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# Physical and Chemical Characteristics of Water from Ede Onyima Creek, Okarki-Engenni, Rivers State, Nigeria

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**Abstract** Water samples were collected from Ede Onyima Creek following standard procedures and were analyzed for some physical and chemical parameters. The samples were collected from three stations bimonthly for a period of one year. The result obtained showed that the physical characteristics such as conductivity, Total dissolved solids (TDS), total suspended solids (TSS) and temperature were within the WHO limit, while turbidity was higher than the limit. For the chemical parameters, pH, salinity, chlorides ($Cl^-$), nitrates ($NO_3^-$) and sulphates ($SO_4^{2-}$) were within the acceptable limits for consumable water, while dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and phosphates $PO_4^{3-}$ were above the WHO limit for drinking water. There were higher values of conductivity in the dry months as against the wet months, while those of temperature were almost the same throughout the period, but TDS, TSS and turbidity were higher in the rainy months than the wet months. For the chemical parameters, pH and DO did not show significant difference ($p>0.05$) within the months, while salinity, BOD, $Cl^-$, $NO_3^-$ , $SO_4^{2-}$ and $PO_4^{3-}$ showed significant differences difference ($p>0.05$) with higher values observed in the wet months and COD values were significantly different ($p>0.05$), with higher values in the dry months. These observations in the different parameters indicated a creek water greatly influenced by external factors, which if not controlled by relevant monitoring agencies might lead to very serious pollution of the creek.

**Keywords** Physical parameters, chemical parameters, environment, water, pollution

## Introduction

The lives of humans are bettered through his association with the different ecological elements. The initial settlements of communities were at points close to where natural feature such as streams and rivers can easily be assessed. To improve human life, the idea and action of interfering with nature through the modification of natural form of life came into play. These actions, resulted in detrimental consequences to both man and the environment and therefore change the natural equilibrium of the ecosystem [1].

Water is a well-known central and critical resource in human and environmental survival. Although water is commonly available, but only a fraction of 3% occur as fresh water and of this little percentage, only a fraction of 5% is readily available to man for usage both at home and industries [2-3]. The water that was used either in the homes or industries were later discarded as wastewater (effluents or produce water), which are then transported back to the river with its attendant contaminants [4]. Due to the rapid increase in population coupled with a rise in anthropogenic activities, industries have sprung up in diverse forms, which has resulted in the greater quantity of contaminant burden and pressures borne by aquatic environments. Humans later go back to reap the consequences of

their action when they go back to the same system they have corrupted. This is manifested generally in different health issues associated with water usage**.**

The river system or ecology show a reflection of the level to which it has been degraded due to different human activities [5]. The Efficiency, suitability and continuous usage of water is based on the qualities of different physical and chemical parameters of the water. As a result of discharge of wastes into rivers without following due processes, there is an accompanied change in the physical and chemical behaviour of water. Despite the fact that water naturally contains some elements and compounds, yet a change in these parameters from normal to abnormal levels has the tendency to cause serious harm to aquatic organisms [6].

The presence of pollutants at elevated levels has protracted destructive effects on aquatic biota and also terminate self – purification processes of water and the behaviour of plants and animals present in the receiving aquatic medium [7] and other uses to which water may be applied [8].

When there is an interference of pollutant chemicals with water, there is a resultant decrease in its quality and this can only be known when the different parameters of water assessment have gone beyond the regulated limit for consumption [9], through laboratory measurements. Hence, the need to examine some physical and chemical parameters in Ede Onyima Creek, an important water body and fishery reserve in Okarki Community, Rivers State, Nigeria.

## Materials and Methods

The Ede Onyima Creek is situated in Okarki-Engenni, Rivers State, Nigeria. The creek takes its root from the Orashi River passes through several Ogbia communities and empties to the sea at the Nembe axis of Bayelsa State. although as the creek progresses, it is known by another name (Kolo Creek) by the Ogbia people. The creek serves as a means of transportation of goods and services between the Ediro Clan in Engenni, Rivers State and the Ogbia people of Bayelsa State.

Water samples were collected from three different stations bimonthly with 1.5L plastic containers. They were put immediately to ice pack containers filled with ice. They were then transported to the laboratory for analysis of those parameters that were not performed on the site.

