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SPATIO-TEMPORAL EVALUATION OF FERORO STREAM WATER QUALITY, CHIKUN LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

***[1]Dawuda, K. D., [2]Adakole, J. A., [2]Auta, J. and [3]Japhet, W. S.**

[1]Kaduna State Environmental Protection Authority, Kaduna
[2]Department of Biology, Faculty of Life Sciences, Ahmadu Bello University, Zaria
[3]Department of Botany, Faculty of Life Sciences, Ahmadu Bello University, Zaria

*Corresponding authors' email: kabadiyadawuda@gmail.com

ABSTRACT

Aquatic environment is faced with pollution problems most of which are anthropogenic in nature. Feroro stream water was evaluated for its quality and suitability for the growth of organisms. The temporal and spatial qualities of the water was observed to be deteriorating. Water sampling was done once monthly for twenty-four months from five stations along the stream. The water samples were put into 2-litre sterilized plastic bottles. Some physical and chemical parameters were determined using HANNA meter, Dissolved oxygen meter, titration and colorimeter methods. All the parameters tested ranged within Federal Ministry of Environment standard limits. Turbidity and Total Hardness are above the standard limits. There was significant difference temporally $P<0.05$. Electrical Conductivity was significant different in all the stations $P<0.05$, lowest at Station 1(137.55µS/cm) and high at Station 5 (235.21µS/cm). Across the wet and dry seasons, the parameters significantly varied except in Temperature (25.79±0.12 and 25.57±0.26) and Total Hardness (119.68±6.13 and 109.50±3.38) $P<0.05$.

Keywords: Physicochemical, Water quality, Spatial, Temporal, Variation, Feroro stream

INTRODUCTION

Water is an important resource for organisms, human life and in meeting the demand for irrigation of lands and industries. Streams receive different types of water water making them vulnerable to impact and changes their properties (Chavarria *et al*., 2021; Samuel *et al*., 2015). The water quality of Feroro stream reveals the suitability of the water for human use and growth of organisms. In Chikun Local Government Area, there are dendritic drainage network of streams among which is Feroro stream, which lies between latitude 10º 20´N and 10º 31´N, longitude 6º 40´00´´E and 7º 50´00´´E.The stream flows throughout the year but its water volume decreases and increases during dry and wet seasons respectively. The stream of about 17.5Km in length and having source from the Damishi hills flows into River Kaduna. The stream course meanders through gullies and rocks, flows behind some settlements such namely; Unguwan Boro, Narayi, Kamazo and Rimi. The stream is used for anthropogenic purposes such as agricultural, domestic and commercial purposes. The area has an annual rainfall range of 850mm to 1200mm, has tropical continental climate of about 6-7months distinct wet season and about 5-6months dry season (Stanley *et al*., 2017; Musa *et al*., 2016). It is important The physical and chemical evaluation of the stream water quality became necessary to identify monitoring strategies which will quantify its water quality and help policy makers make useful laws that will protect other aquatic environment. The assessment of the stream water quality is also fundamental for management of freshwater resources in Chikun Local Government Area of Kaduna State, Nigeria.

MATERIALS AND METHODS

Sample collection and locations description

Sample collection: Samples were collected into 2-litre sterilized plastic bottles between the hours of 6:00am and 9:00am, once monthly for twenty-four months. Table 1 is the location and predominant activities done around the sampling stations. Five (5) sampling stations were selected along the stream based on anthropogenic activities such as agricultural and waste disposal. Station 1 was the reference (control) station.

Table 1: The Location, Predominant Activities and distance from pervious station of the sampling stations

Station	Latitude	Longitude	Predominant activities	Distance from the pervious
1	10º26´59´´N	7º30´14´´E	Farming	
2	10º27´38´´N	7º28´27´´E	farming, and waste dumps	2.8Km
3	10º28´12´´N	7º27´48´´E	Farming, waste dumps and sand excavation	2Km
4	10º28´34´´N	7º27´33´´E	farming, and waste dumps	1.8Km
5	10º29´15´´N	7º26´34´´E	Farming, fishing, waste dumps and sand excavation	2Km

Physicochemical Analyses: the following parameters were analyzed;

Water pH; was determined using Hana instrument HANNA meter (HI 9813-6N) in the field, by inserting the meter probe into the water at each station for 2minutes before the reading was recorded. The probe was rinsed in distilled water before being used for further measurement.

Water Temperature; was also determined using HANNA meter (HI 9813-6N) in the field, where the meter probe inserted into the water at each station for 2minutes before the reading was recorded. The probe was rinsed in distilled water before being used for further measurement.

Electrical Conductivity; was also determined using HANNA meter (HI 9813-6N) in the field, where the meter probe inserted into the water at each station for 2minutes before the reading was recorded. The probe was rinsed in distilled water before being used for further measurement.

Turbidity; was determined using Sherwood Colorimeter (model: 257) in the Laboratory. Distilled water was put into a measuring cell to erase stored turbidity values in the meter. Each sample was poured into another measuring cell and inserted into the meter, the readings were obtained at 430nm.

Dissolved Oxygen (DO); was determine using DO meter (model JPB-70A) in the field by inserting the meter probe into the water for 2minutes, then DO value recorded.

Total hardness was determined titrimetrically in the Laboratory by diluting 25mL of the sample with 25mL of distilled water in a conical flask. 2mL of buffer solution and 0.1g of Eriochrome black T-dye were added and titrated with EDTA solution drop by drop until a blue coloured end point was observed. The titrant value was multiplied by 40, as $CaCO_3$/L (APHA, 1999).

Phosphate-phosphorous determination (PO_4-P); was determined using ammonium molybdate and stannous chloride reagents. 100ml of the water was transfered into a conical flask, 1.0ml of ammonium molybdate and one drop of stannous chloride reagents were added. It was allowed to cool for 12minutes and put into sherwood colorimeter 257 at wavelength 600nm using, the readings were then recorded.

