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Some physicochemical parameters in the surface water of mini Whuo Stream in Port Harcourt, Rivers State, Nigeria

Edori ES [1,*], Iyama WA [2] and Awari JO [1]

[1] *Department of Chemistry, Ignatius Ajuru University of Education Rumuolumeni, P.M.B. 5047, Port Harcourt, Rivers State, Nigeria.*

[2] *Institute of Geosciences and Environmental Management, Rivers State University, Port Harcourt.*

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Abstract

The levels of physicochemical properties of Mini Whuo Stream in Port Harcourt, Rivers State, Nigeria was evaluated. The physicochemical parameters were analyzed using standard conventional procedures. The average values recorded for the physicochemical parameters during the months of investigation were in the range; temperature; 30.00±0.42-30.26±0.83°C, with all-round mean of 30.14±0.47°C, pH; 6.22±0.33-6.42±0.25 (6.29±0.29), electrical conductivity; 146.01±74.04-147.26±75.13µS/cm (146.58±74.69 µS/cm), total alkalinity; 61.63±6.37-62.20±6.41mg/L (61.91±6.41 mg/L), sulphates; 109.67±51.34-110.67±51.88mg/L (110.22±51.81 mg/L), nitrates; 12.20±2.38-12.60±2.86mg/L (12.31±2.65 mg/L), turbidity; 49.32±1.49-50.18±2.02 NTU(49.83±1.55 NTU), TDS; 74.20±36.43-75.61±37.50 mg/L (75.00±36.81 mg/L), TSS; 27.14±2.12-28.37±0.78mg/L (27.64±1.89 mg/L), chlorides; 15.17±2.90-15.66±2.70mg/L (15.34±2.65 mg/L) and salinity; 24.36±4.83-24.82±4.97mg/L (24.66±4.78 mg/L). The evaluation of the physicochemical parameters showed that the Mini Whuo Stream has been contaminated due to human activities within the stream and therefore adequate measures should be taken to forestall the present situation of the stream in order to mitigate any possible increase in deterioration of the studied physicochemical parameters in the stream beyond acceptable limit.

Keywords: Aquatic environment; Contamination; Ecological system; Mini Whuo Stream; Physicochemical parameters

1. Introduction

The contamination of water bodies, most often is majorly caused by humans. The input of contaminants and pollutants through human activities usually lead to increase in contamination of the receiving environment more than the natural background levels for that area and for the organisms that inhabit the environment (Ibrahim *et al*., 2016). The occurrence of hazardous substances in the water environment results in reduction in the general quality of the marine environment and the consequence in most cases is the impairment of some physicochemical properties of the water (Ibrahim *et al*., 2016).

Pollution is the damages (physical, chemical and biological) of the environments which may be in water, air or land according to Etim and Onianwa (2013) and it is a serious problem internationally. Man in his need for better living has predisposed nature through upsetting of the ecological systems. The resulting consequence of pollution on the environment makes it quite challenging to apply the available resources of the environment for improved living due to the harmful effects which has been initiated from the changes in the original quality of the environment (Uzoekwe & Oghosanime, 2016). The notable rise in population growth, urbanization and industrialization has actually increased

* Corresponding author: Edori Es
Department of Chemistry, Ignatius Ajuru University of Education Rumuolumeni, P.M.B. 5047, Port Harcourt, Rivers State, Nigeria.

both the load on the environment and pollution originating from human activities (Omoregie *et al*., 1997), hence the need for regular evaluation and assessment of the environment to limit the resultant consequences of pollution.

The degradation and deterioration of the coastal waters as a result of contamination has produced certain grave consequences on the natural system, which have caused adverse consequences on the littoral ecosystem by impacting negatively on fishing, tourism, wild life, transportation and other related businesses operational within that area (Ogri, 2001). Environmental records have revealed that high concentration of both organic (including petroleum hydrocarbons) and inorganic chemicals have negatively impacted on the environment, due to the activities of industries. The resultant effects of such occurrences have been adverse and have surpassed both national and international tolerable limits in various environments (Olobaniyi & Efe, 2007).

Industrial, commercial, domestic and agricultural activities are the key contributors of pollution and contamination in the environment with organic and heavy metals as the major pollutants. The various water bodies such as rivers, creeks, lakes, estuaries and ground water experience changes in the level of contamination by these pollutants as a result of the impact, input and influence of humans. The influx into the rivers and creeks from homes, industries, and the air daily increases the pollution problem. The unrestrained discharge of agricultural wastes, application of pesticides, petroleum wastes from oil bunkering and refineries also has led to the deterioration and degradation of the environment.