The pH, conductivity and TDS were measured in situ with a portable meter (Jenway model 350). A turbidity meter (HACH Model 2100An) was used to determine the turbidity of the water samples on site.The salinity of the samples were determined by the use of a digital electronic meter. Total suspended solid (TSS) was analyzed using the method of APHA [10].

Dissolved Oxygen (DO) was determined by the use of DO instrument. Biochemical oxygen demand (BOD) was analyzed on the same sample of water initially analyzed for DO. The water samples after the DO test were kept in a BOD incubator (a dark cupboard) at a temperature of 20 $^{o}$C for five days. On the fifth day, the samples were analyzed as was done for DO. Chemical oxygen demand (COD) was determined by the method prescribed by APHA [10].

The concentrations of phosphate were determined by converting the phosphates in the sample to the orthophosphate, which is soluble. Then a colorimetric determination of the concentration of phosphate was carried out on the sample. Sulphates and nitrates concentrations in the water samples were determined using the HACH spectrophotometer (model 3900 DR, USA). The concentrations of chloride in the samples were determined through titrimetric method.

## Results and Discussion

The results of the physical and chemical parameters of water samples from the different sample points and months are given in Tables 1 to 4. The investigation of the different parameters used in water quality assessment of any water body is an important aspect of water quality examination. It gives insight into the suitability of the water to its users whether domestic or industrial.

**Conductivity**

The conductivity values obtained from the different sample stations from the Ede Onyima Creek, ranged from 42.33 ± 6.46 – 78.75 ± 6.88 µS/cm. The monthly variations fall within 33.78 ± 6.17 µS/cm in August to 99.77 ± 14.16 µS/cm in February. The conductivity values obtained in the water from the creek were lower than the WHO and NAFDAC values of 500 to 1000 µS/cm. The conductivity values observed in the creek were low. This may have resulted from nature of the creek and the speed of the water current which determine the removal or retention of conducting species in the water environment [11].

The values of conductivities obtained in this work were higher than those obtained by Etim *et al*. [12] in stream water samples from a Niger Delta river and those observed in a small pristine stream in the Niger Delta [13], but lower than the values obtained from Nta-Wogba stream in Port Harcourt, Rivers State [14]. They are however, within the range of the values obtained in five rivers in Delta State, Nigeria [11].

The capacity of an aqueous solution to transfer electric current is known as Conductivity or electrical conductivity. This property of matter is dependent on the presence of such factors as the number of ions present, the temperature of the environment, the movement of ions and the valence. High conductivity value indicate the presence of high concentration of heavy metals within the environment.

**Total Dissolved Solids (TDS)**

The values of total dissolved solids obtained from the different stations in the creek ranged from 49.41 ± 5.12 - 70.84 ± 8.95 mg/L. The monthly variations of TDS creek ranged from 22.15 ± 3.32 in April to 75.61 ±7.72 in June. The values obtained in all the stations and months in the creek were below the WHO and NAFDAC requirement for drinking water. However, the results show higher TDS values in the wet periods than the dry periods. The range of values observed in this work in the surface water of the three rivers is in agreement with the values observed in five different rivers in Delta State [11]and Okoroette community in Eastern Nigeria [15]. Increase in TDS values may not be unconnected with contributions arising from surface runoffs from soil and increased turbulence of river flow that may have caused re-suspension of sediments [15-16]. In normal aquatic environment, TDS is predominantly the dissolved salts of metal ions such as carbonates, bicarbonates, chlorides, sulphates and phosphates [17].

**Total Suspended Solids (TSS)**

The concentrations of TSS in the creek varied from 17.61 ± 3.98 - 18.00 ± 4.03 mg/L. Variations of TSS in the creek within the sampled months ranged between 14.32 ± 2.76 in December to 22.48 ± 4.99 mg/L in June. All the values of TSS observed in this research were below the 500 mg/L recommended for drinking water by NAFDAC and WHO. The values observed in the creek were very low.

The observed values in this work are very low when compared to the 240 mg/L value observed in Iju River by Chinedu *et al*. [18], but higher than the values reported by Etim *et al*. [12], from different streams in Niger Delta and Osokpor *et al*. [19], in OMA fields.