Nitrate-nitrogen determination (NO_3-N); was determined using phenol disulphonic acid and ammonia reagents. 100ml of water sample was heated in a clean dry crucible in an oven at 100ºC till dryness. It was removed and allowed to cool. 2ml of phenol disulphonic acid was added and swirled round uniformly. It was allowed to cool for 10minutes and 10ml of distilled water and 5ml of ammonia solution were added and allowed to cool further for colour change. The mixture was passed into sherwood colorimeter 257 at wavelength 430nm, then the reading was recorded.

Data analyses: variations in physiochemical parameters in the different statins and months were determine using Analysis of Variance. Student t-test was used for variations across the seasons. Duncan's multiple range test was used to show significant difference in parameters.

RESULTS AND DISCUSSION

Temperature: mean monthly Temperature variation in the water is in Figure 1, with two peaks observed in November and March in all the stations. The temperature was not significantly different across the stations (Tables 3). The temperature relatively decreased in all the stations from the month of May to October, which was significantly different across the sampling months (Figure 1) but not across the seasons (Tables 4) $P<0.05$. The decrease in temperature in the month of June to September can be due mixing together of the water as a result of wind action and losing heat gained from solar radiation. This correlated with the report of Mustapha and Abodunrin (2021). The temperature variation could be due to the time of sampling and season, this correlate with the studies of Francis and Jonathan (2016). The temperature range in this study (table 2) was similar with the findings of Sun *et al*. (2019) that water temperature of Duliujian River ranged between 1.9°C to 32.1°C due to the season. High temperature values recorded at all the stations in March could be as result of poor vegetation cover at the stations and the month of March is the peak of dry season in the area. This is similar with the observation by Samuel *et al*. (2021) in Gurara reservoir, Kaduna with highest temperature in April and lowest in May. Temperature values were within acceptable standard limits of <40°C (FMEnv, 2011). The relative increase in temperature in the wet season though not significantly different could be due mixing together of the water as a result of wind action, which correlated with the report of Eliku and Leta (2018), where water temperature was high during the rainy season. Temperature decrease in the months of December to February could be due to cool harmattan wind experienced, which is similar with the findings of Samuel *et al.* (2015) that had temperature of 14.00±0.32ºC in January that does not pose any danger to aquatic organisms.

Table 2: Range Values and Standard Limits of Physico-chemical Parameters of the stream water

Parameters	**Range**		**Federal Ministry of Environment Standard**
	Minimum	**Maximum**	
Temperature (ºC)	23.36	27.62	<40
Turbidity (NTU)	28.93	89.48	5.00
Electrical Conductivity (µS/cm)	137.60	292.40	1000
Dissolved Oxygen (mg/L)	1.99	4.98	>6.00
pH	6.65	8.46	6.5-8.0
Total Hardness (mg/L)	65.33	173.07	150
Phosphate-Phosphorous (mg/L)	0.029	0.128	5.0
Nitrate-Nitrogen (mg/L)	0.13	0.34	50

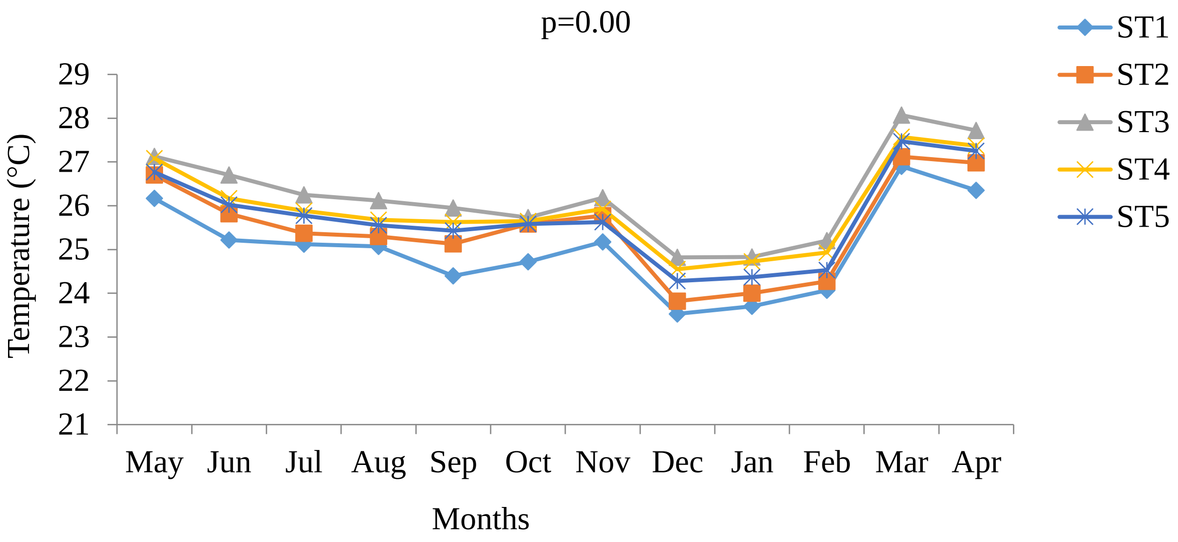

Figure 1: Mean Monthly Temperature variation of the water with the Stations and months

Table 3: Mean Spatial Physico-chemical Parameters of the Water

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5	P-value
	ϰ±SD	ϰ±SD	ϰ±SD	ϰ±SD	ϰ±SD	
Temperature(°C)	25.04±0.30	25.49±0.32	26.23±0.30	25.93±0.29	25.72±0.30	0.08
Turbidity (NTU)	69.78±4.49	65.64±4.54	64.06±4.59	64.86±3.74	64.10±4.29	0.88
EC (µS/cm)	137.55±11.03c	177.19±13.43b	220.43±12.16a	225.11±11.10a	235.21±14.19a	0.00
DO (mg/L)	3.82±0.26a	3.36±0.21c	3.29±0.24c	3.34±0.21c	3.57±0.23b	0.47
pH	7.49±0.11b	7.38±0.19c	7.57±0.16a	7.41±0.17bc	7.57±0.15a	0.87
T. Hardness (mg/L)	100.43±6.82e	112.57±7.15d	114.33±7.33c	118.45±8.44b	127.17±8.82a	0.20
PO_4-P (mg/L)	0.05±0.01c	0.06±0.01ab	0.07±0.01a	0.07±0.01a	0.07±0.01a	0.55
NO_3-N (mg/L)	0.22±0.01b	0.21±0.01c	0.24±0.01a	0.20±0.01d	0.22±0.01b	0.21

NOTE: Means with the same superscript across rows are not Significantly different at p<0.05. ϰ = Mean, SD = Standard Deviation, EC= Electrical Conductivity, T=Total, NO_3-N = Nitrate-Nitrogen, PO_4-P = Phosphate-phosphorous, DO= Dissolved Oxygen, pH= Hydrogen ion.

