glass thermometer. Turbidity values were read off a spectronic 21D spectrophotometer (Milton Roy). Total Dissolved Solids was measured by HACH conductivity/total dissolved solid meter. pH was measured using a Jenway digital pH meter. Conductivity was measured with HACH conductivity meter. Dissolved Oxygen was determined trimetrically by the alkali-azide modification Winkler's method. Total hardness, Alkalinity, Nitrate, Sulphate, Phosphate, Silicate, Chloride, Calcium, Magnesium and Ammonium concentrations were determined as described in APHA (2005).

Statistical Analyses: Mean and standard error for each parameter were calculated for the various sampling stations, while one way analysis of variance was performed to know the level of significant differences between the stations. These were done using Excel and SPSS packages.

RESULTS AND DISCUSSION

The monthly variations in air and water temperature are shown in figures 1 and 2. The air temperature values ranged from 23ºC to 30ºC with a mean value of 28.ºC while the water temperature values ranged from 22ºC to 29ºC with a mean value of 26.4ºC. The maximum air temperature of 30ºC was recorded at station I in February; station II in February, March and April while the minimum air temperature of 23ºC was recorded at station II in May. Maximum water temperature of 29ºC was recorded at station I in February, station II in February. Minimum water temperature of 22ºC was recorded at station I in May and station III in May. There was significant variation in air and water temperature values (p>0.05). In all the three stations, air temperatures closely followed the variations in water temperatures with the former being higher than the latter except in few cases when higher water temperatures were recorded in stations II and I respectively. Egborge *et al*. (1986); Skliris *et al.* (2012), reported that although water temperatures closely followed the changes in atmospheric temperatures, atmospheric temperature values usually follow a seasonal pattern but that was not the case in this study. The values were erratic, an indication of the changing climatic condition in the study area.
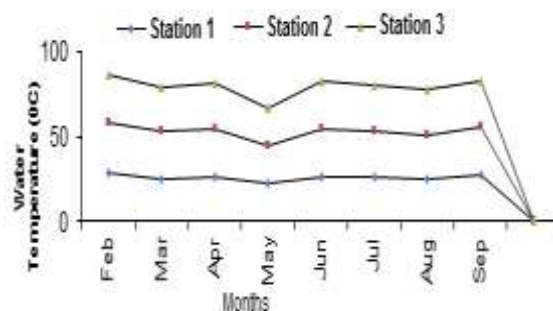

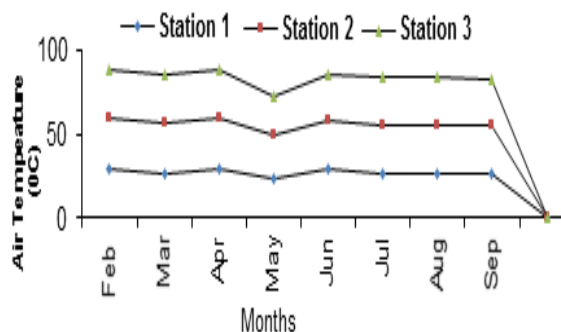**Fig 1:** Temporal and Spatial variation in air temperature along Ikoro Stream

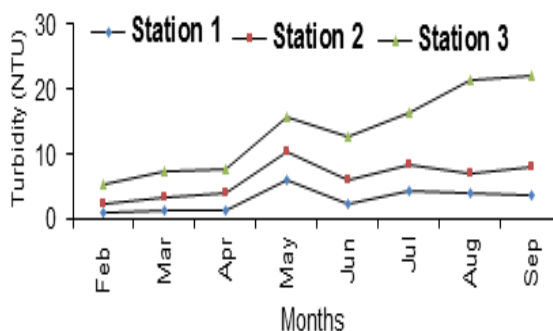**Fig 2:** Temporal and Spatial variation in water temperature of Ikoro Stream