The presence of high levels of total suspended solids has the capacity to block fish gills. At very high concentration, it can cause reduction in growth rate and death of aquatic animals. The amount of light that penetrates through water is reduced by high content of TSS and thus affecting the food production of algae and available oxygen. The importance of suspended particles in water lies in the fact that lethal compounds such as pesticides and metals get adsorbed unto them or forms a complex, thus reducing their toxic effects on plant and animals within the aquatic environment.

**Turbidity**

The values of turbidity in the creek in the different stations varied from 11.47 ± 2.46 - 12.14 ± 2.61 NTU. The variations of turbidity in the sampled months ranged from 7.82 ± 2.65 in December to 16.35 ± 2.88 NTU in August. The observed values of turbidity in both stations and months were above the Nigerian NAFDAC and WHO standard of 5.0 NTU for drinking water. The values of turbidity observed in this work were within the range reported by

Chinedu *et al*. [18] in Iju river, Ota South West Nigeria, but either lower or higher than the values reported by Nduka *et al*. [20] in some rivers within the Warri axis of Delta State, Nigeria.

The observations were higher in the wet months than the dry months. This increase may have resulted from the fact that runoffs from adjoining land and increased water or river currents which may have washed off the river banks into the rivers. Runoffs are associated with different combinations of substances or matter such as; microbes, colloids, suspended solids particles, organic and inorganic compounds, which slow down the amount of light rays that penetrate through the water [21]. High turbidity has the capacity to reduce the amount of dissolved oxygen that any water body can carry, because it absorbs the heat of the penetrating sunlight, thus increasing the temperature of the water system and releasing oxygen from the water. When the rays of the sun is prevented from passing through the water body, photosynthetic activities of aquatic plant is affected and also the food chain and food web of the ecosystem.

**Temperature**

The values of temperature obtained within the sampled stations in the creek fall within the range of 28.26 ± 0.34 - 28.31 ± 1.33$^{o}$C in the stations. The variation of temperature values fall between 28.14 ± 1.37 in June to 28.53 ± 0.19 $^{o}$C in December. The observed values of temperature in all the stations and months did not vary significantly (P>0.05). They all fall within the WHO and NAFDAC requirement for drinking water.

These values are in consonance with the observation of other authors within the same environment [22-23], but higher than the values of other authors elsewhere [24-25].

The temperature of any aquatic environment affects organisms' behaviour. A temperature variation in water causes a resultant change in the physicochemical characteristics of the water, which affects the physiological adaptation of organisms within the environment [22, 26]. Moreover, the assessment of the ecological factors or conditions of both biological and non-biological organisms to fit into the environment is temperature dependent. This is due to the fact that temperature has direct effect on the normal behavioural functions of an aquatic ecosystem [27] and the amount of dissolved gases eg oxygen, whose concentration can either be detrimental or important for migration, growth and death of water inhabiting animals and plants [28].

**Table 1:** Physical Parameters of Water Samples from Onyima Creek at the Different Stations

| **Physical Parameters** | **Stations** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| Conductivity (µS/cm) | 42.33 ± 6.46 | 44.41 ± 7.61 | 78.75 ± 6.88 |
| TDS (mg/L) | 53.37 ± 11.20 | 70.84 ± 8.95 | 49.41 ± 5.12 |
| TSS (mg/L) | 18.00 ± 4.03 | 17.61 ± 3.98 | 19.12 ± 4.28 |
| Turbidity (NTU) | 12.14 ± 2.61 | 11.47 ± 2.46 | 13.67 ± 1.56 |
| Temp. $^{o}$C | 28.30 ± 0.11 | 28.31 ± 1.33 | 28.26 ± 0.34 |