Turbidity: the mean monthly Turbidity is shown in Figure 2, showing monthly variations of high in the months of September and October and the lowest in February. The high values (69.78NTU) in Station 1, 65.64NTU in Station 2 and the lowest 64.06NTU in Station 3 were not significantly different P<0.05 (Table 3). At Stations 1, 3 and 5 turbidity increased in June (71.42NTU, 75.30NTU and 63.75NTU) then decreased at Stations 1 and in July (68.07NTU and 65.75NTU)

Table 4: Mean seasonal variations of Feroro stream water physicochemical parameters

Parameters	Wet Season	Dry Season	P-value
Temperature (⁰C)	25.79±0.12	25.57±0.26	0.448
Turbidity (NTU)	73.69±1.87	57.69±2.59	0.000
Electrical Conductivity (µS/cm)	222.97±8.81	175.23±9.65	0.000
Dissolved Oxygen (mg/L)	4.07±0.11	2.89±0.09	0.000
pH	7.10±0.05	7.86±0.08	0.000
Total hardness(mg/L)	119.68±6.13	109.50±3.38	0.225
PO_4-P (mg/L)	0.074±0.006	0.053±0.004	0.006
NO_3-N (mg/L)	0.238±0.006	0.196±0.006	0.000

pH= Hydrogen ions, NO_3^-N= Nitrate-Nitrogen, PO_4-P = Phosphate-phosphorus

respectively, which was significantly different P<0.05 (Figure 2). The Turbidity was also significantly different across the season P<0.05, It was high in wet season than the dry season (Table 4). This could be due to surface runoff from agricultural farms, bare soils and sewages which carries suspended materials into the stream, similar with the work of Eliku and Leta (2018). The turbidity concentration had wide range between 28.93 NTU and 89.48 NTU, indicating that the water was moderately to highly polluted, which is also in line with that observed in the work of Eliku and Leta (2018) in Awash River which had wide variation. According to Barakata *et al*. (2016), a waterbody having wide range of turbidity concentration between 0 and 61107NTU, indicate that such water is moderately to highly polluted in quality. The highest mean turbidity at Station 1in the month of September could be attributed to high concentrations of dissolved solids materials in the stream depending upon the degree of turbulence. Edori *et al*. (2019) and Amel *et al.*

(2021) also attributed high turbidity to the amount of dissolved solids materials present in the Silver River. Martins *et al.* (2019) associated increase in turbidity with rainy season that brings in clay from watershed and stream bank erosion in streams and shallow rivers. It decreased gradually towards the end of dry season. Higher values in this study were recorded during the rainy season as compared to the dry season (Table 4), this reveals that suspended particles are always in motion due to turbulence while in the dry season the particles tend to settle down due to low or little turbulence. Turbidity variations across the months could also be due to rainfall and increases water velocity.

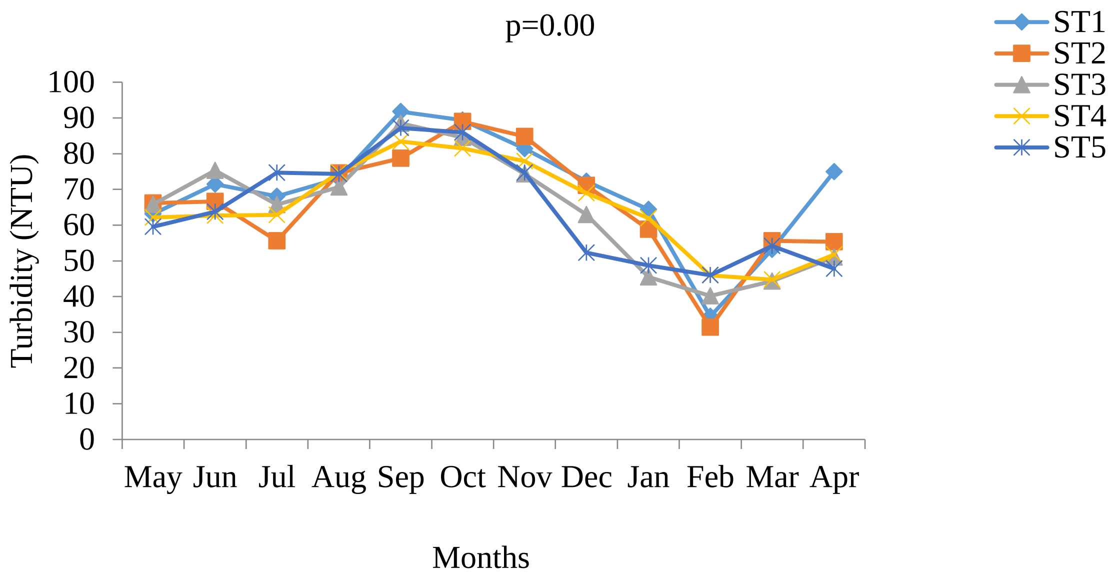

Figure 2: Mean monthly turbidity of the water with the stations and months of sampling.

