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Spatio-Temporal Physico-Chemical Quality of Feroro Stream Sediment in Chikun Local Government Area, Kaduna State, Nigeria

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ABSTRACT

Streams are important in an ecosystem for the survival of aquatic organisms and their quality fundamentals. Streams are important in an ecosystem and their quality is fundamental for the survival of aquatic organisms. Feroro stream is threatened from anthropogenic activities which affects the quality of its sediment temporally and spatially. Sediment was collected on monthly bases for twenty-four months from five stations along the stream based on anthropogenic activities using calibrated standard tubes. Physicochemical parameters were determined using multiparameter HANNA meter, Dissolved oxygen meter, Titration and Colorimeteric methods. All the physicochemical parameters were within World Health Organization limits and Nigerian Standard for Drinking Water Quality limits except Total Hardness (77.87-156.00mg/L), Dissolved Oxygen (1.51-3.79mg/L) and pH (6.59-8.67). There was significant (P<0.05) temporal variation in the physicochemical parameters but no significant variation spatially (P<0.05). Across the wet and dry seasons, there was significant variation except in Temperature (25.79℃ and 25.54℃) and Total Hardness (116.72mg/L and 121.66mg/L) respectively P<0.05. There was a significant difference P<0.05, in all the parameters across the wet and dry seasons, except in Temperature (25.79℃ and 25.54℃) and Total Hardness (116.72mg/L and 121.66mg/L).

Keywords: Feroro Stream, Physico-chemical Parameters, Spatial, Temporal, Sediment.

1.0. Introduction

Sediments are soil particles that settle at the bottom of a water body and major sites for decomposition from (Bellasi *et al*., 2020). They serve as reservoir for pollutants, therefore potential source of pollutants to the water column, organisms, and ultimately humans (Adesuyi *et al*., 2016). The people living around Feroro stream are mostly farmers, fishermen, traders and civil servants, using the stream as source of water for various activities such as domestic, cement-block manufacturing molding, irrigation, fishing, swimming and spiritual purposes. The absence of bridges at some points along the stream makes people to cross the stream by wading through the water during the dry season. Increasing population and urbanization around the stream has resulted in increased demand for farmlands. Consequently, resulted increased activities such as crop farming, indiscriminate domestic sewage and solid waste discharge and disposal, open defecation, used of pesticides around the stream. The concentration of contaminants in stream sediment changes with season as a result of variation in precipitation (Srinivas *et al*., 2020). Contaminated sediment can cause lethal and sub-lethal effect in benthic and other sediment associated organisms (Akhtar *et al*., 2021). Therefore, monitoring of Feroro stream Sediment for its physical and chemical qualities was necessary. This will provide useful instrument to policy makers to formulate management strategy policies for control and abatement of pollution sources around the stream. Increasing anthropogenic activities such as crop farming, indiscriminate domestic sewage and solid waste discharge and disposal, open defecation, used of pesticides around the stream, has resulted in increased contaminants level in stream sediment which can cause lethal and sub-lethal effects in benthic organisms (Akhtar *et al*., 2021). Therefore, evaluating Feroro stream sediment for its physical and chemical qualities spatially and temporally was necessary. This serve as useful instrument to policy makers to formulate management strategy policies for control and abatement of pollution sources around the stream

2.0. Methodology

2.1. Study Area

The stream is about 17.5Km in length from sampling Station 1 and is known as 'Quwe stream' by the natives (Gbayi) Gbagyi ethnic group that live around it. The stream receives domestic and agricultural wastes and flows into the larger River Kaduna. It is characterized by tropical continental climate with distinct wet season of about 6-7months and dry season of about 5-6months.

