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Physical and chemical characteristics of water from Okamini Stream, Obio/Akpor, Rivers State, Niger Delta, Nigeria

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Abstract

Water samples were collected from Okamini stream and analyzed for some physicochemical parameters. The values showed that electrical conductivity, total dissolved solids, total suspended solids, chlorides, sulphates, nitrates and phosphates were within the range of values acceptable for domestic water use by WHO. Others such as turbidity, pH and salinity were not within acceptable range in water for human consumption. Although, the water from the stream at the time of evaluation may not be at an alarming situation, but calls for adequate surveillance and protection to avert possible decay that looks eminent.

Keywords: Water; physicochemical characteristics; Environment; Pollution Control; River System

1. Introduction

Aquatic environments in the past few years have been subjected to deleterious environmental attack. This attack is due to the rising number of population, rise in industrial activities and human quest for monumental arts (Kinsiclounon *et al*., 2013). Deterioration of water bodies is an issue that is presently worrisome, especially among city dwellers, since the provision, distribution and maintenance of water within the requirement for quality uses and maintenance of sanitation infrastructure is relatively scares when compared to human population and spread (Edori and Edori, 2021a).

The value given to any river water is dependent on the worth of nourishing sources. These natural nourishing sources are superficial runoff water, glaciers, wetland, rainfall and ground water seepages, and nature of discharged liquid waste from homes and industries and size of population living within the immediate environment (Al-Zubaidi, 2012). The term quality of water mostly talk about to the constituent of water that is desired at the optimal level for the development of plants and animals. The quality of water is affected by different environmental dynamics such as pH, temperature, opacity or turbidity, amount of nutrients, hardness, alkalinity and the amount of oxygen present in water (Edori, 2020).

The assessment of physicochemical parameters are necessary to ascertain the level to which the quality of water can be appreciated by individuals, homes and cooperate bodies. Also they are readily available tools to determine the level of water acceptability for consumption and irrigation purposes (Solomon and Kehinde, 2017; Banunle *et al*., 2018). Under natural conditions river system, the different chemical constituents that may be present in water usually occur at very low concentration. However, these concentrations are raised when there is an upsurge of population growth, urban drift, enlargement of industrial activities, taking of undue advantage of natural resources, absence or weak environmental regulatory laws and intense use of the water for irrigation (Mehedi *et al*., 1999).

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Plants and animals which dwell in water require a healthy environment to inhabit which can equally provide the necessary food and mineral requirement for growth. For optimum aquatic productivity, there must be a corresponding balance in the characteristic constitution of the physicochemical components of the water (Onyegeme-Okerenta *et al*., 2016). Therefore, when considering the quality of water for maximum output, the physicochemical parameters cannot be neglected. This is the reason that in pollution control and management, water quality is very important (Kamal *et al*., 2007; Adewuyi *et al*., 2017).

This research, therefore investigated the levels of some physicochemical parameters in Okamini Stream, an important water source for rural communities in Egbelu and Elioparanwo communities in Obio/Akpor local Government Area of Rivers State, Nigeria.

2. Materials and methods

Sampling of water was done in the morning period between 7:00-8:00 am. Water sampling was done at three different positions with plastic vials, which had been previously washed and dried. The depth of water sampling was maintained at 20 cm below the water surface and covered immediately. The obtained samples were placed in iced packed vessel and moved to the laboratory where the analysis were carried out. Sampling was done in January and March.

The conductance of the water samples and total dissolve solids (TDS) were determined on site using a portable hand-held meter (Mettler Toledo MC-226). The meter has selections buttons which represents each of the parameters. When the probes are inserted into the water samples, the meter reads of the conductivity or the total dissolved solids depending on the button pressed. Reading were taken after the meter has stabilized for at least five seconds. The photometric method was used to measure the turbidity of the water samples. This was achieved through the passage of a stream of light through the water and light which scattered at right angles to the stream of light were measured photometrically. The total suspended solids (TSS) were measured by first recording the weight of a filter paper and thereafter, the water was passed through the filter paper and the filter paper was allowed to dry to constant weight. The increase in weight was taken as TSS (Bertram and Balance, 1996).