The purpose of this research is to investigate or determine the level of some physicochemical parameters of the Mini Whuo Stream which will be useful in verifying the level of contamination and pollution of the surface water by physicochemical parameters which may have been altered due to the anthropogenic influence within the studied area.

2. Material and methods

2.1. Water Sampling for Physicochemical Parameters

Plastic bottles earlier rinsed with acid were used in the collection of water samples. The sample bottles were initially washed with detergent and comprehensively rinsed with water and then kept to dry. The dried plastic bottles was rinsed with dilute nitric acid and was allowed to dry before being used for sampling. The dried plastic bottles were then dipped into the water at a depth of 30-40cm and then covered below the water surface so that air will be prevented from interfering with the collected sample and was instantly transferred to containers filled with ice and then taken to the laboratory for determination and analysis.

2.2. Analysis of Water Samples for Physicochemical Parameters

The water samples were analyzed for physicochemical parameters as follows: Turbidity, total dissolved solids (TDS), electrical conductivity, water hardness, salinity and hydrogen potential (pH) were done in-situ by means of U-52 multi parameter water checker Horriba. Nitrate concentrations were determined by the use of nitrover tablets which were dissolved in 100 ml of water and the levels read off from Wagtech Spectrophotometer model 5000 and then compared to standard charts provided. The concentrations of sulphates were determined spectrophotometrically after 5 ml of a conditioning reagent was added to 100 ml of water and a spatula full quantity of $BaCl_2$ mixture.

The colorimetric end point technique was used to determine the concentrations of phosphates in the water samples. Then the concentration of phosphate was determined spectrophotometrically at 490nm wavelength. The result was compared with those in a prepared chart of calibration curve of standard phosphate solution.

3. Results and discussion

The results obtained for the different physicochemical parameters in the Mini Whuo Stream are provided in Tables 1-3 while the average level of the physicochemical parameters during the months of investigation carried out are provided in Figure 1.

Table 1 Physicochemical Parameters of Water Samples of the Rumuokoro, Eliozu and Rukpokwu axis of the Mini Whuo Stream in April

Parameters	Stations/Locations			Mean ±SD	WHO Limit
	Rumuokoro	Rukpokwu	Eliozu		
Temperature °C	30.5	30.2	29.5	30.0±0.42	30
pH	6.20	5.86	6.60	6.23±0.29	6.5-8.5
Electrical Conductivity µS/cm	90.65	250.66	96.72	146.01±74.04	5000
Total Alkalinity (mg/L)	61.70	53.80	69.40	61.63±6.37	6.5-8.5
Sulphates (SO_4^{2-}) (mg/L)	182	68	79	109.67±51.34	400
Nitrates (NO_3^-) (mg/L)	15.10	9.30	11.60	12.00±2.38	10
Turbidity (NTU)	48.80	51.60	49.60	50.00±1.18	15
Total Dissolved Solids (TDS) (mg/L)	48.53	125.72	48.36	74.20±36.43	2000
Total suspended Solids (TSS) mg/L	26.50	28.40	27.30	27.40±0.78	30
Chlorides (Cl^-) mg/L	18.60	15.40	11.50	15.17±2.90	200
Salinity mg/L	30.69	23.40	18.98	24.36±4.83	600

Table 2 Physicochemical Parameters of Water Samples of the Rumuokoro, Eliozu and Rukpokwu axis of the Mini Whuo Stream in June

Parameters	Stations/Locations			Mean ±SD	WHO Limit
	Rumuokoro	Rukpokwu	Eliozu		
Temperature °C	30.00	30.40	30.10	30.17±0.17	30
pH	6.23	5.81	6.63	6.22±0.33	6.5-8.5
Electrical Conductivity (µS/cm)	91.25	252.35	95.78	146.46±74.89	5000
Total Alkalinity (mg/L)	60.79	54.60	70.31	61.90±6.46	6.5-8.5
Sulphates (SO_4^{2-}) (mg/L)	184	72	76	110.67±51.88	400
Nitrates (NO_3^-) (mg/L)	16.11	10.00	10.86	12.32±2.70	10
Turbidity (NTU)	47.38	50.90	49.69	49.32±1.46	15
Total Dissolved Solids (TDS) (mg/L)	49.43	128.64	48.77	75.61±37.50	2000
Total suspended Solids (TSS) (mg/L)	27.50	29.40	28.20	28.37±0.78	30
Chlorides (Cl^-) (mg/L)	18.65	16.24	12.10	15.66±2.70	200
Salinity (mg/L)	30.63	24.20	19.58	24.80±4.53	600