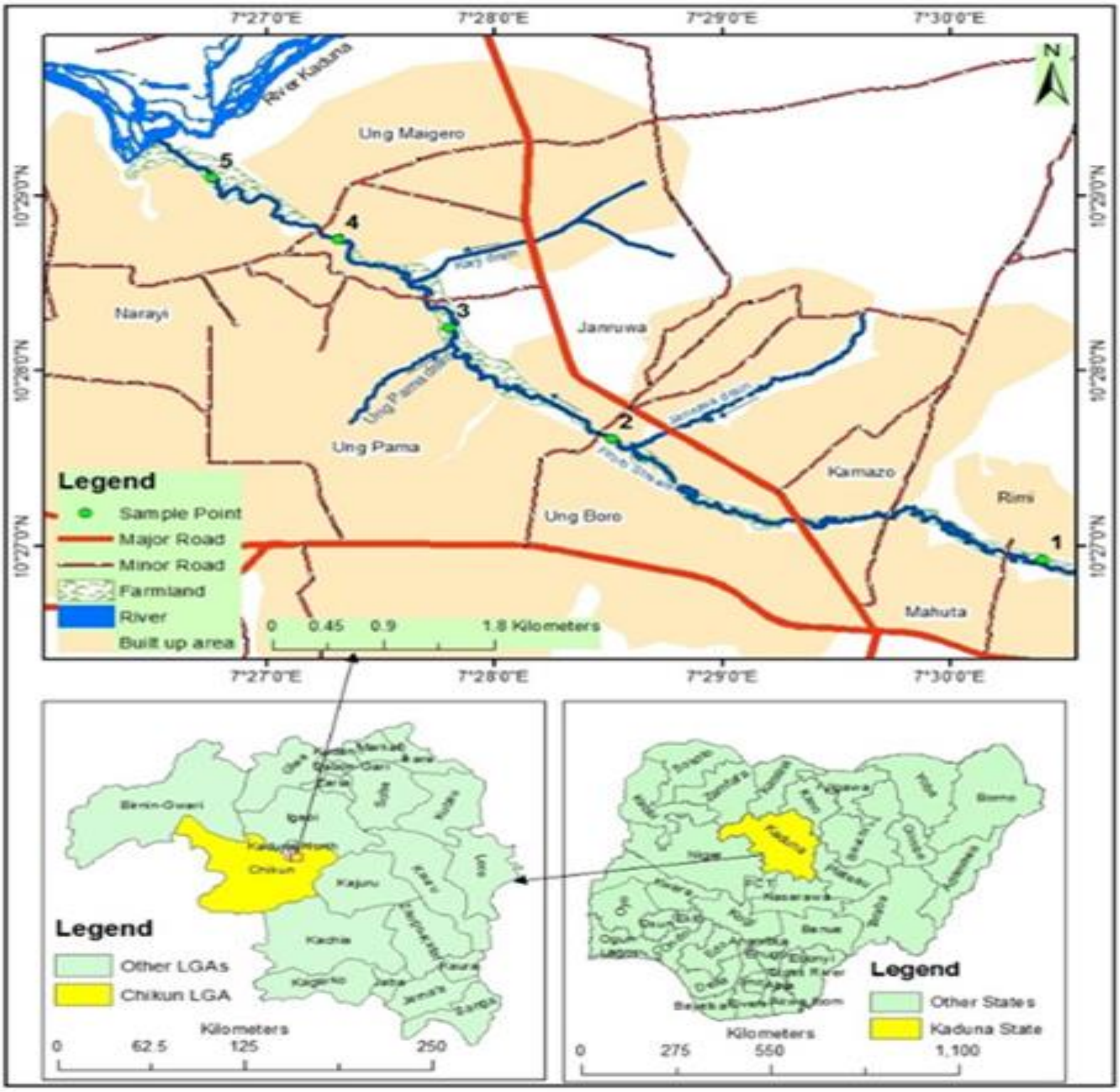

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Figure 1: Map of Study Area Showing Sampling Stations.

2.2 Sampling Stations

Five sampling stations (ST) were selected along the stream based on anthropogenic activities such as farming, waste disposal, sand excavation and accessibility. Sediment were collected once monthly using standard method and transported to the laboratory for further physicochemical analysis. Station 1 lies on Latitude $10^0$26´59´´N and longitude $7^0$30´14´´E. It is dominated by farming and irrigation activities. Station 2 lies on Latitude $10^0$27´38´´N and longitude $7^0$28´27´´E. Activities such as farming, and indiscriminate waste dumps are done around this station. It is about 2.8Km downstream of Station 1. Station 3 lies on Latitude 10^{0}28´12´´N and longitude 7^{0}27´48´´E. The stream is used for indiscriminate dumping of waste, sand excavation and farming activities. It is located about 2Km downstream of Station 2. Station 4 lies on Latitude 10^{0} 28´ 34´´N, Longitude 7^{0} 27´ 33´´E and about 1.8km downstream of Station 3. Farming, sand excavation and indiscriminate waste dumping into the stream in this station. Station 5 lies on Latitude10^{0} 29´ 15´´N and longitude7^{0} 26´ 34´´E. It is 1.5km from Station 4 and close to the point where the stream enters into River Kaduna. Farming, fishing, waste dumping, sand excavation carried out here.

2.3 Physico-chemical analyses

pH, Temperature and Electrical Conductivity were determined using calibrated portable Dissolved Oxygen using Dissolved Oxygen meter (model JPB-70A) and HANNA meter (model: HI 9813-6N) in situ. The meter probes were inserted into the sediment, wait for 2minutes before the reading was recorded respectively (Figure 2a and b). The probe was rinsed in distilled water before being used for further measurement. In the laboratory, the sediment was mixed with distilled water using an electric shaker to mix (Figure 3). The content was mixed properly for chemical analyses using titration and Colorimetric methods. Titration for Total hardness determination (Figure 4a) by measuring 25ml of sediment mixture into conical flask, 25ml of distilled water was added to it. 2ml buffer solution of pH 10.4 was then added, followed by addition of 0.1g Erochrome black T dye and It was titrated with EDTA (0.01Molar) titrant (Figure 4a).

Nitrate-Nitrogen was determined using by measuring 100ml of the sediment mixture into a clean dry metallic crucible and kept in an oven at 100°C till dryness. It was then removed and allowed to cool after which 2ml of phenol disulphonic acid was added and swirled round uniformly. It was then left to stand for 10 minutes and 10ml distilled water added. Then, 5ml ammonia solution was added and allowed to cool. Absorbance was read at 430nm wavelength using the colorimeter 257 (Figure 4b).

Phosphate-Phosphorus was determined by measuring 100ml of the sediment mixture into a conical flask, 1ml Ammonium molybdate reagent and 1 drop of stannous chloride were added. It was allowed to stand for 12 minutes and reading was taken at 600nm using the colorimeter 257 (Figure 4b).

a).  b). 

Figure 2: a) Dissolved Oxygen meter. b) HANNA meter used during the physicochemical measurement

Figure 3: An electric shaker mixing sediment samples

a)  b) 

Figure 4: a) Titration for Total hardness determination. b) Colorimeter 257

2.4 Data analyses

Analysis of Variance, t- test and descriptive statistics were used to analysed the data. Analysis of Variance was used to determine variation among the sampling stations and months. Student t- test was used to determine variations between seasons.

3.0 Results and Discussion

The Physico-chemical parameters range values of the stream sediment are in Table 1 with their standard acceptable limits. Each parameter was within the World Health Organization (WHO) standard limit except Dissolved Oxygen was below and Total Hardness was high.

The Physico-chemical parameters range values of the stream sediment are in Table 1 with their standard acceptable limits. Each parameter was within the World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) standard limits except Total Hardness (77.87-156.00mg/L) and Dissolved Oxygen (1.51-3.79mg/L), pH (6.59-8.67) was above Nigerian Standard for Drinking Water Quality limit.

Table 1: Range Values and Standard Limits of Physico-chemical Parameters in Feroro Stream Sediment

Parameters	Range		WHO	NSDWQ
	Min	Max	standard	standard
Temperature (ºC)	23.19	27.68	23-35	<40
Electrical conductivity (µS/cm)	146.13	510.40	350-750	
pH	6.59	8.67	6.5-8.5	6.0-9.0
Dissolved oxygen (mg/L)	1.51	3.79	>5	20
Total hardness (mg/L)	77.87	156.00	150	150
Phosphate-phosphorous (PO_4-P) (mg/L)	0.032	0.185	5	10
Nitrate-Nitrogen (NO_3-N) (mg/L)	0.17	0.36	50	50

WHO =World Health Organization (2017), NSDWQ =Nigerian Standard for Drinking Water Quality (2007), pH= Hydrogen ion

Temperature: mean monthly temperature (°C) variation of the sediment in each sampling stations is shown in Figure 5, with highest peak variation in the month of March. Highest temperature of 26.23℃ recorded in Station 3 and the lowest 25.03℃ in Station 1 in Table 2. It was significantly different (*P<0.05*) across the months, though the Means with the same alphabet across rows are not significantly different (Table 4). Temperature across the Sampling stations was not significantly (Table 2). High temperature at all the stations in March (Figure 5) could be as result of poor vegetation cover and the month of March is in the peak of the dry season, which was similar with the observation by Eliku and Leta (2018) during the dry season. Increasing temperature in an aquatic environment enhances the growth and metabolic activities in microorganisms (Brenner *et al*., 2016). Decreased temperature in the months of December to February was due to the cool harmattan wind. The low temperature observed in Station 1 showed that there was less dissolved organic matter.