Fig 3: Temporal and Spatial variation in Turbidity of Ikoro Stream

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Turbidity values fluctuated in all the stations during the sampling period with a mean value of 4.55NTU. The maximum value of 14.48 NTU was recorded at station III in August while the minimum value of 1.28NTU was recorded at station I in February and station II in February. This is shown in figure 3. There was significant differences in turbidity values (p<0.01).The high turbidity values obtained in one of the stations were occasioned by human activities, while the low turbidity values were obtained from the stations with little or no human activities and washing of clothes. These activities may also lead to the continued accumulation of silt in the bed of the water, which become suspended at the slightest agitation. Total dissolved solid (TDS) values are shown in Figure. 4 with the maximum value of 10mg/l recorded at station II in February and station III in March. The minimum value of 1mg/l was recorded at station I in March. The mean TDS value is 5mg/l. There was no significant variation in TDS values (p>0.05).The total dissolved solids content of the stream during the study period was generally low. This could be attributed to low discharge of industrial effluents and sewage.
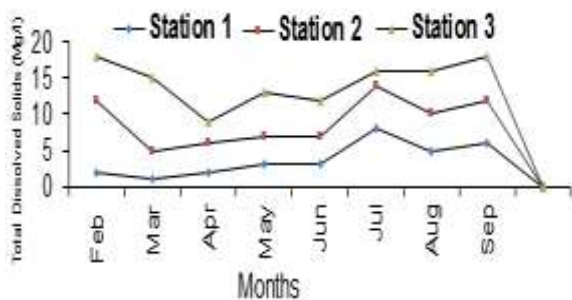

Fig 4: Temporal and Spatial variation in Total Dissolved Solids of Ikoro Stream

The pH of water affects the biological and chemical processes in water Jindal *et al.* (2014b). Monthly variations in pH values are shown in figure 5 with a mean value of 5.57. The maximum pH value of 6.43 was recorded at station II in February while the minimum pH value of 4.01 was recorded at station III in June. There was no remarkable variation in pH values (p>0.05).The monthly fluctuations in the pH values of Ikoro stream showed that the stream remained acidic throughout the study period. The pH recorded for Ikoro stream are similar to those obtained for some Nigerian water bodies; 4.0-7.1 for Asata river Ozochi *et al.* (2023), 4.4-5.6 for Imo River Basin Ijeh and Udoinyang (2013), 4.9-6.8 for Ikpoba Reservoir (Kadiri, 2000a).

Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentrations and on the temperature of measurement. Conductivity values are shown in figure 6 with a mean of $10.4\mu scm^{-1}$. The maximum conductivity value of $21.7\mu scm^{-1}$ was recorded at station III in March while the minimum conductivity value of $2.3\mu scm^{-1}$ was recorded at station I in March. There was no remarkable variation in conductivity values (p>0.05).
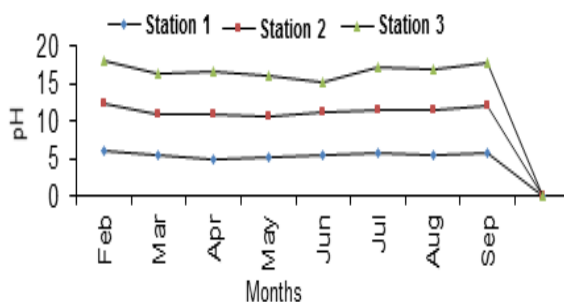

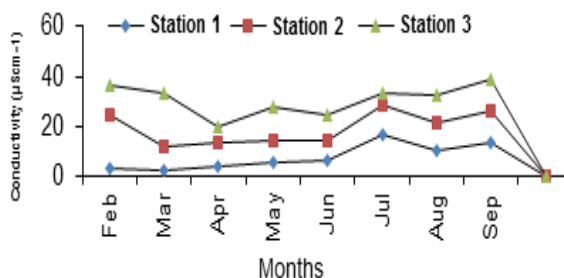**Fig 5:** Temporal and Spatial variation in pH of Ikoro Stream

Fig 6: Temporal and Spatial variation in Conductivity of Ikoro Stream

The conductivity values of Ikoro stream were relatively low ($2.3-21.7\mu scm^{-1}$) when compared with the conductivities of $16.0-900.0\mu scm^{-1}$ of Bonny River in Chindah and Pudo (1991) , $3.0-79 \ \mu scm^{-1}$ of groundwater in Khana and Gokana, Udom *et al.*(2002) and $10-14500\mu Scm^{-1}$ of U.S. Rivers, Potapova and Charles (2003). It is however comparable to Ikpoba Reservoir with a conductivity range of $14.0-20.7\mu scm^{-1}$(Kadiri 2000a). The fluctuations in conductivity values observed in this report can be compared with that of Ogbeibu and Victor (1995), who found that the pattern in which conductivity rises during the dry season and falls during the rainy season is more pronounced in lentic water and it is attributable to the direct dilution of rainfall or the dilution effect of the run-off water containing low mineral content or to rapid run-off which gives little opportunity for the rainwater to contact ion exchange sites in the soil. Biological activities affect the concentration of oxygen in water with photosynthetic activities of autotrophs leading to increased oxygen concentration. Conversely, bacteria and other microorganisms' proliferation as well as increasing temperature deplete