**Table 2:** Mean Monthly Variation of Physical Parameters of Water Samples from Kolo Creek

| **Physical Parameters** | **Months** | | | | | |
|---|---|---|---|---|---|---|
| | **December** | **February** | **April** | **June** | **August** | **October** |
| Conductivity (µS/cm) | 82.05 ± 12.07 | 99.77 ± 14.16 | 41.36 ± 8.17 | 39.59 ± 8.38 | 33.78 ± 6.17 | 34.42 ± 5.07 |
| TDS (mg/L) | 40.70 ± 6.83 | 68.05 ± 9.28 | 22.15 ± 3.32 | 75.61 ±7.72 | 70.36 ±8.98 | 70.38±10.33 |
| TSS (mg/L) | 14.32 ± 2.76 | 17.00 ± 3.60 | 16.86 ± 4.82 | 22.48 ± 4.99 | 19.79 ± 5.65 | 18.96 ± 4.24 |
| Turbidity (NTU) | 7.82 ± 2.65 | 9.48 ± 2.96 | 12.20 ± 3.56 | 14.52 ± 3.98 | 16.35 ± 2.88 | 14.19 ± 3.31 |
| Temperature $^{o}$C | 28.53 ± 0.19 | 28.21 ± 0.15 | 28.20 ± 0.54 | 28.14 ± 1.37 | 28.30 ± 0.16 | 28.37 ± 1.85 |

**pH**

The pH values of the water from the creek varied from 7.17 ± 2.01 - 7.42 ± 1.40 within the stations. The monthly variations in pH ranged from 6.60 ± 1.57 - 7.56 ± 2.35. The observed pH values in the water body examined were all within the WHO and NAFDAC value of 6.5 - 8.5 for drinking water. The observed values of pH fall within the range observed by other researchers [12, 14, 29] in the Niger Delta environment. The non-significant difference in the pH values obtained at the various stations and months suggested that input sources into the water bodies had no remarkable effect to change the pH of the water bodies [14]. Also, the flow nature and size of the rivers have the capacity to neutralize the effect of the inputs. pH is a vital factor that regulates the suitability of water for several

purposes [30]. Higher or lower values of pH than the recommended values are detrimental, because, they will either impart a bitter or sour taste to the water. Also, pH values determine the level of organic matter that will be present in that water and has negative consequences on corrosion of metal pipes and other water equipment [31]. When the pH level is high, it lowers the efficiency of disinfection through chlorination, thus demanding the use of extra chlorine or lengthier contact periods [17]. According to Edet *et al*. [32], the pH of most natural water bodies falls within the range from 6.5 to 8.5 (as observed in this work) and alterations outside this range is a consequence of carbon dioxide or bicarbonate input.

**Salinity**

The result obtained from the sampled stations in the creek varied from 30.33 ± 4.16 - 43.89 ± 6.36 mg/L. In the months of sampling, values of salinity observed ranged from 10.33 ± 2.64 in December - 53.65 ± 5.44 mg/L in June. The values obtained in the various stations and months were within the value range of 0 – 5% expected in any freshwater system. The salinity values observed in this work were higher than the values observed by Abowei [33] in Nkoro River, Niger Delta, Olomukoro [34], in the downstream of Warri River, William and Benson, [35] in Qua Iboe and Cross River estuaries of Akwa Ibom and Cross River States, Niger Delta and those of Mbah *et al*. [36] at point of use on Yenagoa River, Bayelsa State. Salinity is very important factor when considering ecological conditions. This is because it affects the type and species of plants and animals that dwell or inhabit the water environment and also affects the portability or use to which the water is applied.

**Dissolved Oxygen (DO)**

The result obtained from the different stations in the creek ranged from 5.33 ± 1.56 - 5.56 ± 0.95 mg/L. The variations of DO in the sampled months range from 3.77 ± 0.72 in February to 6.35 ± 2.20 mg/L in April in the creek. The observed values of DO in the various stations and months did not show any significant difference. The observed values of DO in the present work were lower than the standard requirement of 10 mg/L by the relevant agencies (WHO and NAFDAC). However, aquatic organisms require at least a value of 5.0 – 6.0 mg/L to function in any aquatic environment.

The values of DO observed in this work are in agreement with findings of Osokpor *et al*. [19] in OMA fields in Niger Delta who observed value range of 5.7 - 7.24mg/L and Ogolo *et al*. [37] who observed DO value range of 5.21 – 5.78 mg/L in tributaries of the New Calabar River, Rivers State, but were either lower or higher than the values observed by Rim-Rukeh [38] in different lakes and rivers of Niger delta.