Table 2: Mean Spatial Physicochemical Parameters of Feroro Stream Sediment

Parameters	Station 1 ϰ ±SD	Station 2 ϰ ±SD	Station 3 ϰ ±SD	Station 4 ϰ ±SD	Station 5 ϰ ±SD	P-value
Temp (℃)	25.11±0.09e	25.49±0.32d	26.23±0.30a	25.92±0.26b	25.72±0.3c	0.08
EC (µS/cm)	213.03±7.68e	270.72±8.35b	244.81±15.73d	307.12±35.92a	261.86±17.59c	0.07
pH	7.38±0.12ab	7.28±0.18c	7.33±0.15bc	7.26±0.19c	7.43±0.18a	0.95
DO(mg/L)	3.23±0.15a	2.87±0.16c	2.93±0.14c	2.88±0.15c	3.06±0.16b	0.43
T. Hard(mg/L)	111.50±3.42d	126.31±4.68a	115.28±3.69c	121.78±5.89b	121.08±3.68b	0.15
PO_4-P (mg/L)	0.11±0.01a	0.10±0.01b	0.09±0.01b	0.10±0.01b	0.10±0.01a	0.92
NO_3-N (mg/L)	0.29±0.01a	0.27±0.02a	0.29±0.00a	0.31±0.02a	0.29±0.01a	0.59

NOTE: Means with the same alphabet across rows are not significantly different at P>0.05. ϰ = Mean, SD = standard deviation, EC= Electrical conductivity, T. Hard = Total Hardness, NO_3-N = Nitrate-nitrogen, PO_4-P = Phosphate-Phosphorous, DO= Dissolved Oxygen, Temp=Temperature, pH= Hydrogen ion.

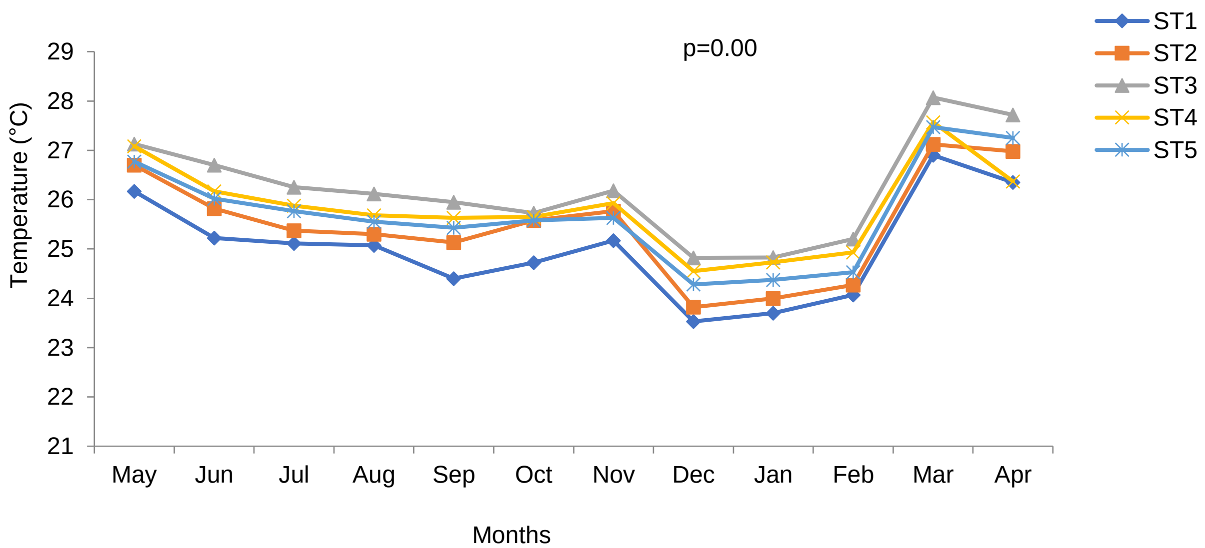

Figure 5: Mean Monthly Temperature of the Stream Sediment with the Stations.

Electrical Conductivity: Mean monthly Electrical Conductivity in the stream sediment with the sampling stations shown in Figure 6. Monthly variations of EC show highest value of 377.43µS/cm in August, followed by 337.33µS/cm in September and the lowest in January 164.27µS/cm was significantly different *P<0.05*. The highest EC of 307.12µS/cm was recorded in Station 4, followed by 270.72µS/cm in Station 2 and the lowest 213.03µS/cm in Station 1 (Table 2). There was no significant (*P<0.05*) difference in EC across the sampling Stations. Electrical conductivity (EC) is the capacity to conduct electric current (Kosha and Geeta, 2017). The increasing EC from May could be attributed to increased concentrations of free ions in the sediment from runoff into the stream, similar with the findings of Samuel *et al*. (2015). High values of EC obtained in August (377.43µS/cm), September (337.33µS/cm) and October (325.27µS/cm) is an indication of more ions in the wet season which could also be due to increased influx and dilution of inorganic materials. This disagrees with the report of Gadhia *et al*. (2012) that EC decreased with increased rainfall but in line with the study of Mustapha and Abodunrin, (2021). High EC can result in imbalance of aquatic organisms and decreased Dissolved Oxygen concentrations (Aniyikaiye *et al*., 2019).