Table 3 Physicochemical Parameters of Water Samples of the Rumuokoro, Eliozu and Rukpokwu axis of the Mini Whuo Stream in August

Parameters	Stations/Locations			Mean±SD	WHO Limit
	Rumuokoro	Rukpokwu	Eliozu		
Temperature ^oC	31.40	29.92	29.45	30.26±0.83	30
pH	6.44	6.11	6.72	6.42±0.25	6.5-8.5
Electrical Conductivity (µS/cm)	92.45	253.51	95.87	147.28±75.13	5000
Total Alkalinity (mg/L)	62.30	54.30	70.00	62.20±6.41	6.5-8.5
Sulphates (SO_4^{2-}) (mg/L)	184.	69	78	110.33±52.22	400
Nitrates (NO_3^-) (mg/L)	16.20	9.20	12.40	12.60±2.86	10
Turbidity (NTU)	47.70	52.65	50.20	50.18±2.02	15
Total Dissolved Solids (TDS) (mg/L)	48.66	126.82	50.12	75.20±36.51	2000
Total suspended Solids (TSS) (mg/L)	25.30	30.11	26.00	27.14±2.12	30
Chlorides (Cl^-) (mg/L)	17.90	15.50	12.20	15.20±2.34	200
Salinity (mg/L)	31.61	22.98	19.87	24.82±4.97	600

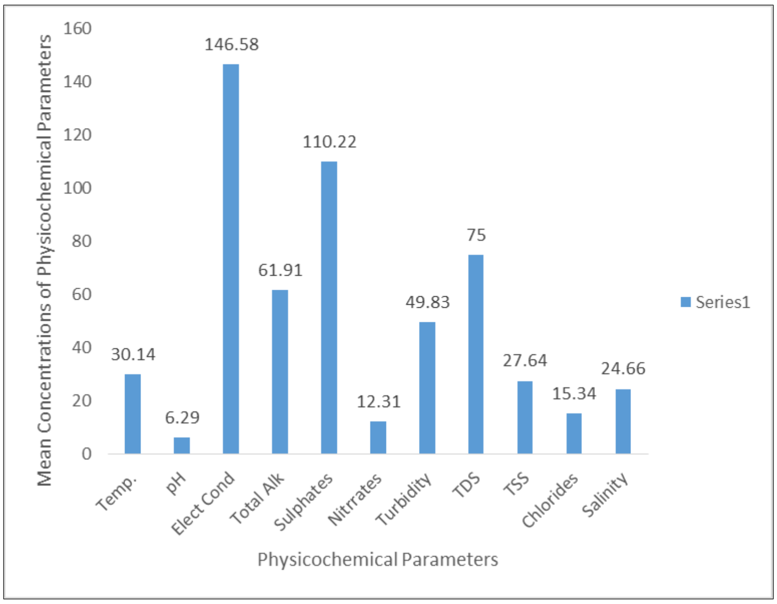

Figure 1 Mean Concentrations of Physicochemical Parameters during the Months of Investigation in the Mini Whuo Stream

3.1. Temperature

The mean monthly results obtained for temperature in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 30.00±0.42 to 30.26±0.83^oC. The mean value obtained for temperature in the studied months was 30.14±0.47^oC. The values recorded for temperature during the time of investigation from the stream were within the standard limit of temperature permissible in the aquatic space acceptable by WHO which falls between 28.5-32^oC. The high values of temperature recorded in the stream may be due to the semi-stagnant nature of the stream and shallowness of the stream which allows the penetration of the sun rays to the bottom of the water body and the level of suspended solids in stream due to humans throwing refuse into the stream. The results obtained from the stream was higher than that obtained from the Isiodu River Water during dredging in Niger Delta, Nigeria which fell between 5.81-

13.20 ^{o}C (Iyama & Edori, 2013) and that of Iyama and Edori (2014) at the Imonite River which was in the temperature ranges of ^{o}C (26.70, 26.40, 26.08, 24.94) and that which was obtained by Kurnaz*et al*., (2016) in the water column of Cigdem pond in Turkey.