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oxygen. Figure 7 shows the monthly variations in dissolved oxygen values for the period of sampling. The maximum dissolved oxygen value of 13mg/l was recorded at station I in April and station II in July while the minimum dissolved oxygen value of 4.00mg/l was recorded in station I in September. The mean value of dissolved oxygen was 9.16mg/l. There were no significant variations in DO values. ($p > 0.05$).
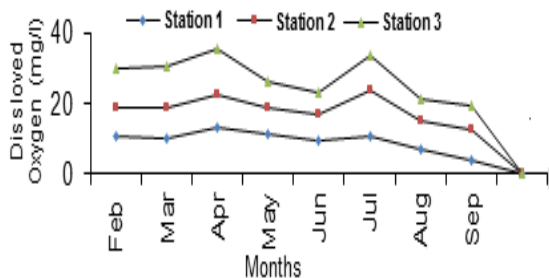

Fig 7: Temporal and Spatial variation in Dissolved Oxygen of Ikoro Stream

Dissolved oxygen values range from 4.00 to 13.00mg/l, values high enough to regard the water as healthy. The high dissolved oxygen content is traceable to increased photosynthetic activities of autotrophic organisms; low values of dissolved oxygen is due to the presence of many dead and decaying leaves common to drier months.

The maximum sulphate value of 0.227mg/l was recorded in station III in September while the minimum sulphate value of 0.005 mg/l was recorded in station I in February. The monthly variation in sulphate values is shown in figure 8. The mean value of sulphate is 0.065mg/l. there was no significant variation in sulphate values ($p > 0.05$).
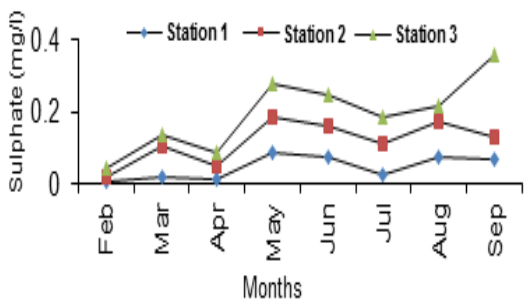

Fig 8: Temporal and Spatial variation in Sulphate of Ikoro Stream

Remarkably low Sulphate values (0.005mg/l - 0.227mg/l) recorded are similar to the findings of (Beauchamp 1953) which states that African inland waters are noted for their generally low in sulphate content which is attributable to the low concentration in the non-sedimentary rocks of drainage areas. Omoigberale and Ogbeibu (2007) also reported low sulphate values for some Nigerian rivers.

Nitrate is an essential constituent of aquatic plants. It generally occurs in trace quantities in surface water. The highest nitrate value of 0.047 mg/l was recorded at station III in April and September respectively while the lowest nitrate value of 0.004 mg/l was recorded at station II in March. The monthly variation of nitrate values is shown in figure 9. The mean nitrate value is 0.09mg/l. there was no significant variation in nitrate value ($p > 0.05$).

Fig 9: Temporal and Spatial variation in Nitrate of Ikoro Stream

There was no discernable trend in nitrate values that ranged from 0.004 - 0.047mg/l. The observation of generally low values of nitrate in the Ikoro stream is a confirmation of the fact that African waters are generally low in this ion Kebede and Belay (1994). Low nitrate values observed on the continent are caused by low pH, which is responsible for the reduction in nitrates to nitrites and molecular nitrogen (Mtada, 1985). Phosphate is essential to the growth of organisms and can be a limiting factor in primary productivity. Figure 10 shows the monthly variations of phosphate values with a mean value of 0.09mg/l. The highest phosphate value of 0.15 mg/l was recorded at station I in May while the lowest phosphate values of 0.05mg/l was recorded in station I in July, August and station III in August. There was no remarkable variation in phosphate values ($p > 0.05$).
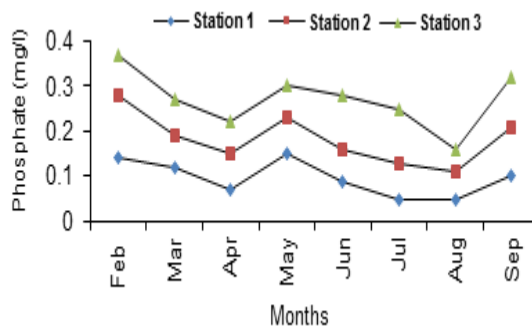

Fig 10: Temporal and Spatial variation in Phosphate of Ikoro Stream

Phosphate values (0.05 - 0.14mg/l) were remarkably low. This may be due to the consumption/utilizaton of phosphate by autotrophic organisms.