The Thermo Orion pH meter was used to measure the water pH on site. The procedure follows the manner which conductivity and TDS were measured. The method of Cataldo *et al*. (1985) was used to analyze nitrate concentrations. A volume of water 2 mL and 8mL (5% w/v) salicylic acid in concentrated sulphuric acid were mixed together and put in 250 mL conical flask and kept standing for twenty minutes. A volume of 190 mL of 2M sodium hydroxide were slowly dropped into the mixture until the pH was raised beyond 12 and allowed to cool. The proportion of the nitrate sample to salicylic acid-H_2SO_4 was maintained at 1:3 (v/v). The absorbance of the nitrate spectrophotometrically evaluated at a wavelength of 410 nm and concentrations determined through calibration curve.

To determine the concentration of phosphates in the water samples, the method of APHA (1995) was used. To a clear colourless water of 100 mL volume was added a drop of 0.05 mL phenolphthalein indicator. Further added to this mixture was 2 drops of 2M sulphuric acid and a pink colour was formed. Drops equal to 4 mL molybdate and 0.5 mL of stannous chloride were mixed together and allowed to react. The mixed solutions were left standing for 11 min. Thereafter, the concentrations of phosphates were determined with a Spectrophotometer (Model 752 Shimadzu, Japan) at a wavelength of 690 nm.

3. Results and Discussion

The physical characteristics of water from Okamini Stream are given in table 1. The electrical conductivity of the various stations along the stream varied from 27.5-38.0 μS/cm and a mean value of 31.87±4.46 μS/cm in January. The values observed in March varied from 29.2-40.3 μS/cm and a mean value of 34.67±4.50 μS/cm. The conductance values observed in the river were lower than the WHO value of 500 μS/cm. The values of conductivity from the present work is lower than values observed in Silver River, Bayelsa State, Nigeria (Edori *et al*., 2019) and also lower than the values observed in Mini-Whuo, Eliozu, Obo/Akpor, Rivers State (Allison *et al*., 2020), and were within the range of values observed in Onyima Creek, Engenni, Rivers State (Edori, 2020), but higher than the values observed at effluents discharge points along the mangrove stretch of New Calabar River, Rumuolumeni, Port Harcourt, Rivers State (Edori and Nna, 2018). Conductivity measures the ability with which aqueous solutions transmits electricity. This is based on the mobility rate of a number of current carrying species available in the medium, the environmental temperature, the nature and type of ions present and the charges of the species present (Sharma and Walia, 2017). When conductivity is high, it can be inferred to have resulted from elevated concentration of heavy metals in the water (Edori, 2020). Conductivity of an important factor when considering the number of dissolved ionic species or electrolytes in water and also play a role the examination of hardness and alkalinity of water. According to Karato and Wang (2013), ions of sodium, potassium and chloride enhances conductance of water and are associated with mining pollution and or other elated anthropogenic interference. The low conductance of the water from the stream may be interpreted from the angle of low anthropogenic influence or that the associated influence may not be related to input of conductivity enhancers. This observation is in agreement with those of Banunle *et al*., 2018).

The turbidity values observed in the stream varied from 6.95 - 18.48 NTU and a mean value of 11.67±4.91 NTU in January and 7.42- 25.61 NTU with a mean value of 14.80±7.81 NTU in March. All the values observed at the various stations and months were higher than the 5.0 NTU value stipulated for turbidity in domestic water use. The turbidity values observed in Okamini Stream was lower than the values of Onyegeme-Okerenta *et al* (2016) in Otamiri-oche River in Etche, River State, Nigeria and also lower than those of Banunle *et al* (2018) in Tano River situated along the Ahafo Mine, Brong-Ahafo, Ghana. However, these values are slightly lower than the values recorded in Jabi Stream, Abuja, Nigeria (Solomon and Kehinde, 2016) and also those of Fellman *et al* (2015) in two streams in Alaska, USA.