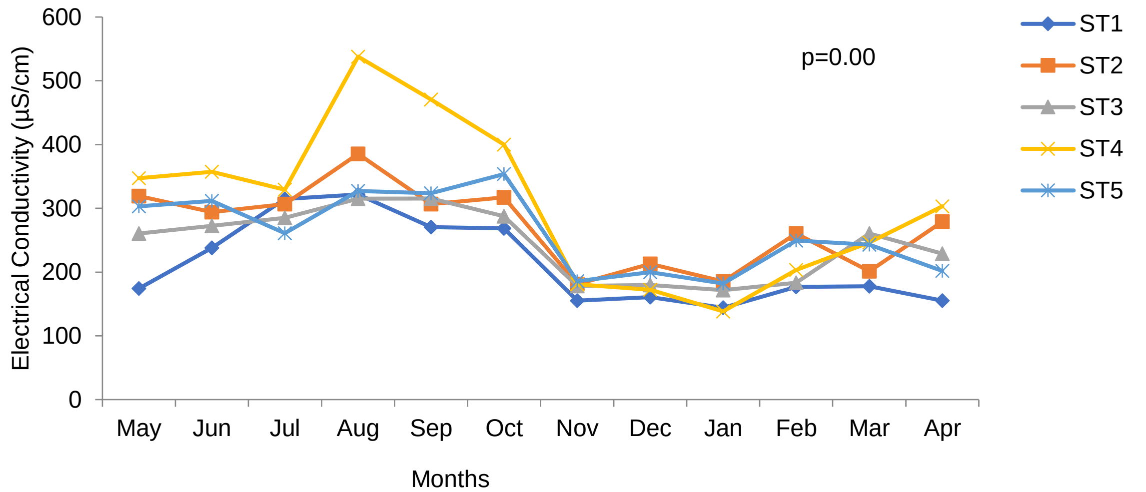

Figure 6: Mean Monthly Electrical Conductivity of Feroro Stream Sediment with the Stations.

Hydrogen ions (pH): mean monthly pH of the sediment presented in Figure 7. Monthly variations of pH showed the highest value of 8.43 in April, followed by 8.11 in March and the lowest in June 6.76, was significantly different $P<0.05$. Highest pH of 7.43 was in Station 5, followed by 7.38 in Station 1 and the lowest 7.26 in Station 4, was not significantly different $P<0.05$, (Table 2). There was significant difference in pH in the sampling months, though the same in the months of September and October (Table 4). The pH range and narrow fluctuation falls within the standard WHO limits indicating good buffering quality, which is similar with the findings of Radfard *et al.* (2019) and Kosha and Geeta (2017). Variations in pH at all the stations was due to the presence of domestic and agricultural wastes, which is in line with the findings of Amel *et al*. (2021). The pH range obtained in this study can support aquatic life which is similar to the range obtained in the studies of Rabiu *et al*. (2021). High and low pH level (under 5.0 or rise above 9.0), can denature cellular membranes (Halim *et al*., 2018).

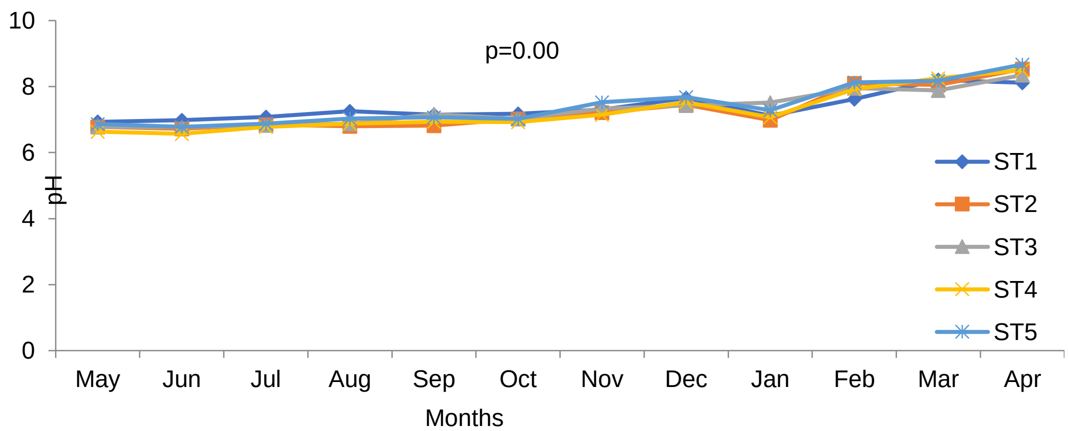

Figure 7: Mean Monthly Hydrogen ions (pH) of Feroro Stream Sediment with the Stations

Dissolved Oxygen: Mean monthly Dissolved Oxygen variations in the sediment with the sampling stations is shown in Figure 8. Monthly variations of DO shows the highest value of 3.73mg/L in October, followed by 3.65mg/L in September and the lowest 2.13mg/L in March. The highest DO of 3.23mg/L was in Station 1, followed by 3.06mg/L in Station 5 and the lowest 2.87mg/L in Station 2, which was not significantly different *P<0.05* in Table 2. The Dissolved Oxygen increased from May to June, then decreased in July in all the stations and further increased continuously in August through to October followed by decrease in November to April in all the sampling stations. There was significant difference *P<0.05* in Dissolved Oxygen in the sampling months, though not different in the months of December, January and February (Table 4). Increasing DO in the months of August to October could be due to increase water velocity of the stream. Slight increase in the DO from January to February could be due to the cool harmattan weather. The highest DO observed at station 1 during this study could be due to increased water velocity, atmospheric oxygen contact with the stream water, photosynthesis by algae and other aquatic plants and strong wind diffusion. This is similar with the study of Oniye *et al*. (2014) and Samuel *et al*. (2021). The significant difference of DO in the seasons is similar with the studies of Basu *et al*. (2021). DO is an important parameter for assessing aquatic quality as it regulates the distribution of aquatic flora and fauna (Bassey *et al*., 2020). The low DO of the sediment indicated high contamination level of the stream, which is similar with the study of Gijo *et al.* (2016). Presence of DO in water bodies in good quantity have the tendency of improving the water quality of such stream by oxidizing poisonous elements.