Magnesium is a common constituent of natural water and a major contributor to water hardness. The monthly variations of magnesium values are shown in figure 11 with a mean value of 0.39mg/l. The highest magnesium values of 2.43mg/l was recorded at station II in February while the lowest magnesium value of 0.49 mg/l was recorded at station I in February, March, April, June respectively; station II in June and station III in August. There was no remarkable variation in magnesium values (p>0.05).
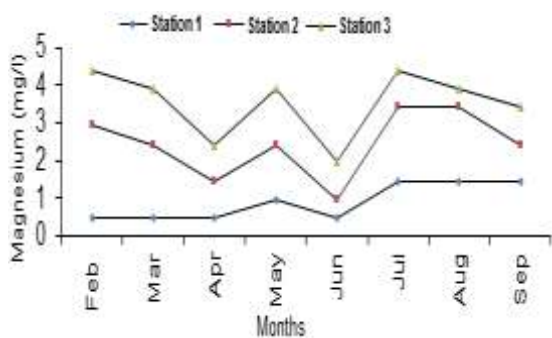

Fig 11: Temporal and Spatial variation in Magnesium of Ikoro Stream

In this study, there was no discernible fluctuation pattern in magnesium values; this is similar to those recorded by (Kadiri 2000a) for Ikpoba Reservoir.

Calcium contributes to the total hardness of water. The maximum calcium value of 8.02 mg/l was recorded at station II in May while the minimum value of 2.41 mg/l was recorded in station I in February, March and April respectively as shown in figure 12 with a mean value of 4.31mg/l. There was little variation in calcium values (p<0.05)
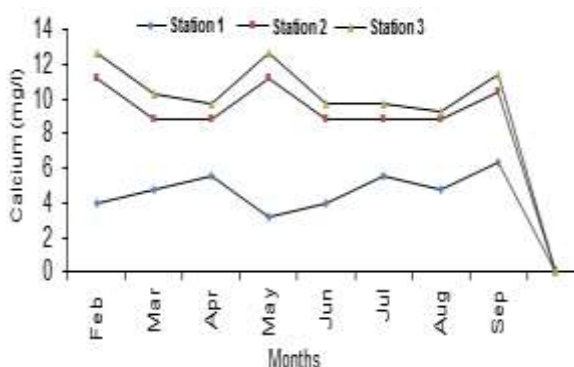

Fig 12: Temporal and Spatial variation in Calcium of Ikoro Stream

Calcium ion values range from 2.41 - 8.02mg/l with no discernible fluctuation pattern. This could be attributable to the geology of the surrounding area, discharge, local conditions and introduction from other sources like seepage. The calcium ion concentration of Ikoro stream is comparable to that of

Tavera and Martinez-Almeida (2004); Potapova and Charles (2003)

Ammonia values fluctuated significantly throughout the period of sampling. (p<0.001) with a mean value of 4.01mg/l and the maximum ammonia value of 8.71 mg/l was recorded at station II in June and the minimum ammonium value of 0.19 mg/l was recorded at station I in August (shown in figure 13).
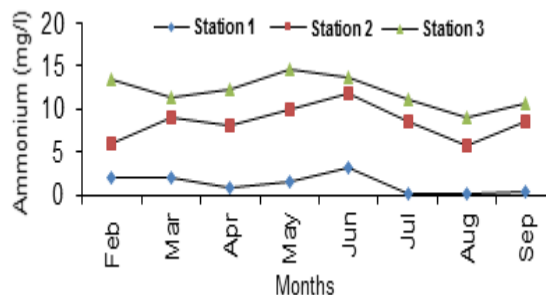