The importance of DO lie in the fact that all life functions in aquatic environment need it for metabolism and aerobic respiration. The amount of DO found in water is a direct consequence of air diffusion and photosynthetic activity of aquatic plants. Another factor that has negative influence on DO concentration is direct discharge of waste and dead organic matter which when decaying make use of the available water oxygen. In adverse situations, the water body stinks or smells**.**

**Biochemical Oxygen Demand (BOD)**

In the creek, BOD values varied between 17.13 ± 3.01 - 18.74 ± 3.41 mg/L. Variations of BOD within the sampled months in the creek ranged from 13.31 ± 3.85 in December to 20.16 ± 3.92 mg/L in April. BOD values within the period of sampling at the stations and months were all higher than WHO and NAFDAC recommended value of 4.0 mg/L. The values of BOD observed in the present research are higher than those observed in OMA fields in Western Niger Delta [19], Ekpan River, Delta State [39], in New Calabar River [37], but are either higher or within the same range of values observed in different Niger Delta rivers [38].

The quantity of oxygen essential for microorganisms to break down or decompose organic substances or matter that is found in any aquatic medium (water, wastewater and discharged effluents) is known as biochemical oxygen demand. It can be used as a measure of surficial concentration of organic matter existing in water [40]. The data obtained from this work is an indication of environment influenced by gross organic pollutants. The high level of

BOD in these environments is attributable to such factors as; illegal oil bunkering activities (without due regard to proper effluent discharge regulations), direct source of waste discharge by the locals and agricultural activities. Seasonal variations which showed higher values during the rainy months probably resulted from runoffs and transport of dead organic materials from flooding.

**Chemical Oxygen Demand (COD)**

In the creek, COD values in the stations varied from 15.46 ± 3.48 - 17.10 ± 2.10 mg/L, while those of the sampled months fall between 11.32 ± 2.69 in August to 24.79 ± 5.66 mg/L in February. The observed values of COD in the creek in all the stations and months were higher than the set limit by NAFDAC and WHO for Drinking water. Higher wet month values observed in the present work are consistent with published works [19, 41].

The values of COD recorded in this work are higher than those observed by Dienye and Woke [41], in the lower reaches of New Calabar River and those of Osokpor *et al* [19] in OMA fields in Western Niger Delta. However, the values of COD observed in this work are lower than those observed in Bodo Creeks, Niger Delta [42].

Chemical oxygen demand, (COD) is a measure of the quantity of oxygen needed to degrade organic matter through acid oxidation to carbon dioxide and water that is present in the examined water sample.

**Chlorides ($Cl^-$)**

In the creek, chloride values in the sampled stations varied from 20.04 ± 3.75 - 32.33 ± 4.69 mg/L. The values observed in the months Creek for chlorides varied from 7.08 ± 2.98 mg/L in December to 34.82 ± 8.92 mg/L in August. The concentrations of chlorides observed in the creek were lower than the stipulated limit of 250 mg/L in drinking water by NAFDAC and WHO.

The observed values of chlorides in the samples were within the same range as those of Etim *et al*. [12], who obtained a value range of 12.00 – 18.47 mg/L in water samples from different streams in the Niger Delta, Nigeria and those of Nduka *et al*. [20] who observed a value range of 9.00 – 14.20 mg/L from seven different rivers in Warri area of Delta State, Nigeria. However, these values recorded in the present work were far lower than the value range of 319 – 9266 mg/L obtained in brackish water environments or rivers in Bayelsa State, Nigeria [43].

The observed alteration in the concentration values of chloride could be as a result of spacio-temporal and environmental forces and dynamics at work. Although, chlorine in its natural form (gas) is a known toxicant, but its ionic form, which is referred to as chloride ions are important for life and existence of plants and animals [44]. Increased chloride ion is always found in natural water, but high chloride concentrations is indicative of pollution from sewage, waste from industries or interference of seawater or salt water into fresh water aquifer [45]. The human body has the tendency to adapt to levels of chloride up to 200 mg/L. Salty taste due to chloride ion is observed in water when its concentration exceeds 250 mg/L [46].