Electrical Conductivity (EC): Mean monthly EC variations of the stream water in each stations and months of sampling is shown in Figure 3. Monthly variation of EC was highest in September followed by October and the lowest February. Highest EC of 235.21µS/cm was in Station 5, followed by 225.11µS/cm in Station 4 and the lowest 137.55µS/cm in Station 1, with significant difference across the stations $p<0.05$ (Table 3). Electrical Conductivity at Stations 1, 2 and 3 increased from the Month of May (118.67µS/cm, 154.33µS/cm and 220.00 µS/cm) through to July (174.67µS/cm, 222.33µS/cm, 268.67µS/cm). It was significantly different across all the months. The increasing EC from the month of May to August could be due to dilution of suspended particles into the stream due to the beginnings of rains and increased concentrations of free ions in the water from agricultural runoff near the stream. This is similar with the observations of Eze *et al*. (2018) where high concentrations of free ions were attributed to be responsible for the increase in Electrical Conductivity. Similar trends were also observed for the EC across the stations, which could be as a result of increase in free ions in the stream. The Electrical Conductivity observed was within the acceptable standard limits and it directly affects the quality of the water used for drinking and irrigation (Kosha and Geeta, 2017). High values of EC obtained in the months of August (199.33µS/cm), September (267.80µS/cm) and October (239.60µS/cm) is an indication of more ions exchange in the wet season which could also be due to increased influx and dilution of inorganic materials and turbidity as result of rainfall. This disagrees with the report of Gadhia *et al*. (2012) that EC decreased with increased rainfall. High EC could also be due to increased degree of anthropogenic activities such as waste disposal, presence of salts and agricultural runoff. It is in line with the findings of Emenike *et al*. (2018), where high EC was caused by heavy application of agrochemicals and ion exchange. The increase EC in the stream water in March could be due to water evaporation and dissolution of soil minerals, as suggested by Muhammad *et al.* (2017). High EC could result in imbalance for aquatic organisms and decreased dissolved oxygen concentrations (Aniyikaiye *et al*., 2019).

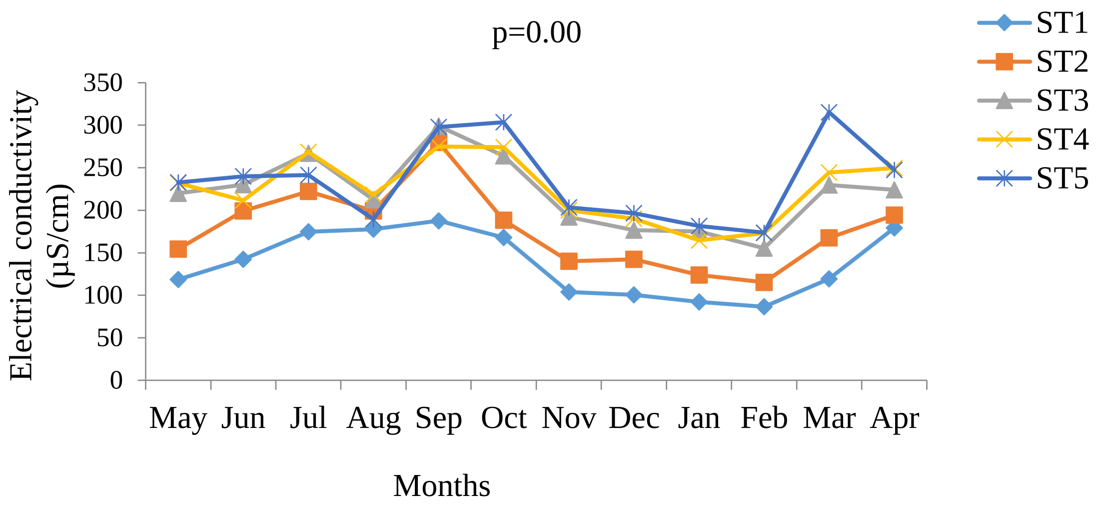

Figure 3: Mean Monthly Electrical Conductivity of the water with the Stations and months of Sampling

Dissolved oxygen: Mean monthly Dissolved Oxygen variations in the stream water during the study is shown in Figure 4. High Dissolved Oxygen of 3.82mg/L was observed in Station 1, followed by 3.57mg/L in Station 5 and the lowest of 3.29mg/L in Station 3 (Table 3). At Station 1, Dissolved Oxygen increased from May (3.53mg/L) through to October (5.30mg/L) followed by decrease from November (3.85mg/L) to March (2.48mg/L). In Stations (ST) 3, 4 and 5, DO increases from May through to October followed by decrease in November through to April. Dissolved oxygen was significantly different across all the months $p<0.05$ (Figure 4), but was not significantly different across the stations $p<0.05$ (Table 3). Dissolved oxygen is the dissolved gaseous form of oxygen (Halim *et al*., 2018), was not significantly different in the dry season (Table 4). This could be due to decrease water velocity and volume, which is similar with the study of Ibezute *et al*. (2016) that low DO values was due to reduced water velocity and volume. The low value of DO in the month of January at Station 3 could also be due to decrease water volume and turbulence which reduced the diffusion of atmospheric oxygen, discharge of sewage and accumulation of waste into the stream. This is similar with the findings of Amel *et al*. (2021) which observed lowest value of dissolved oxygen in semiarid region (El Hodna watershed, Algeria) due to discharge of sewage and other waste. The low DO in the dry season could also be due to high organic matter, decomposition of organic materials and activities of organisms in the stream which consumes appreciable amount of oxygen as a result of metabolic activities. Increasing DO in the months of May to October could be due to increase volume and velocity of the stream water. Slight increase in the DO from December to February might be due to the cool harmattan weather, as cool water holds dissolved oxygen during dry season. The DO was higher in wet season than in dry season, which was also observed by Basu *et al*. (2021) that DO vary significantly between seasons. The highest DO observed at station 1 could be due to increased atmospheric oxygen contact with the stream water, photosynthesis by algae and other aquatic plants and strong wind diffusion as a result of more vegetation cover. This is similar with the study of Oniye *et al*. (2014), According to Mustapha and Abodunrin (2021), the reduction in reservoir storage capacity, volume and low species assemblages of phytoplankton due to siltation were some of the contributing factors to the low Dissolved oxygen concentration. The low DO in stations 2 and 3 could also be due to the meandering nature of the stream as close meanders reduce water velocity and dissolution of atmospheric oxygen. The effect of waste discharge on surface water source is largely determined by the oxygen balance of the system, as the discharge increases, the aeration decreases (Farzin *et al*., 2021). The low DO of the stream indicated high contamination level of the stream water, which is similar with the study of Gijo *et al.* (2016) that suggested the Nun river estuary was highly contaminated. Presence of DO in water bodies in good quantity have the tendency of improving the water quality by oxidizing poisonous elements. Dissolved oxygen concentration obtained during this study was within the acceptable limit for drinking. Contamination of water bodies leads to changes in their trophic nature (Uba *et al.*, 2020).