Increase in turbidity above the threshold value is related to release of wastewater from industries and from sand dredging (Iyama and Edori, 2013; Onyegeme-Okerenta *et al*., 2016), which re-suspends sediment particles to surface water due to disturbance. Another cause of turbidity increase in water is due to transportation of solid waste and top soil particles as a result of runoffs (Okeke and Adinna, 2013; Edori and Nna 2018), the transparency or opacity of water impacts on fish and other aquatic life negatively. The effect is a result interference of the turbid particles with sunlight penetrating through the water. Another contributor to turbidity of water is the presence of high level of chlorophyll. Although turbidity may not a major source of health concern, but it is related to lake eutrophication, aesthetics, disinfection and medium for microbial growth, through supply of nutrients available from the turbid particles.

The levels of total dissolved solids (TDS) in Okamini Stream varied from 13.27 - 15.41 mg/L and a recorded mean value of 15.04±1.31 mg/L in January. In the March, the values varied from 14.55 - 20.11 with a mean value of 17.56±2.29 mg/L. Stations and months values recorded were low when compared to WHO value of 500 mg/L. The values of TDS in the present study is lower than those of Kamal *et al* (2007) in Mouri River, Bangladesh, those of Solomon and Kehinde (2016) in Jabi Stream, Abuja Nigeria and those of Banule et al (2018) in Tano River, Ahafo, Ghana. However, the measured values in the present study are higher than the values observed in Elelenwo River, Rivers State, Niger Delta, Nigeria (Edori *et al*., 2020)

The evaluation of the status of water based on TDS take into consideration the levels of organic and inorganic that is present in the water solution (Rahmanian *et al*., 2015). The magnitude of aquatic pollution is a function of amount of dissolved solids existent. It was observed that the values of TDS was slightly higher in March when compared to January. This situation is not unconnected with the beginning of rainfall in March, which through runoffs carry soluble particle from the adjoining lands to the stream. This observation is inconsonance with thee observation of (Abdar, 2013). The importance of TDS as a water parameter cannot be undermined because it controls both biotic and abiotic conditions of water system and also very vital when considering treatment procedures (Thirupathaiah *et al*., 2012).

The values observed for total suspended solids (TSS) in the stream varied from 4.95 - 6.51 mg/L and a mean value of 5.57±0.68 mg/L in January, while the values for March varied from 6.48 - 10.22 mg/L and a mean value of 8.31±1.53 mg/L. These values are lower than the WHO recommended value of 500 - 1000 mg/L. The value of TSS in the present work is within the range of values observed in Kalaigidama and Basambio Creeks, Ke, Rivers State, Nigeria (Vincent *et al*., 2020), but higher than the values of Atwebembeire *et al* (2018) in River Rwizi, South Western Uganda.

Total suspended solids is a parameter that is linked to turbidity of water. Increase in TSS is directly proportional to turbidity of water (Edori *et al*., 2019). Turbidity of water is influenced by human induced factors which include land tilling and other forms of land loosening, which enhances erosion and transportation of surface soil particles into the stream through runoffs (Songa *et al*., 2015). Natural enhancer of TSS are algae and re-suspended particles of silt and sediments. The major causes of re-suspension of sediment particles include turbulent movement of water and disturbance of shallow water through boat engines. At elevated levels, TSS introduces smell, colour and taste to water (Edori and Nna, 2018).

The chemical characteristics of water from Okamini Stream is give in Table 2. The pH of the waterbody in January varied from 5.60 - 5.63 and a mean value of 5.64±0.03. In March, the observed range fall between 5.80 - 6.42 and a mean of 6.18±0.27. These values are lower than the required value for drinking water by WHO, which is in the range of 6.5 – 8.5.

The results of pH in the Okamini Stream is in consonance with the observation of (Onyegeme-Okerenta *et al* (2016) in Otamirioche River in Etche, Rivers State, Nigeria, where the pH values were in the acidic range. The acidic nature of the water from Okamini Stream is not unconnected with slow flowing nature due to tidal effects which allows organic waste to remain at a position for a long time and therefore continue to add up. This cannot be farfetched because of the presence of waste dumps, abattoir and fish farms along the stream coupled with drainage discharge point that discharges directly to the stream. According to Keith (2013), aerobic organisms which degrades organic wastes produces carbon dioxide, which solubilize in water to produce carbonic acid, thus keeping the water in acidic form.