The level temperature of any coastal setting has direct or indirect impact on the organisms' biological effects or conditions. At a time when a change is detected in the temperature of any water body, there is also a resultant change in the physicochemical characteristics of the water that is subsequent on the physiological adaptation of organisms within the system (Edori & Nna, 2018). In addition to that, the assessment of the ecological factors or conditions of both biological and non-biological organisms to fit into the environment is dependent on temperature. This is due to the fact that temperature has direct bearing on the normal lifestyle and behavioural characteristics in an aquatic ecosystem (Palamuleni & Akoth, 2015) and the level of gases dissolved in the water body such as oxygen, might be either harmful or vital for migration, reproduction, growth and even death of water dwelling animals and plants (Patil *et al*., 2012).

3.2. pH

The mean monthly results obtained for pH in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 6.22±0.33 to 6.42±0.25. The mean value obtained for pH in the studied months was 6.29±0.29. The observed values of pH were slightly lower than the acceptable value required for drinking water by WHO which ranged from 6.5 to 8.5. The values obtained in this work were in the same range with that obtained by Iyama and Edori, (2013) from the Isiodu River water. The values obtained in this work were higher than that obtained by Edori and Nna (2018) from different locations of the New Calabar River which lie in the range of 3.43 ± 0.24 and 5.06 ± 1.42. The pH values reported in this research were all within the acidic level and are similar to that reported by certain scholars (Onwughara *et al*., 2013). Acidic water increases the rate of corrosion of metallic materials, pipes, cement walls and plumping materials, but alkaline water is a revelation that the water is disinfected and suitable for use (Rahmanian *et al*., 2015; Edori & Kpee, 2016). The acidic nature of the water in the stream may be due to semi-still nature of the stream and the prevailing domestic and industrial activities which has led to the deposition of metallic materials in the stream within the sampled locations. When the pH values of water, is on the extreme, it affects the taste and sweetness of the water. The efficiency and effectiveness of biochemical reactions within any water body hinges on pH.

3.3. Electrical Conductivity

The mean monthly results obtained for electrical conductivity in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 146.01±74.04 to 147.26±75.13µS/cm. The mean value obtained for electrical conductivity in the studied months was 146.58±74.69µS/cm. The values reported for electrical conductivity in this work were lower than that desired or allowed for electrical conductivity by WHO in Any aquatic environment. The electrical conductivity of any aquatic environment depends solely on the concentrations of ions or current carrying species that are present in that water body (Sharma & Walia, 2017). Since conductivity is a function of the ionic content of the sample, which gives an idea of the level of dissolved ions or electrolytes present in the sample, it becomes a very important factor or tool to express or investigate the level of hardness and alkalinity of that water environment (EPA, 2001). The values reported for conductivity in this study were quite higher in comparison to that from Edori and Nna (2018) which lie within 11.60±2.68 and 15.61±3.01µS/cm and that reported by Abdar (2013) in Morna Lake, Shirala, India and those detected by Sharma and Walia (2017) in Satluj River, Himachal Pradesh, India. The high level of the conductivity observed in the stream possibly might be connected to the extremely slow movement of the stream water and the type of materials dumped into the stream by humans that assess the stream on daily basis.

3.4. Total Alkalinity

The mean monthly results obtained for total alkalinity in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 61.63±6.37 to 62.20±6.41 mg/L. The mean value obtained for total alkalinityin the studied months was 61.91±6.41 mg/L. These values obtained were observed to be far greater than the recommended value allowed by WHO for domestic water usage especially for drinking which is between 6.5-8.5mg/L. Alkalinity is used by hydrologists to describe temporary hardness of water. It is useful and significant in the determination of a river's capability to counterbalance acidic pollution which is occasioned by rainfall, effluents or wastewater. Alkalinity is an excellent determining means for the sensitivity of aquatic systems to the contributions of acids (USEPA, 2013). The likelihood of longstanding variations can take place in the concentrations of alkalinity in the aquatic environments as a result of anthropogenic input like acid rain that is carried about as a result of the discharge of SOx and NOx (Kaushal *et al*., 2013).