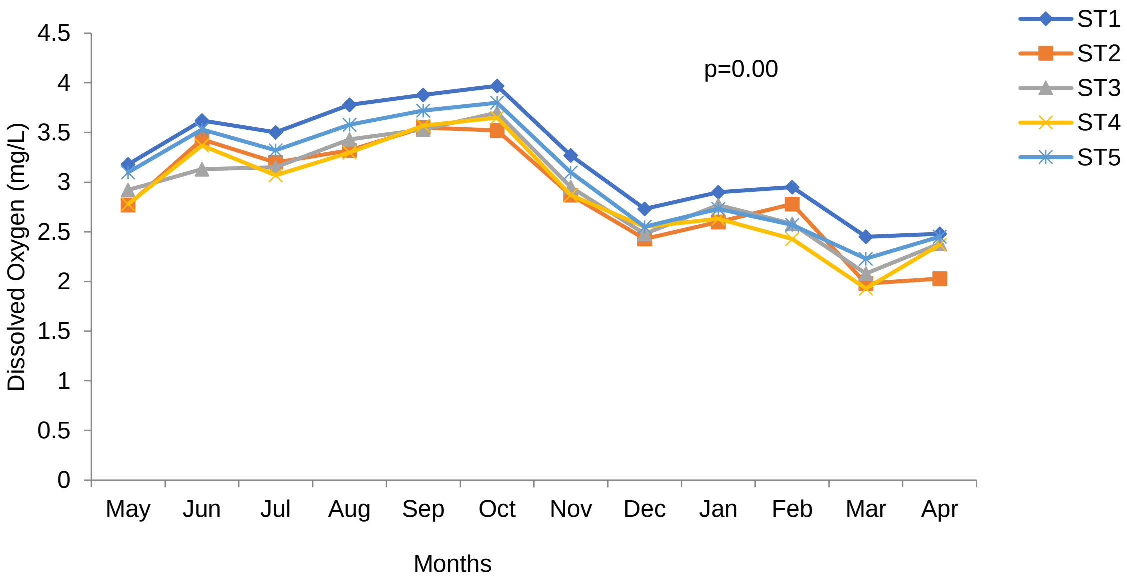

Figure 8: Mean Monthly Dissolved Oxygen (DO) of the Stream Sediment with the Stations.

Total Hardness: mean monthly Total Hardness variations during the sampling period are shown in Figure 9. Monthly variations of Total Hardness show highest value of 138.54mg/L in May, followed by130.53mg/L in December and lowest of 93.08mg/L in October. There was significant difference *P<0.05* in the sampling months (Table 4). Across the Stations, highest Total Hardness of 126.31mg/L was in Station 2, followed by 121.78mg/L in Station 4 and the lowest of 111.50mg/L in Station 1, there was no significant difference *P<0.05* (Table 2). Increasing concentrations of total hardness in the sediment in all the stations during the wet season is due to increasing dissolution of materials containing calcium and magnesium in the stream, similar with the report of Sikoki and Anyanwu (2013) and contrary with the findings of Seiyabal and Izah (2017). The Total Hardness concentrations obtained at station 2 to station 5 was hard since their values were >100mg/L.

Phosphate-phosphorous: The mean monthly Phosphate- Phosphorous of the stream sediment is presented in Figure 10. Monthly variations of PO_4-P showed highest value of 0.160 mg/L in September, followed by 0.152mg/L in March and lowest of 0.053mg/L in December was significantly different *P<0.05*. At the Stations, the highest PO_4-P of 0.11mg/L was in Station 1, followed by 0.10mg/L in Station 5 and

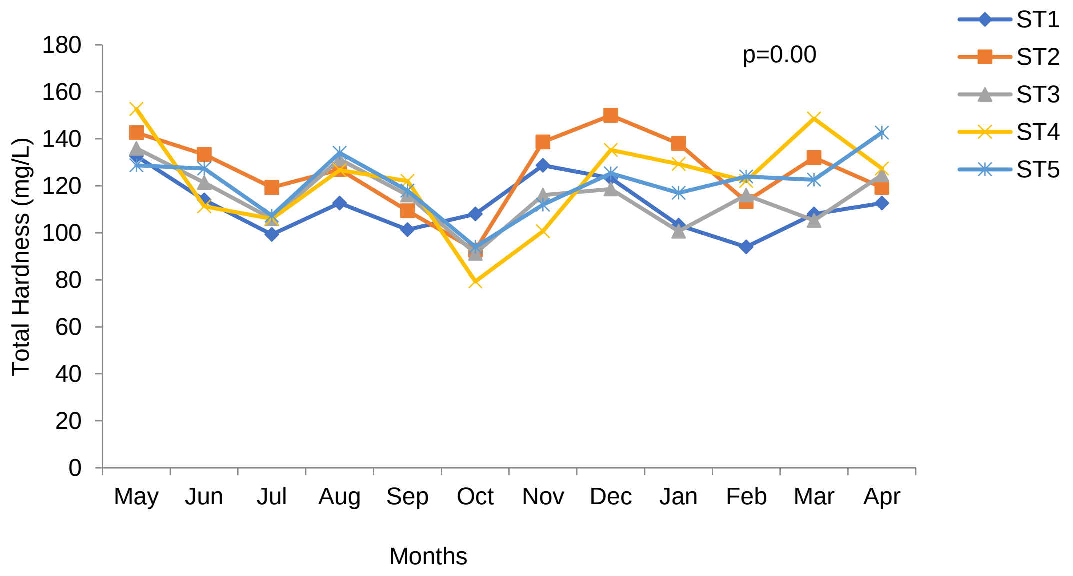

Figure 9: Mean Monthly Total Hardness of the Stream Sediment with the Stations

lowest of 0.09mg/L in Station 3, with no significant difference (*P<0.05*) Table 2. High concentrations of PO_4-P during the wet season could be due to artificial and organic fertilizers applied to farmlands near and around the stream which find their way into the stream as runoff, similar with the findings of Sun *et al*., (2019). Increased in PO_4-P recorded in the months of February and March (Table 4) at station 1 could be due to irrigation farming practiced at that station. High Phosphate-Phosphorus can result in excessive growth of algae thereby limiting Dissolved Oxygen in the stream causing eutrophication (Akintayo *et al*., 2021).