Table 1 Physical Characteristics of Water Samples from Okamini Stream

January				
Physicochemical Parameters	**Stations**			**Mean±SD**
	1	**2**	**3**	
Electrical Conductivity (μS/cm)	27.5	38.0	30.1	31.87±4.46
Turbidity (NTU)	6.95	18.48	9.57	11.67±4.91
Total Dissolved Solid (mg/L)	13.27	15.40	16.41	15.04±1.31
Total Suspended Solid (mg/L)	4.95	6.51	5.24	5.57±0.68
March				
Electrical Conductivity (μS/cm)	29.2	40.3	34.5	34.67±4.50
Turbidity (NTU)	7.42	25.61	11.38	14.80±7.81
Total Dissolved Solid (mg/L)	14.55	18.01	20.11	17.56±2.29
Total Suspended Solid (mg/L)	6.48	10.22	8.22	8.31±1.53

Adequate aquatic pH is necessary for all human industrial, domestic and physiological activities. Its importance is based on the fact that several chemical and biological processes is related to the pH of the system, of which when it is at the extreme causes a lot of physiological impairment and damage to manufacturing equipment. Most changes in aquatic pH is caused by presence of industrial contaminants, pollutants and or agents, photosynthesis and respiration of algae which feeds on the contaminants (Dorleku, 2013).

Salinity values in the stream fall between 20.63 - 27.20 mg/L and a mean of 23.75±2.69 mg.l in January, while March values fall between 19.68 - 26.32 mg/L and 22.65±2.76 mg/L. The observed values for salinity in the Okamini Stream is higher than 0.5 mg/L for freshwater environment. The values observed for salinity indicated that water is in the brackish category.

Salinity can be used to define the amount of salt present in a medium. High salinity increases the density of water and lead to water stratification (Edori *et al.*, 2020). The amount of salts present in water (ie level of salinity) enables fast deterioration of manufacturing and structural equipment. This is due to the ability of the saline water to provide charged species thus creating room or medium of electron movement and exchange, thus causing oxidation-reduction reaction into play within the equipment on contact. High salinity discourages some biotic processes. For example, some fishes migrate away from salty environment, worms and leeches do not in any way come in contact with saline environment or else instant death is recorded and at extreme levels affects the osmotic behaviour of some aquatic plants and animal and lead to death of such if the situation is prolonged. Thereby causing changes to natural biodiversity of aquatic vegetation and fauna (water ecologies) (Godfrey, 2000).

Chloride values in the examined aquatic environment fall in the range of 12.5 - 18.0 mg/L in and a mean value of 14.90±2.30 in January, while the values observed in March ranged from 14.25 - 20.11 with a mean of 17.30±2.40 mg/L. The observed values in stations and months were lower than the 250 mg/L recommended by WHO. The chloride level observed in the present work is higher than the values observed in Sombreiro River, Ahoada, Rivers State, Nigeria (Iyama *et al.*, 2014) and also higher than the values observed in Orashi River, in the Engenni Axis, Rivers State, Nigeria (Edori and Edori, 2021b).

The presence of influence of brackish water from the New Calabar River may have influenced the salinity of the stream under study. When the level of chloride is high in water, it promotes conductance behavior of the water and also enhances the corrosivity of the water on metallic materials (Gregory, 1990). The presence of chlorides in surface water results from different sources such as sediment re-suspension of chloride containing particles, manure and sewage discharges and industrial wastes (Gregory, 1990). The stream may have received chlorides input outside tidal incursions from discharge of agricultural wastes from nearby slaughter house, direct sewage and solid waste discharge and leached effluents from the dumpsite by the streamside.