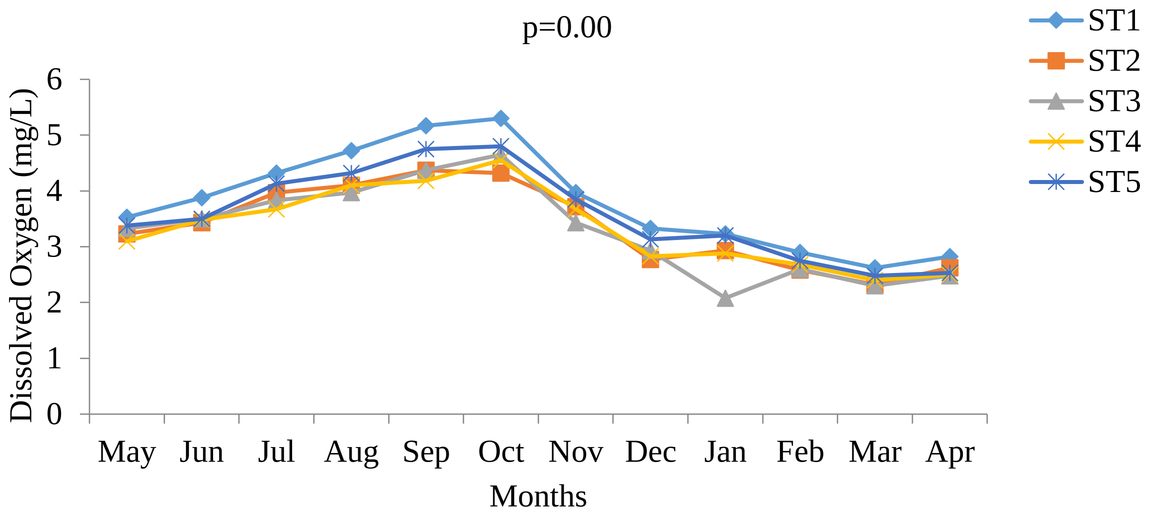

Figure 4: Monthly mean Dissolved Oxygen of the stream water with the stations and months

pH of the water: mean monthly pH of the water is presented in Figure 5. Monthly variations of pH were highest in April, followed in February and the lowest in July. pH across the stations in the water was not significantly different $p<0.05$ (Table 3). The pH was significantly different in the sampling months (Figure 5) but not significantly different across the stations was $p<0.05$ (Table 3). The pH range during this study falls within the standard limits (Table 2), indicating good buffering quality. This agrees with the findings of Kosha and Geeta (2017), which had pH range of 6.5-8.9. Similarly, Ogundiran and Fawole (2014), also reported that most natural freshwater bodies having pH values within 5-10, have good buffering quality. Low pH observed in this study might have been caused by the constant dredging and some unregulated sand-mining activities in the stream, as also observed by Jonah *et al*. (2020) findings. The narrow fluctuation of the pH during the study indicated good buffering ability for productivity. According to Francis and Jonathan (2016) and Eze *et al*. (2018) that the variation in pH of water suggest high productive nature of a stream and an essential indicator of the extent of pollution. The high pH values in some months during this study shows alkaline condition. This agrees with the findings of Uddin, (2014) that suggested high values of pH to indicate that there is high chloride, bicarbonate and carbonate in the water. Variations in pH at the stations was probably due to the presence of wastes agricultural or domestic wastes such as soap, detergent, cleansers and other organic matters, photosynthesis and other metabolic process. This is similar with the findings of Salman *et al*. (2013) that pH variations maybe caused by discharge of waste into water and other metabolic process, leads to raising in the pH. The pH of the stream water falls within the acceptable limit, which will not pose any negative effects on the biota of the stream since most aquatic animals prefer a pH range of 6.5 - 8.0 which is slightly acidic and slightly alkaline. This also agrees with the studies of Uba *et al.* (2020) that recorded pH value of (8.5) which was within the normal pH range as recommended standard for drinking and domestic purposes. The shift in pH values observed in January indicated slight acidity which may be harmful to non-tolerant organisms. This agrees with the studies of Mustapha and Abodunrin (2021), that recorded pH of the water slightly alkaline with no significant variations ($p>0.05$) across the stations. The lack of significant variation in pH across the stations may be attributed to the different anthropogenic activities carried out in the stations. The pH range obtained in this study is recommended for support of aquatic life which is similar to the range obtained by Agbugui and Deekae (2014). According to Eze *et al*. (2018), unpolluted rivers usually show neutral to slightly alkaline pH (7.0 - 7.5), outside this range water could be corrosive. Increased pH during the dry season could be due to increased productivity activities (photosynthesis).