3.5. Sulphates (SO_4^{2-})

The mean monthly results obtained for sulphates in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 109.67±51.34-110.67±51.88mg/L. The mean value obtained for sulphates in the studied months was 110.22±51.81 mg/L. The concentrations obtained in the stream fell below the maximum allowable limit of sulphates in water for drinking and other domestic uses of 400 mg/L required by the WHO. The concentration values obtained in this work was far more than that obtained by Kaizer and Osakwe (2010) in the five river systems of Delta State, Nigeria. The results of sulphates obtained in this work were lower than that reported by Edori *et al.*, (2019) in the water-column of Elelenwo River that was between 747.333±24.253 and 757.000±33.146 mg/l concentration range. It is very difficult to remove sulphate from water, apart from distillation, reverse osmosis or electrodialysis which are very expensive methods. When sulphate is present in water to a level range of 500 – 700 mg/L, it can result into serious health difficulties in humans. Sulphate produces a little taste in water, but at values lower than 300 mg/L, the taste will not be felt. Certain side effects of sulphate on human consumers are catharsis, water loss from the body and intestinal ailment. These ailments have been linked to high concentrations of sulphate in water for domestic use (Bertram & Balance, 1996). Sulphate at extremely high concentrations in any water body have the likely tendency to reduce the pH of the water and thereby causing proliferation of bacterial growth in the aquatic environment.

3.6. Nitrates (NO_3^-)

The mean monthly results obtained for nitrates in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 12.20±2.38 to 12.60±2.86 mg/L. The mean value obtained for nitrates in the studied months was 12.31±2.65 mg/L. The concentration values obtained were higher than the 10 mg/L accepted for nitrates in water for drinking and other domestic purposes by WHO. The level of nitrates recorded in this investigation were higher than that reported by Etim *et al.*, (2013) in the Qua Iboe River in Akwa Ibom State and Cross River in Cross River State and also that reported by Sikoki and Anyanwu (2013) in Onu-Iyi-Ukwu Stream in Niger Delta, Nigeria.

Nitrate is an element of any hydrologic setting and a product of excretion and wastes of water dwelling organisms, which further increases the level of nitrate in the aquatic setting. This is due to the activities of microbes, the high levels of ammonia in excreted products to nitrates and nitrites. Nitrate is a domineering eutrophic agent when it exists at high concentration in an aquatic environment. Eutrophication reduces the quantity of obtainable oxygen that is dissolved in an aquatic system. Low level of dissolved oxygen decreases the efficient conversion of ammonia to nitrite and then to nitrate, that leads to an increased level and quantity of ammonia and nitrite in the aquatic systems, and thereafter producing higher level toxicity to the water environment (Suthar *et al.*, 2009).

3.7. Turbidity

The mean monthly results obtained for turbidity in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 49.32±1.49 to 50.18±2.02 NTU. The mean value obtained for turbidity in the studied months was 49.83±1.55 NTU. The values recorded for turbidity in this present work is far higher than the WHO value of 10 NTU for drinkable water and water for other domestic use. Turbidity is the extent to which a water body is clear or opaque. The values recorded for turbidity in this research was found to be higher in value than those reported by Edori and Nna (2018), in the New Calabar and that obtained by Yapo *et al.*, (2012), in a river in Abidjan City. The level in which particles are suspended or dissolved in any given aquatic system contributes to the high turbidity of that aquatic environment. The high values of turbidity observed from the stream might have originated from high level of chemicals and effluents discharged into the stream from drainages and run-offs from adjoining lands without passing through due processes. Another possible reason might be from the degree of concentration of dissolved solids (organic or inorganic matter) observed in the stream might also be the cause of the high level of turbidity. High turbidity levels in a water body hinders the effective penetration of light into greater depth and hampers the photosynthetic activities and destroys or decreases normal aquatic life and upsets the value and appearance of surface water (Gupta *et al.*, 2017). The level in which micro-organisms, phytoplanktons and zooplanktons occur in the aquatic system increases the level of water turbidity (Edori & Kpee, 2016; Edori & Nna, 2018).

3.8. Total Dissolved Solids (TDS)

The mean monthly results obtained for total dissolved solids in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 74.20±36.43 to 75.61±37.50mg/L. The mean value obtained for total dissolved solids in the studied months was 75.00±36.81 mg/L. The values obtained in this work were far lower than the maximum allowable value of 2000 mg/L by WHO for potable water. The total dissolved solids observed in this work were far lower than that which was observed by Edori *et al.*, (2019) in the water samples of the Silver River in Bayelsa State which ranged from 13,050 to 13,500 mg/L. The values in this work were also lower than that obtained and observed in the upper reaches of Orashi River (Davies *et al.*, 2018) and a stretch of the New Calabar River (Dienye & Woke, 2014). TDS is a water quality index that measures the presence of both inorganic and organic matter that are in solution (Rahmanian *et al*., 2015). The level to which pollution has affected any aquatic environment or coastal ecology has an association to the concentration of TDS present in the water. TDS is a pointer of water quality since it has effects on the taste, colour and smell of the water body and also possess the capacity to hamper light penetration in to depth of the water body. Increased level of TDS make water not suitable for drinking and for agricultural purposes as a result of the decrease in photosynthetic ability and increase in water temperature (NRCC, 2011).