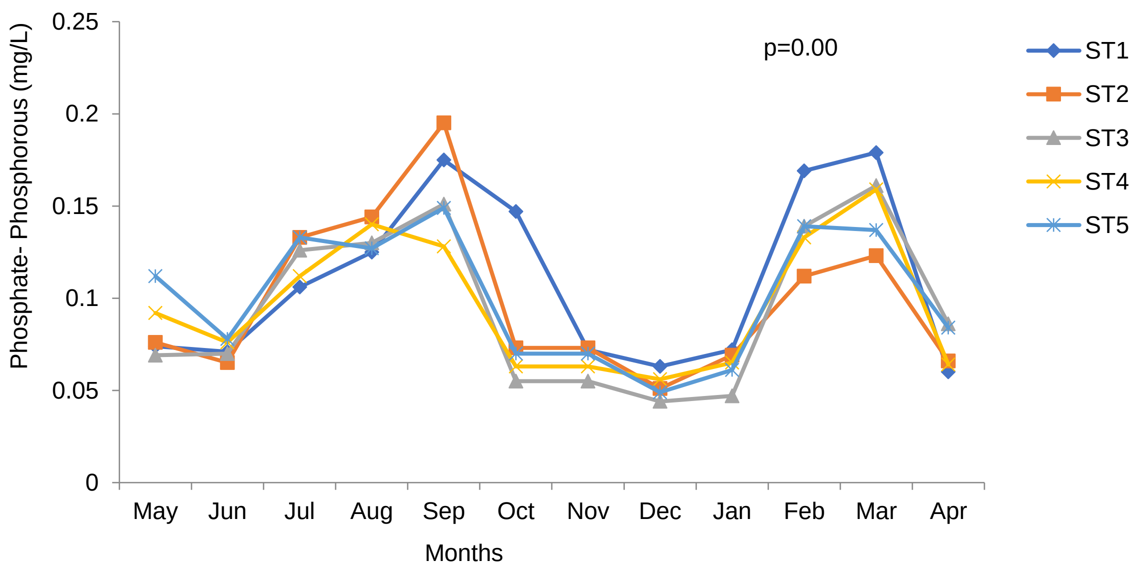

Figure 10: Mean Monthly Phosphate-Phosphorous of Feroro Stream Sediment with the Stations

Nitrate-Nitrogen: mean monthly Nitrate-nitrogen (NO_3-N) of the sediment is shown in Figure 11. Monthly variations of NO_3-N showed highest value of 0.348mg/L in August, followed by 0.341mg/L in June and the lowest 0.227mg/L in January. Across the stations, the highest NO_3-N value of 0.29mg/L were in Stations 1, 3 and 5 respectively and the lowest of 0.27mg/L in Stations 2 and 4 in Table 2. There was no significant difference among the Stations Table 2 but was significantly different (*P<0.05*) in the sampling months (Table 4). The low Nitrate-nitrogen concentration could be due to dilution from precipitation, denitrification and uptake by plants, similar with the studies of Nemcic-Jurec *et al*. (2017) and Wangji *et al*. (2021). High levels of NO_3- N can cause eutrophication (Kosha and Geeta, 2017).

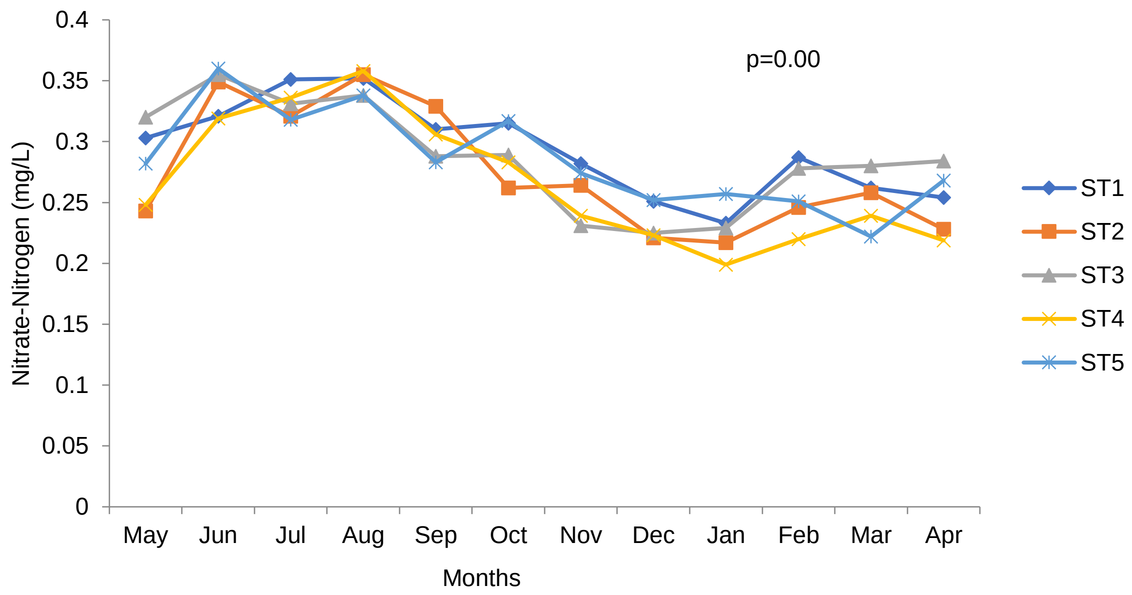

Figure 11: Mean Monthly Nitrate-Nitrogen (NO_3-N) of Feroro Stream Sediment with the Stations

Seasonal physicochemical variations of the stream sediment: Table 3 revealed the physicochemical parameters seasonal variations of the stream sediment. There was significant difference (*P<0.05*) in all the physicochemical parameters during wet and dry seasons, except in Temperature and Total Hardness. pH (7.76±0.09) was high during the dry season as compared to the wet season (*P<0.05)*. The high Total Hardness in the sediment during the dry season is due to the nature of the bed rock material of the stream and reduction of water level of the stream due to heating and evaporation. This is similar with the studies by Amel *et al.* (2021). The none significant difference and low Dissolved oxygen in all the stations during the dry season could be due to decrease water velocity, accumulation of organic-rich effluent, waste into the stream and activities of organisms in the stream sediment which consumes appreciable amount of oxygen as a result of metabolic activities. This is similar with the study of Ibezute *et al.* (2016). The high Phosphate-Phosphorus obtained during dry season could be due to reduction in water volume of the stream and discharge of sewage into the stream. The high nitrate-nitrogen concentrations during wet season might be due to increased usage of fertilizer, domestic waste, sewage and runoff of these fertilizer residues and animal waste into the stream, observed also in the studies of Mohammadi *et al.* (2017). NO_3-N recorded in the dry season could be due to increased evaporation resulting concentration of nutrients, similar with the observed by Abolude *et al.* (2012).