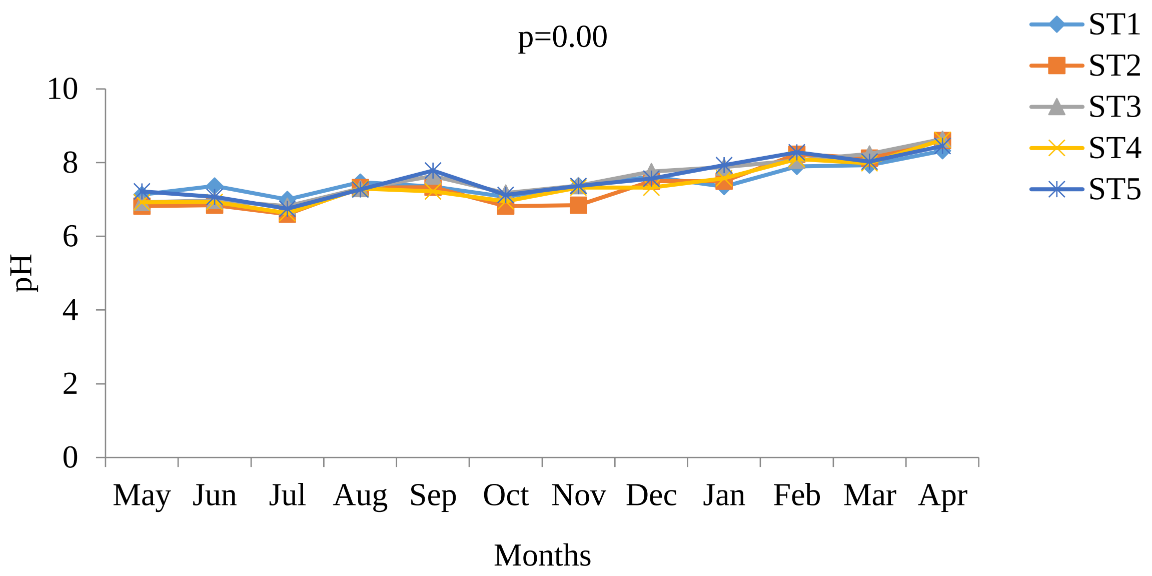

Figure 5: Mean monthly pH variation of the stream water with the stations and months of sampling

Total hardness of the water: The mean monthly total hardness variation in the water is shown in Figure 6. Monthly variations of Total hardness showed highest value of 159.20mg/L was observed in October, followed by 153.87mg/L in September and the lowest 76.40mg/L in May in the water. With respect to stations, the highest Total hardness of 127.17mg/L was in station 5, followed by 118.45mg/L in station 4 and the lowest 100.43mg/L in station 1 (Table 2). At Station 1 Total hardness increased from May (64.00mg/L) through to October (138.67mg/L) followed by decrease from November (121.33mg/L) to April (83.33mg/L). The Total hardness fluctuates in December to April. At Station 2, total hardness also increased from May (77.33mg/L) through to October (157.33mg/L), then decreased in November (124.00mg/L) through to April (84.00mg/L). Although the total hardness increased slightly in the month of March (122.67mg/L) in station 2. Total hardness in stations 3, 4 and 5 also increased from May through to October then decreased in November through to February with slight increase in March and decreased in April respectively. Total hardness in the stream water was not significantly different across the stations but significantly different across the months of sampling. Total hardness in waterbody is caused by certain salts (calcium and magnesium) in solution (Yadav *et al.*, 2016). Increasing concentrations of total hardness in the water in all the stations during the wet season could be attributed to increasing dissolution of materials containing calcium and magnesium into the stream. Similar observation was made by Sikoki and Anyanwu (2013) in small Pristine stream in Niger Delta, Nigeria but contrary with the findings of Seiyabal and Izah (2017), which reported that total hardness was lower during the wet season due to dilution effects. The low total hardness observed could be due to low concentrations of ions in the stream, especially at Station 1. According to Halim *et al.* (2018) the desirable limit for total hardness is 300mg/L and the optimum hardness for aquaculture is in the range of 40 to 400ppm. The total hardness concentrations obtained at Station 2 to Station 5 had hard water since their total hardness values were >100mg/L. This could be due to discharge of agricultural and domestic waste containing high amount of inorganic nutrients into the stream at these stations. The high total hardness range observed during this study could also be due to evaporation and increasing dissolution of materials containing calcium and magnesium in the stream. This was also observed by Shahida and Ummatul (2015). Hardness is that property of water that prevents lather formation with soap. Excess intake of calcium can increase the risks of osteoporosis, kidney stones, hypertension and stroke (Akram and Rehman, 2018).

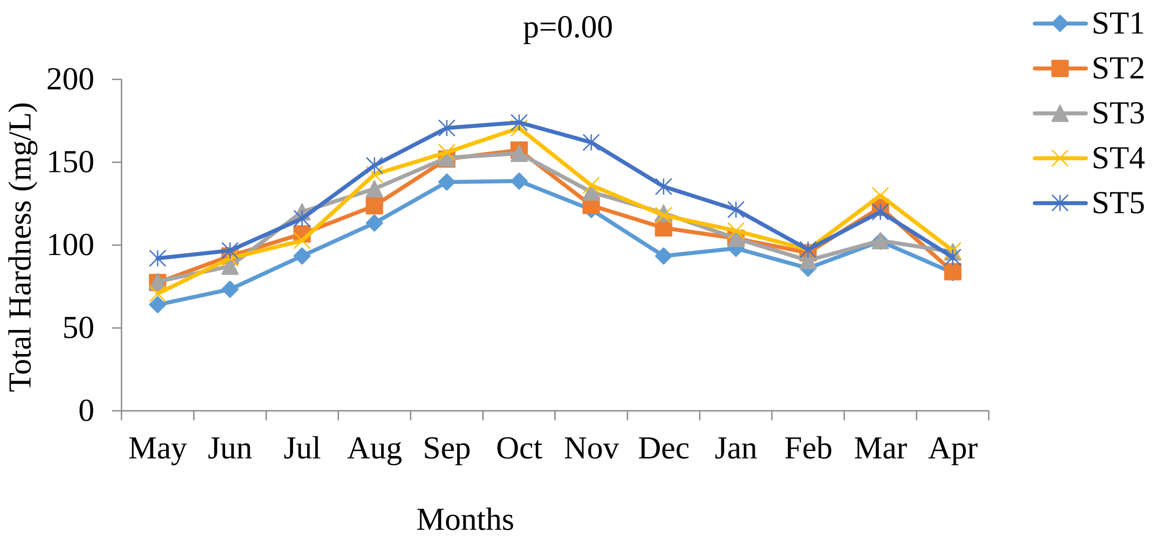

Figure 6: Monthly mean Total Hardness of the stream water with the stations and months of sampling