3.9. Total suspended Solids (TSS)

The mean monthly results obtained for total suspended solids in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 27.14±2.12 to 28.37±0.78mg/L. The mean value obtained for total suspended solids in the studied months was 27.64±1.89 mg/L. The concentration values recorded were less than the approved level of TSS in water by WHO for domestic and drinking purpose which is 30 mg/L. The observed value of TSS in this work was above the value reported in the Silver River which ranged from 14.23 to 17.40 mg/L (Edori *et al*., 2019). The Increased TSS in water increases the turbidity of the water. Certain factors that affect the level of TSS in water include; the farming system, building and constructions works, mining and season (wet or dry). All these factors have the ability to expose the soil surface and thereby giving way for runoffs and erosion, which transport particles to the water. Suspended particles are mostly of natural occurrence than artificially induced and are mainly composed of components such as algae, silt and sediment. Sediment re-suspension which comes as a result of the pattern of water flow and type of current prevalent in the water body also affects the level of TSS. Increased suspended particles concentration in water provide information on the degree of contamination of the water and also accountable for some organoleptic characteristics of water viz.; odour and colour (Edori & Kpee, 2016).

3.10. Chlorides (Cl^-)

The mean monthly results obtained for chlorides in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 15.17±2.90 to 15.66±2.70mg/L. The mean value obtained for chlorides in the studied months was 15.34±2.65 mg/L. The values recorded for chlorides in the stream were far below that which is the maximum required level by WHO which is 200 mg/L for domestic water. The level of chloride ion in the stations of the stream were far below that reported in the water sample from effluent discharge points of the New Calabar River by Edori and Nna (2018) which was 6550.83 mg/L. Origin of chloride in water arises basically from re-suspension of sediments contaminated with chlorides and industrial effluents/discharges. One foremost effect of chloride contamination in water is that it heightens the electrical conductivity of water and corrosion of metals on contact with the water. Metals in the presence of chlorides reacts to give soluble salts, WHO (2003)**,** hence increasing the level of metals in water. Both pitting and galvanic corrosion are quickened by the presence of chlorides **(**Gregory, 1990; WHO, 2003).

3.11. Salinity

The mean monthly results obtained for salinity in the surface water samples of Mini Whuo Stream in the three stations sampled varied from 24.36±4.83 to 24.82±4.97mg/L. The mean value obtained for salinity in the studied months was 24.66±4.78 mg/L. The mean values of salinity obtained in the different months across the stations of the stream were far below the maximum recommended value of 600 mg/L by WHO for water to be used for drinking and other domestic uses. The values of salinity recorded in this research were higher than that reported by Abowei (2009) in Nkoro River, Niger Delta, William and Benson, (2009) in Qua Iboe and Cross River estuaries of Akwa Ibom and Cross River States, Niger Delta and those of Mbah *et al*. (2017) at point of use on Yenagoa River, Bayelsa State. Salinity is a very important aspect when in view of environmental situations. This is as a result of its effects on the different types and species of floras and faunas that inhabit the water environment and also upsets the potability or use to which the water is used for.

4. Conclusion

The water obtained from the stream is not suitable for domestic or home consumption such as drinking and bathing.

Relevant authorities should take definite steps and put in place laws to reduce the effect of pollution arising from human activities within or close to the stream. This could be made possible through constant campaign to create awareness and also adequate monitoring of the stream and its environs. Aquatic plants and animals from the stream commonly sold and consumed within the area should be examined to determine levels of physicochemical parameters in their tissues.

The continuous monitoring of any aquatic environment is vital in the assessment for the renewal, rebuilding, safety and fortification of the aquatic environment. This will assist in putting in place the integrity of marine plants and animals and the general environment**.** The observed results of the physicochemical parameters of the water samples from the stream showed that all the parameter examined were within the acceptable limits for drinking water except total alkalinity and nitrates.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest existed among the authors.

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