**Nitrate ($NO_3^-$)**

In the creek, stations variations in nitrates concentrations ranged from 5.45 ± 0.91 - 5.87 ± 1.44 mg/L. The variation of nitrates in the months varied from 4.82 ± 1.17 in December to 8.12 ± 2.30 mg/L in February. The values of nitrates observed in the stations or locations in the creek were lower than the required value for drinking water by WHO (10 mg/L), NAFDAC (20 mg/L), CCME (13 mg/L) and ANZECC (0.017 -17 mg/L).

The concentrations of nitrates observed in this present work were higher than the values observed in Qua Iboe River in Akwa Ibom State and Cross River in Cross River State [12] and those of Sikoki and Anyanwu [13], in Onu-Iyi-Ukwu Stream in Niger Delta, Nigeria, but falls within the same range of values reported by Ihunwo *et al*. [47], in Anya-Ogologo River, Rivers State, Nigeria and those of Tony *et al*. [14] in Nta-Wogba Creek, Rivers State, Nigeria.

Nitrate is a component of any hydrologic environment. Excreted products or wastes of water dwelling organisms usually increase the level of nitrate within the aquatic habitat. This is due to high level of ammonia in the excreted waste, which is further converted to nitrate and nitrite through the action of specific microbes. Nitrate is an important eutrophic agent when present in high concentration in a river. Eutrophication causes decrease in the amount of oxygen that is dissolved in an aquatic environment. Low level of dissolved oxygen reduces the

effectiveness of the conversion of ammonia to nitrite and then to nitrate, leading to increased level of nitrite and ammonia in the water, thus creating a more toxic environment [48].

**Sulphate ($SO_4^{2-}$)**

The values or concentrations of sulphates observed in the sampled stations in the creek varied from 1.51 ± 0.02 - 1.85 ± 0.08 mg/L. The observed values of sulphate ions in the months varied from 0.61 ± 0.12 in December to 2.32 ± 0.12 mg/L in October. The observed values of sulphate in this work in all the sampled stations and months of investigation in the creek were lower than the WHO and NAFDAC value of 500 mg/L. The observed concentrations of sulphate in the present work were lower than the values obtained in a similar work in the Upper reaches of Orashi River [49], but agrees with those of Etim *et al*. [12] in two rivers within Niger Delta, Nigeria.

It is very difficult to remove sulphate from water, apart from distillation, reverse osmosis or electrodialysis which are very expensive methods. When it is present in water to a concentration range of 500 – 700 mg/L, it can cause serious health problems in humans. Sulphate add a little taste to water, but at values lower than 300mg/L, taste is not felt. The side effects of sulphate on human consumers include catharsis, loss of water from the body and intestinal disorder. These disorders have been associated with high levels of sulphate in portable water [45]. Sources of Sulphate in water include discharges from industrial wastes, mining activities, tanneries, paper production industries and from atmospheric precipitation. Extremely high levels of sulphate in water have the potential to reduce the pH of the water and thus cause a proliferation of bacterial growth in the water.

**Phosphate ($PO_4^{3-}$)**

The values of phosphate observed in the different stations in the creek varied from 14.03 ± 3.10 - 25.01 ± 4.23 mg/L. The variation of phosphate concentrations in the months in the creek varied from 3.32 ± 0.69 mg/L in December to 27.63 ± 6.69mg/L in June. The values of phosphate observed in the present work exceeded the WHO standard of 0.5 mg/L and the 10 mg/L NAFDAC value for domestic water use. The concentrations of phosphate observed in this work were higher than those observed by Olatunji and Osibanjo [50], in lower and upper reaches of River Niger, North Central Nigeria, Kaizer and Osakwe [11] in five different rivers in Delta State, Nigeria and those observed by Ogamba and Ebere [51], in parts of Kolo Creek, Bayelsa State, Nigeria.

Phosphate is a major factor responsible for eutrophication of aquatic environment. Living organisms require phosphate for proper growth and functioning. Cell bound phosphates set-up energy produced from eating food and remove it to where they are required to perform locomotive, reproductive, and developmental activities. It is the building block of high energy compounds, which give cell proper functioning. When dissolved phosphates combine with suspended particles in water, it increases turbidity, thereby reducing the amount of light that penetrates through the water.