Table 3: Mean Seasonal Physico-chemical Variations of Feroro Stream Sediment

Parameters	Wet Season	Dry Season	P-value	WHO standard
Temperature (^{0}C)	25.79±0.12	25.54±0.25	0.373	23-35
Electrical Conductivity (µS/cm)	319.11±12.24	119.91±7.54	0.000	350-750
pH	6.91±0.03	7.76±0.09	0.000	6.5-8.5
Dissolved Oxygen (mg/L)	3.41±0.06	2.57±0.06	0.000	>5
Total hardness(mg/L)	116.72±3.05	121.66±2.58	0.220	150
PO_4-P (mg/L)	0.108±0.01	0.091±0.01	0.006	5
NO_3-N (mg/L)	0.316±0.01	0.246±0.00	0.000	10

NO_3-N= Nitrate-nitrogen, PO_4-P = Phosphate-phosphorus, WHO=World Health Organization, pH= Hydrogen ion

Table 4: Mean Temporal Physicochemical Parameters of Feroro Stream Sediment

Parameter	May	June	July	August	September	October	November	December	January	February	March	April	P-va
℃	26.77±0.17b	25.99±0.24c	25.68±0.20c	25.31±0.26c	25.31±0.26c	25.45±0.19b	25.74±0.17b	24.42±0.24d	24.33±0.21d	24.60±0.21d	27.43±0.20a	26.93±0.26ab	0.00
EC (µS/cm)	280.67±30.13bcde	294.60±19.89bcd	299.33±11.97bc	377.43±34.46a	337.33±34.46ab	325.27±23.60ab c	176.07±5.41f	184.94±9.41f	164.27±9.74f	214.73±17.17ef	225.73±15.17def	233.73±26.52cdef	0.00
pH	6.80±0.05g	6.76±0.07g	6.88±0.05fe	6.97±0.08fg	7.03±0.07ef	7.03±0.04ef	7.31±0.06d	7.55±0.05c	7.19±0.10de	7.94±0.09b	8.11±0.07b	8.43±0.09a	0.00
DO (mg/L)	2.95±0.08f	3.42±0.08cd	3.25±0.08d	3.48±0.09bc	3.65±0.07ab	3.73±0.08a	3.01±0.08e	2.55±0.05fg	2.73±0.05f	2.66±0.09f	2.13±0.09h	2.34±0.08g	0.00
T. Hard (mg/L)	138.54±4.21a	121.46±4.08bc	107.60±3.25cd	126.33±3.63ab	113.33±3.63bc	93.07±4.56d	119.20±6.61bc	130.53±5.58ab	117.67±7.23bc	113.87±5.33bc	123.33±7.99abc	125.33±5.01ab	0.00
PO_4-P (mg/L)	0.085±0.008d	0.072±0.002de	0.122±0.006c	0.133±0.004bc	0.160±0.012a	0.082±0.017d	0.067±0.003de	0.053±0.003e	0.063±0.004d	0.138±0.009abc	0.152±0.010ab	0.072±0.005de	0.00
NO_3-N (mg/L)	0.279±0.015bc	0.341±0.009a	0.331±0.006a	0.348±0.004a	0.303±0.008b	0.293±0.010b	0.258±0.010cd	0.234±0.007d	0.227±0.010d	0.256±0.012cd	0.252±0.010cd	0.251±0.012cd	0.00

NOTE: Means with the same alphabet across rows are not significantly different P<0.05. ϰ = Mean, SD = standard deviation, P-va = P-value, EC= Electrical conductivity, T. Hard = Total Hardness, NO_3-N = Nitrate-nitrogen, PO_4-P = Phosphate-Phosphorous, DO= Dissolved Oxygen, Temp=Temperature, pH= Hydrogen ion.

4.0. Conclusions

The physico-chemical parameters of Feroro stream sediment were significantly different. The physico-chemical parameters of Feroro stream sediment was successfully determined and significantly different (*P<0.05*) temporally and within standard permissible limits except Total Hardness (77.87-156.00mg/L), which was above the standard limit and Dissolved Oxygen of 1.51-3.79mg/L was below the standard limit. There was no spatial variation in the sediment. Seasonally, the stream sediment physico-chemical parameters significant varied *P<0.05,* except in Temperature (25.79℃ and 25.54℃) and Total hardness (116.72 mg/L and 121.66 mg/L) in wet and dry seasons respectively. The stream sediment was hard and of moderate quality.

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References

Abolude, S.D., Chia, A.M., Yahaya,A.S. and Okafor, D.C. (2012). Phytoplankton diversity and abundance as a function of water quality for fish production: a case study of two manmade reservoirs in Zaria, Nigeria. *Tropical Freshwater Biology*. 21(2), pp. 41- 58.

Adesuyi, A.A., Ngwoke, M.O., Akinola, M.O., Njoku, K.C. and Jolaoso, A.O. (2016). Assessment of physicochemical characteristics of sediment from Nwaja creek, Niger Delta, Nigeria. *Journal of Geoscience and Environment Protection*, 4(1), pp. 16-27.

Akhtar, N., Syakir -Ishak, M.I., Bhawani, S.A. and Umar, K. (2021). Various Natural and Anthropogenic Factors Responsible for Water Quality Degradation: A Review. *Water*, 13, pp. 2660.

Akintayo, O. O., Opeyemi, O. O., Oluwatoyin, O.D. and Felix, A.O. (2021). Hydrochemical and microbial assessments of water resources around cassava mills in a sedimentary formation of Ilaro, Southwest Nigeria, *Applied Water Science*, 11, pp. 62.

Amel, F., Mohammad, T.H., Fateh, M. and Ettayib, B. (2021). Surface water quality assessment in semiarid region (El Hodna watershed, Algeria) based on water quality index (WQI). *Studia Ubb Chemia LXVI*, 1, pp. 127-142.

Aniyikaiye, T.E..Oluseyi, T., Odiyo, J., Edokpayi, J.N. (2019). Physiochemical analysis of wastewater discharge from selected paint industries in Lagos, *Nigeria International Journal of Environmental Research and Public Health*, 16(1235), pp. 1-17.

Bassey, B.O., Nosazeogie, E.O., Abdullahi, I. M., Bello, B., Abiodun, O., Olapoju, O., Ajani, G., Igbo, J., Balogun, J.K. and Yakub, A.S. (2020). Macrobenthic invertebrates in relations to some selected water quality parameters in Lagos Lagoon, Nigeria. *Biomedical Journal of Scientific and Technical Research*, 30(1), pp. 22993-23001.