Phosphate-phosphorous of the water: The mean monthly Phosphate- Phosphorous of the water is presented in Figure 7. Monthly variations of PO_4-P show highest value of 0.102mg/L in August, followed by 0.091mg/L in October and the lowest 0.0320mg/L in February in the stream water (Table 3). The highest PO_4-P value 0.072mg/L was recorded in Station 5, followed by 0.068mg/L in Station 3 and the lowest 0.054mg/L in Station 1 of the stream (Table 3). The Phosphate- Phosphorous of the water in Station 1 increased from May (0.038mg/L) through to August (0.100mg/L), then decreased and increase in September (0.051mg/l) through April (0.039mg/L). At Station 2, Phosphate-phosphorous was relatively the same from May (0.050mg/l) to June (0.049mg/L) but increase sharply in July (0.164mg/L). At Station 3, PO_4-P increased from May (0.050mg/L) to August (0.127mg/L) before decreasing to 0.031mg/l March. At Station 4, it also showed same pattern of increased and decreased in August (0.103mg/L) and September (0.062mg/L), October (0.129mg/L) and November (0.076mg/L). At Station 5, PO_4-P increased from May (0.048mg/l) to August (0.116mg/L). There was no significant difference in the phosphate-phosphorous in the stream water across the stations but significant across the months at $p<0.05$. High concentrations of PO_4-P recorded during the wet season could be due to artificial fertilizers applied to farms near and around the stream which are washed into the stream. This is similar with the findings of Bhat *et al*. (2014) that domestic waste water containing detergents and fertilizer runoff contributes to higher levels of phosphates in the water body. This is also in line with the studies of Edori *et al*. (2019), that reported increased concentration of phosphorus in May and June could be due to the presence of inorganic fertilizers and organic matter (animal dungs) that are washed off from neighbouring farmlands. High PO_4-P have resulted in excessive growth of algae thereby limiting flow of oxygen in the stream causing eutrophication (Edori *et al*., (2019). High concentrations of Phosphate-phosphorous in the stream water can be consider as pollution indicator (Amel *et al*., (2021). Low phosphate-phosphorus observed in the water during the dry season could also be due to lower water hardness, thus less co-precipitation of phosphate with calcium carbonate. This is similar with the study of Rabiu *et al*. (2018) that lower water hardness contributed to less co-precipitation of phosphate with calcium carbonate in Watari dam.

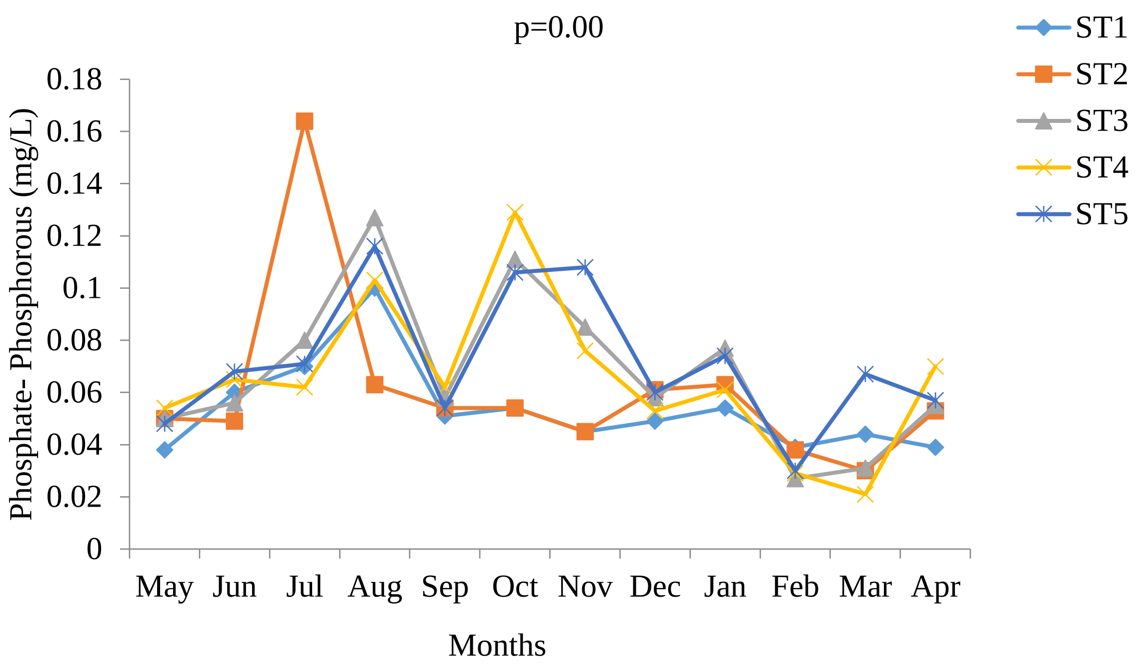

Figure 7: Monthly mean Phosphate-phosphorous of the stream water with the stations and months of sampling