Fig 13: Temporal and Spatial variation in Ammonium

There was a discernable fluctuation in ammonium values throughout the period of study. This could be as a result of large quantity of organic matter in the tropical forest with consequent high microbial activities. The monthly variations in chloride values are shown in figure 14. the highest chloride values of 21.30 mg/l was recorded at station I in February, March, May, April, August, September and station III in February, May respectively. The mean value is 17.21mg/l and there were no significant variations in Chloride values (p>0.05).
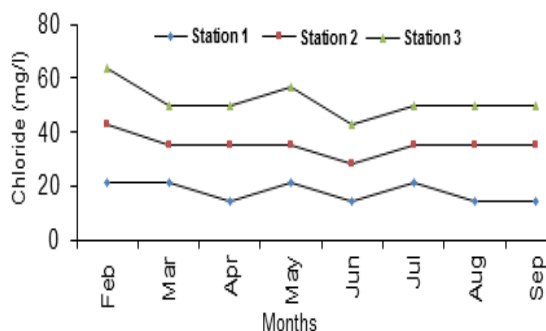

Fig 14: Temporal and Spatial variation in Chloride of Ikoro Stream

There was no discernible seasonal trend in chloride value in Ikoro Stream, which ranged from 14.29 - 21.30mg/l. Kadiri. (2000a) reported lower chloride levels (0.9 mg/l - 3.1mg/l) for the Ikpoba Reservoir. The silicate concentration of natural surface water is greatly influenced by flood influx during the rainy season Puczko and Jekatierynczuk-Rudczyk (2020). Sodium is present in most natural waters. The levels may vary from 1mg Na/L to more than 500mg Na/L.

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The maximum sodium value of 2.57 mg/l was recorded at station II in May and the minimum sodium value of 1.33 mg/l was monthly variations of sodium values are represented in figure 15. The mean value is 1.82mg/l. there was no remarkable variation in sodium values (p>0.05).
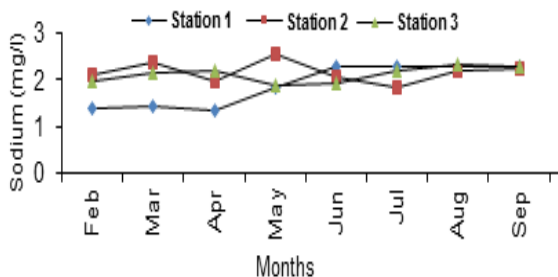

Fig 15: Temporal and Spatial variation in Sodium of Ikoro Stream

The range of sodium ion value: 1.33mg/l - 2.57mg/l is comparable with that of Ikpoba Reservoir with a sodium ion value of range 1.7 - 5.3mg/l.

Potassium is present in most natural waters but its concentration hardly reaches 20mg/L in most drinking water. The potassium ion values are shown in figure 16 with mean values of 1.16mg/l. The highest potassium value of 1.46 mg/l was recorded at station II in May while the lowest potassium value of 0.76 mg/l was recorded at station I in April. There was no significant variation in potassium values (p>0.05).
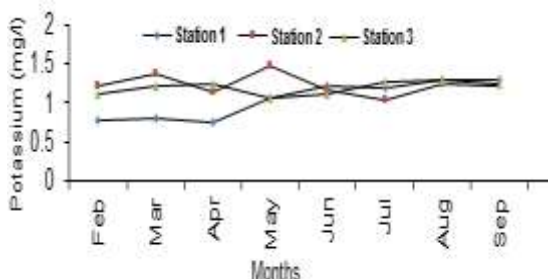

Fig 16: Temporal and Spatial variation in Potassium of Ikoro Stream

Potassium ion values ranged from 0.76mg/l - 1.46mg/l, this is comparable to that of the Ikpoba Reservoir with Potassium ion value of range 0.5mg/l - 2.4mg/l (Kadiri 2000a). Low potassium value is attributable to low discharge of effluents containing detergents and fertilizer run-off.

Silicate ion values are shown in figure 17 with the maximum value of 26.88 mg/l recorded at station II in February while the minimum silicate value of 10.18mg/l was recorded at station III in August. The mean value is 17.97mg/l and there was no remarkable variation in silicate values (p>0.05).
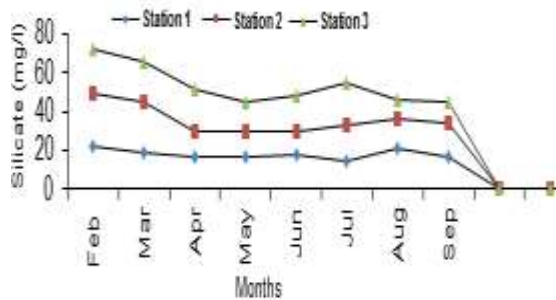

Fig 17: Temporal and Spatial variation in Silicate of Ikoro Stream

Silicate values of Ikoro Stream ranged from 10.18 - 26.88mg/l. This is comparable to that of the Ikpoba Reservoir with a silicate value of range 10.2 - 23.6mg/l (Kadiri 2000a). Most African Rivers have high silicate content (Visser and Villenueve (1975).