Basu, S., Bhattacharyya, S., Gogoi, P., Dasgupta, S. and Das, S.K. (2021). Variations of surface water quality in selected tidal creeks of Sagar Island, Indian Sundarban eco-region: a multivariate approach. *Applied water Science*, 11, pp. 63.

Bellasi, A., Binda, G., Pozzi, A., Galafassi, S., Volta, P. and Bettinetti, R. (2020). Microplastic contamination in Freshwater environments: A review, focusing on interactions with sediments and Benthic organisms. *Environment*, **7**(30), pp.1-28.

Brenner, H., Braeckman, U., Le Guitton, M. and Meysman, F. J. R. (2016). The impact of sedimentary alkalinity release on the water column CO_2 system in the North Sea. *Biogeosciences*, 13, pp. 841–863.

Eliku, T. and Leta, S. (2018). Spatial and seasonal variation in physicochemical parameters and heavy metals in Awash River, Ethiopia, *Applied Water Science* 8, pp.177.

Gadhia, M., Bengani, R. and Ansari, E. (2012). Seasonal variations in physicochemical characteristics of Tapi Estuary in Hazira Industrial Area. Our Nature.10, pp. 249-257.

Gijo, A.H., Hart, A.I. and Seiyaboh, E.I. (2016). The impact of makeshift oil refining activities on the physicochemical parameters of the interstitial water of Nun river estuary, Niger Delta, Nigeria. *Biotechnology Research*. 2(4), pp.193-203.

Halim, A., Sharmin, S., Rahman H., Haque, M., Rahman, S. and Islam, S., (2018). Assessment of water quality parameters in boar environment, Bangladesh: A review. *International Journal of Fisheries and Aquatic Studies*, 6(2), pp. 263-269.

Ibezute, A. C., Asibor, G. I. and Ibezute, S.U. (2016). Ecological Assessment of Brewery Effluent Impact on the Macrobenthic invertebrates of Ikpoba River, Edo state, Nigeria. *International Journal of Ecosystem*, 6(3), pp. 47-54.

Kosha, A. S. and Geeta, S.J. (2017). Evaluation of water quality index for River Sabarmati, Gujarat, India. *Applied water science*, 7, pp.1349-1358.

Mohammadi, A.A., Yaghmaein, K., Hossein, F., Nabizadeh, R., Dehghani, M.H. Khaili, J.K. and Mahvi, A.H. (2017). Temporal and spatial variation of chemical parameter concentration in drinking water resources of Bandare Gaz city using geographic information system. *Desalination and water treatment*, 68, pp.170-176.

Mustapha, M. K. and Abodunrin, I. A. (2021). Is siltation affecting the limnology and gradually eroding the functions of Agba reservoir, Ilorin, Nigeria?- An old tropical African drinking water reservoir. *Lakes and Reservoirs*, 26, pp.1-8.

Nemcic-Jurec, J., Singh, S.K., Jazbec, A., Gautam, S.K. and Kovac, I. (2017). Hydrochemical Investigations of groundwater quality for drinking and irrigational purposes: two case studies of Koprivnica-Krizevci country (Croatia) and district Allahabad (India). *Sustainable Water Resource Management*. 5, pp.467-490

Nigerian Standard for Drinking Water Quality (NSDWQ) (2007). Nigeria Ministry of Water Resources, Nigeria, pp.1-2.

Oniye, S. J., Y. Tanimu, Y., Chia A.M. and Yusuf, D. (2014). Influence of *Clarias gariepinus* (Teugels) Cage Cultures On Water Quality, Phytoplankton And Periphyton Composition: A Case Study Of Ahmadu Bello University Reservoir, Nigeria. *Tropical Freshwater Biology*, 23, pp. 21 – 37.

Rabiu, H.D., Abubakar, M.M. and Mallam, I. (2021). Risk assessment of heavy metals bioaccumulation in *Claris gariepinus* tissues from Jakara reserviour, Kano, Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS)*, **7**(4), pp.110-123.

Radfard, M., Gholizadeh, A., Azhdarpoor, A., Badeenezhad, A., Mohammadi, A. A. and Yousefi, M. (2019). Health risk assessment to fluoride and nitrate in drinking water of rural residents living in the Bardaskan city, arid region, southeastern Iran. *Desalination and Water Treatment*, 145, pp. 249-256.

Samuel, P.O., Adakole, J.A. and Suleiman, B. (2015). Temporal and Spatial Physico-Chemical Parameters of River Galma, Zaria, Kaduna State, Nigeria. *Resources and Environment***,** 5(4), pp. 110-123.

Samuel, P.O., Tolani, R. T., Auta, I. Y., Mohammed, Z. A., Chukwuemeka, I. V. and Solomon, A. B. (2021). Spatial and temporal variations in the Physicochemical parameters and abundance of macro invertebrate in Gurara reservoir, Kaduna state. *International Journal of Fisheries and Aquatic Studies,* 9(2), pp. 19-28.

Seiyaboh, E.I. and Izah, S.C. (2017). Review of impact of anthropogenic activities in surface water resources in the Niger Delta region on Nigeria:A case of Bayelsa state, *International Journal of Ecotoxicology and Ecobiolobgy*, 2(2), pp. 61-73.

Sikoki, F. D. and Anyanwu, I. N. (2013). Spatial and Temporal variations of physicochemical variables in a small Pristine stream in Niger Delta, Nigeria. *Journal of Fisheries and Aquatic Science*, 8(1), pp.129-135

Srinivas, R., Singh, A.P., Dhadse, K. and Garg, C. (2020). An evidence based integrated watershed modelling system to assess the impact of non-point source pollution in the riverine ecosystem. *Journal of Cleaner Production*, 246, 118963.

Sun, X., Zhang, H., Zhong, M., Wang, Z., Liang, X., Huang, T. and Huang, H. (2019). Analyses on the Temporal and Spatial Characteristics of Water Quality in a Seagoing River Using Multivariate Statistical Techniques: A Case Study in the Duliujian River, China. *International Journal of Environmental Research and Public Health*, 16.pp. 1020.

Wangji, J., Jun, X., Gurpal, S.T. and Zhi, L. (2020). Nitatre-nitrogen transport in stream water and groundwater in a loess covered region: sources, drivers, and spatiotemporal variation. *Science of Total Environment*, 761**.**

World Health Organization (WHO), (2017). Guidelines for drinking-water quality: fourth edition incorporating the first Addendum, Geneva. p.1-100.

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