Nitrate-Nitrogen of the water: mean monthly nitrate-nitrogen (NO_3-N) of the stream water is shown in Figure 8. Monthly variations of NO_3-N showed highest value of 0.257mg/L in October, followed by 0.256mg/L in August and the lowest 0.168mg/L in January. Highest NO_3-N value 0.24mg/L was in Station 3, followed by 0.22mg/L in Stations 1 and 5, with the lowest 0.20mg/L in Station 4 (Table 3). Nitrate-Nitrogen of the stream water was significantly different in all the months of sampling. At Station 1, NO_3-N increased from May (0.19mg/L) to October (0.286mg/L), decreased from November (0.171mg/L) to April (0.234mg/L) with the except the month of February (0.308mg/L) which increased. At Station 2, nitrate-nitrogen decreased from May (0.251mg/L) to July (0.203mg/L), increased in August (0.211mg/L) and September (0.311mg/L). In Station 3, it increases from May (0.251mg/L) to September (0.289mg/L), then decreased in October (0.269mg/L) to November (0.192mg/L), again increased in February (0.239mg/L) before decreasing in April (0.194mg/L). At Station 4, nitrate-nitrogen fluctuates across the stations, with decreased from May (0.238mg/L) to July (0.189mg/L), increased and decreased from August (0.251mg/L) through to April (0.203mg/L). At Station 5, the water nitrate-nitrogen concentrations decreased from May (0.250mg/L) to June (0.241mg/L) remained constant in July (0.241mg/l). It increased in August (0.279mg/L) then decreased in September (0.201mg/l), increased in October (0.267mg/L) decreased in November (0.198mg/l) through to January (0.162mg/L) increased in February (0.214mg/L) decreased in March (0.171mg/L) and increased in April (0.245mg/L). The low nitrate-nitrogen concentrations recorded in the water could be due to natural occurring sources, which agrees with the reported of Kosha and Geeta, (2017), that nitrate-nitrogen levels were low in all the three stations which showed no significant increase. Nitrate concentration of surface water is normally low, but can reach high levels from agricultural runoff and/or waste form humans or animals (Bassey *et al*., 2020). Eliku and Leta, (2018) also observed the concentration of nitrate in surface water as 0-18mg/L and in rain water as 5mg/L. The low nitrate concentration in this study could also be due to dilution from precipitation, denitrification and uptake by plants (Nemcic-Jurec *et al*., 2017). Wangji *et al*. (2020) also observed low nitrogen during wet season. The high nitrate-nitrogen concentrations observed in the water during rainy season might be due to increased usage of fertilizer and runoff of these fertilizer residues and animal waste into the stream which increases nitrate concentration, as observed also by Mohammadi *et al*. (2017). Also, nitrate containing waste such as human excreta, domestic waste and sewage which serve as manures in agricultural farms are been washed into the stream (Adimalla, 2018). NO_3-N recorded in the dry season (Table 4) could be due to increased evaporation resulting in more concentration of nutrient load. High levels of NO_3-N can cause respiration efficiency of fish and aquatic invertebrates to lower down. It can cause methemoglobinemia in infants under 4years, as well as in adult with particular enzyme deficiency, thyroid hypertrophy and esophageal and stomach cancer (Ajibde and Ogungbesan, 2013). Excess nitrate-nitrogen can also cause eutrophication of surface waters due to overstimulation of growth of aquatic plants and animals (Kosha and Geeta 2017). According to WHO (2017), the maximum contamination level (MCL) of nitrate for drinking as 44.mg/L and 50mg/L respectively. Nitrate concentrations in natural waters are in the order of 1–10 mg/ L (Adimalla, 2018).

The mean seasonal variations in stream water as shown in Table 4, temperature and Total hardness are not significant difference $p<0.05$ during wet and dry seasons in the stream water. The temperature of the water was slightly lower (25.57ºC) during the dry season. Turbidity of the water was high during the wet season (73.69NTU) than in the dry season (57.69NTU). Total hardness in the stream water (119.68±6.13mg/L) was high in the wet season at $p<0.05$.

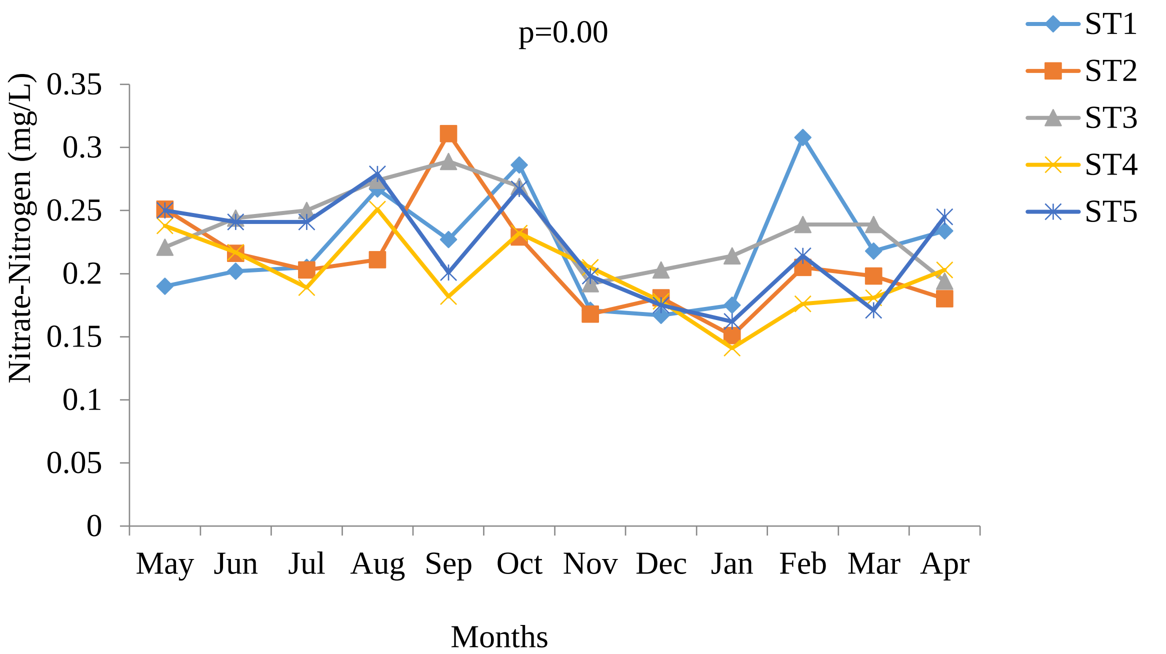

Figure 8: Monthly mean Nitrate-nitrogen of the stream water with the stations and months.

CONCLUSION

The physiochemical parameters of Feroro stream water were significantly different temporally $p<0.05$ and were within the standard limits except Total hardness (65.33-173.07mg/L), which was above the standard. Dissolved oxygen (1.99-4.98mg/L) was below the standard. There was no spatial variation in the physicochemical parameters of the water expect in Electrical Conductivity $p<0.05$. In the seasons the water temperature (25.57 ^{0}C) and Total Hardness (119.68 and 109.50mg/L) were not significant $p<0.05$.

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