The highest alkalinity value of 42.70mg/l was recorded at station I in September while the lowest alkalinity value of 18.30 mg/l was recorded at station I in March, April and station III in July, August, and September respectively. The mean value of total alkalinity is 27.20mg/l. The variation in alkalinity values is shown in figure 18. There was no remarkable variation in total alkalinity values (p>0.05).
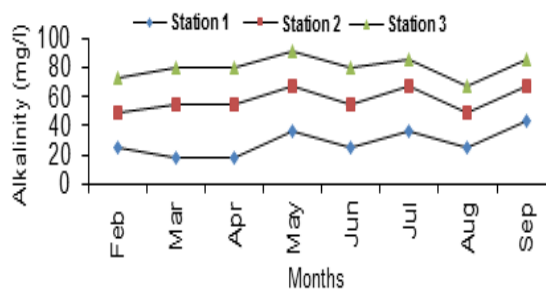

Fig 18: Temporal and Spatial variation in Alkalinity of Ikoro Stream

Alkalinity is a measure of the weak acids and its salts present in a water body. It is the neutralizing capacity of a water body and primarily a reflection of the concentration of carbonate, bicarbonate and hydroxyl ions in water. Alkalinity values varied throughout the period of study with a range of 18.30 - 42.72mg/l. This is comparable to that of two streams in Ekiti State with alkalinity range of 15 - 55mg/l (Kadiri 2000b). The high values recorded indicated that the bicarbonates and carbonates contents were high.

The monthly variation in total hardness values is shown in figure 19. The maximum total hardness value of 9.64 mg/l was recorded at station II in February while the minimum total hardness value of 2.90 mg/l was recorded at station I in February, March, and April respectively. The mean value of total hardness is

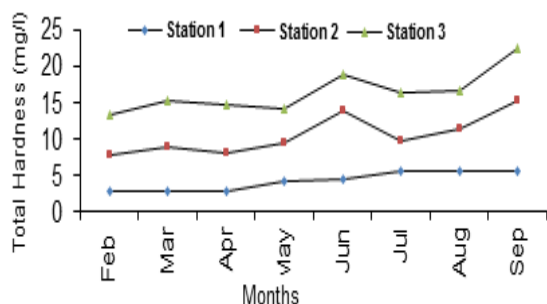5.49mg/l. There was no significant variation in total hardness values (p>0.05).

Fig 19: Temporal and Spatial variation in Total Hardness of Ikoro Stream

The total hardness values range from 2.90 - 9.64 mg/l such low values indicate that the streams are of soft water. This is comparable to that of the Ikpoba Reservoir with a total hardness range of 5.7 -7.7mg/l (Kadiri 2000a). The similar lack of a discernible fluctuation pattern in magnesium and total hardness suggests that the variation in the latter was due to variation in the former.

A comparison of some physical and chemical parameters of Ikoro Stream with that of World Health Organization guideline for drinking water was done and it is shown in table 1 below.

Table 1: Comparison of some physical and chemical parameters of Ikoro stream, with that of World Health Organization guideline for drinking water.

Parameters	Ikoro River	WHO Limit
1. Ammonium	4.011mg/L	1.5mg/L
2. Total Hardness	5.48mg/L	250mg/L
3. Nitrate	0.016mg/L	50mg/L
4. pH	5.56	6.5 - 8.5
5.Total dissolved solids	4.87mg/L	1000mg/L
6. Sodium	2.05mg/L	200mg/L
7. Sulphate	0.065mg/L	250mg/L
8. Turbidity	4.54NTU	5NTU
9. Alkalinity	27.20mg/L	30mg/L

In comparison with the World Health Organization standards, Ikoro Stream recorded lower nitrate, sulphate, sodium, total dissolved solids, alkalinity, pH and total hardness values. The stream recorded a mean turbidity of 4.54NTU which is comparable to the WHO permissible value of 5NTU for drinking water. Treating the water to improve pH and turbidity will bring it to drinkable levels as other element contents are considerably within permissible level.

Conclusion: Generally, Ikoro stream has low level of mineral nutrients which indicates that the stream is relatively free of fertilizers leachates, as well as industrial and sewage pollution. However, the ammonium and turbidity content of the stream was high as well as significant concentrations of calcium, total alkalinity. These findings may not make the water to be suitable as a source of drinking water supply.

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