**Table 3:** Chemical Parameters of Water Samples from Onyima Creek at the Different Stations

| **Chemical Parameters** | **Stations** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| pH | 7.36 ± 1.52 | 7.17 ± 2.01 | 7.42 ± 1.40 |
| Salinity (mg/L) | 30.33 ± 4.16 | 43.89 ± 6.36 | 36.18 ± 5.12 |
| DO (mg/L) | 5.35 ± 1.14 | 5.33 ± 1.56 | 5.56 ± 0.95 |
| BOD (mg/L) | 18.13 ± 2.60 | 18.74 ± 3.41 | 17.13 ± 3.01 |
| COD (mg/L) | 15.46 ± 3.48 | 17.10 ± 2.10 | 16.82 ± 3.21 |
| $Cl^-$ (mg/L) | 20.04 ± 3.75 | 32.33 ± 4.69 | 23.23 ± 5.95 |
| $NO_3^-$ (mg/L) | 5.45 ± 0.91 | 5.45 ± 1.12 | 5.87 ± 1.44 |
| $SO_3^{2-}$ (mg/L) | 1.85 ± 0.08 | 1.51 ± 0.02 | 1.54 ± 0.03 |
| $PO_4^{3-}$ (mg/L) | 14.03 ± 3.10 | 18.29 ± 4.82 | 25.01 ± 4.21 |

**Table 4:** Mean Monthly Variation of Chemical Parameters of Water Samples from Kolo Creek

| **Chemical Parameters** | **Months** |
|---|---|

| | December | February | April | June | August | October |
|---|---|---|---|---|---|---|
| pH | 6.60 ± 1.57 | 7.36 ± 2.01 | 7.34 ± 2.53 | 7.50 ± 1.70 | 7.56 ± 2.35 | 7.54 ± 2.61 |
| Salinity (mg/L) | 10.33 ± 2.64 | 53.01 ± 7.43 | 16.87 ± 1.61 | 53.65 ± 5.44 | 46.51 ± 4.64 | 40.44 ± 5.43 |
| DO (mg/L) | 5.09 ± 1.20 | 3.77 ± 0.72 | 6.35 ± 2.20 | 5.69 ± 1.22 | 5.68 ± 1.31 | 5.88 ± 0.88 |
| BOD (mg/L) | 13.31 ± 3.85 | 16.71 ± 4.55 | 20.16 ± 3.92 | 19.20 ± 4.80 | 19.74 ± 3.56 | 18.89 ± 4.41 |
| COD (mg/l) | 20.57 ± 4.49 | 24.79 ± 5.66 | 14.78 ± 3.87 | 13.63 ± 3.68 | 11.32 ± 2.69 | 13.60 ± 2.92 |
| $Cl^-$ (mg/L) | 7.08 ± 2.98 | 32.38 ± 7.92 | 14.21 ± 3.65 | 33.04 ± 6.82 | 34.82 ± 8.92 | 29.67 ± 4.98 |
| $NO_3^-$ (mg/L) | 4.82 ± 1.17 | 8.12 ± 2.30 | 5.38 ± 1.16 | 5.22 ± 1.17 | 5.09 ± 1.36 | 4.91 ± 0.97 |
| $SO_3^{2-}$ (mg/L) | 0.61 ± 0.12 | 1.60 ± 0.01 | 0.98 ± 0.11 | 2.21 ± 0.08 | 2.07 ± 0.28 | 2.32 ± 0.12 |
| $PO_4^3$- (mg/L) | 3.32 ± 0.69 | 4.04 ± 1.16 | 3.75 ± 0.96 | 27.63 ± 6.69 | 22.98 ± 5.59 | 25.46 ± 4.54 |

## Conclusion

The study revealed that the quality of the creek water has been compromised and therefore not suitable for human use. This is predicated on the fact that all the gross organic pollutants (DO, BOD and COD), phosphates and turbidity were at levels beyond stipulated guidelines for human consumption. It also showed that both human and natural factors may have affected most of the parameters, bearing in mind the increase in value of majority of the parameters during the rainy months. Therefore, communities settled along the coast should discontinue from consuming the water from the creek and government on their part put up regulatory activities to prevent further decay of the creek water and put up remedial process to reinstate the original state of the water.

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