Table 2 Chemical Characteristics of Water from Okamini Stream in January

January				
Chemical Parameters	**Stations**			**Mean±SD**
	1	**2**	**3**	
pH	5.60	5.63	5.68	5.64±0.03
Salinity (mg/L)	20.63	27.20	23.43	23.75±2.69
Chloride (mg/L)	12.5	18.0	14.2	14.90±2.30
March				
pH	5.80	6.33	6.42	6.18±0.27
Salinity (mg/L)	19.68	26.32	21.94	22.65±2.76
Chloride (mg/L)	14.25	20.11	17.55	17.30±2.40

The concentrations of the nutrient parameters in the water are given in Table 3. Nitrate concentrations ranged from 8.43 - 9.82 mg/L and the mean was 9.27±0.60 mg/L in January, while the range of values observed in March ranged from 8.57 – 9.91 mg/L and 9.30±0.55 mg/L as the mean value in March. The concentrations of nitrates in the stream is within the 10 mg/L value recommended by WHO. Nitrates in the present work were higher than those of Edori *et al* (2020) in Elelenwo River, Rivers State, Nigeria, higher than the values observed in streams and rivers in Abakaliki, Ebonyi State (Omaka *et al*., 2013), Nigeria and also higher than the values observed in Otamiri-oche River in Etche, Rivers State, Nigeria (Onyegeme-Okerenta *et al*., 2016).

Redox reactions in water undergone by ammoniacal nitrogen and nitrites give rise to nitrates in water. Another source of nitrates in water is through death and decay of organic matter and some inorganic processes which occur in river system. Application of nitrogen based fertilizers on nearby farmlands, which are washed in water bodies is another contributory factor of water nitration (USEPA, 2012). When nitrates is increased in water, the likely effects include decreased quantity of available oxygen in water, eutrophication and blue baby syndrome disease in children (methemoglobin) which use up oxygen in children.

The values observed in the water for sulphate ranged from 43.64 - 48.62 mg/L and 46.04±2.04 as the mean content in January, while March values ranged from 47.33 - 50.29 mg/L and a mean value of 48.39±1.34 mg/L. The recorded values of sulphate in the water were within the 45-50 mg/L recommended by WHO. However, these values are higher than those of Onyegeme-Okerenta *et al* (2016) in Otamiriri-Oche Stream, Etche, Rivers State, Nigeria and those of Solomon and Kehinde, (2017) in a fast moving stream in Jabi, Abuja, Nigeria. The values recorded in this research is lower than those of Edori *et a*l (2018) in New Calabar River at drainage releasing areas, Port Harcourt, Nigeria.

Sulphate contribute to water acidity if present at high concentration. Although it is not considered as a very toxic matter in water, yet it is related to different physiological effects when consumed above required concentrations (Omaka *et al*., 2014). These conditions include purgation, lack of fluids in the body and abdominal irascibility. At levels above 500 mg/L in domestic water, urgent action is required to remove it otherwise it will be disastrous health wise to consumers after short time intake (Bertram and Balance, 1996). Mining activities, manufacturing processes, paper milling and tanneries are major contributors of sulphate in water medium (Andrews *et al*., 2004 Edori and Edori, 2021b). Discharged sulphur dioxide during combustion processes reacts with oxygen in the atmosphere to form sulphuric acid, which is precipitated during rainfall back to the river of soil. Extremely elevated values of sulphate lead increased acidity of the water and increase bacterial bloom, for example, sulphate reducing bacteria (Edori and Edori, 2021b).

The values observed in the water for phosphate in the water from Okamini Stream ranged from 0.272 - 0.524 and a mean of 0.424±0.11 mg/L. The values observed in March ranged from 0.361 - 0.513 mg/L and a mean of 0.458±0.07 mg/L. The observed phosphate values were within the 0.5 mg/L requirement for domestic water use.

One of the major causes of lake-eutrophication is phosphate, which supply nutrients to microorganisms that culminates in algal bloom. (Wagner, 1974; Omaka *et al*., 2014). Phosphorous as an important element required for plant growth is often applied in farms for maximum yield. However they are sometimes carried to water bodies through runoffs and as such becomes deleterious to organisms and the general aquatic ecology. Phosphates in water combines with suspended particles to increase turbidity. Furthermore, due to its support for algal growth, the more algae present in water the more turbid the water is likely to be. Phosphate presence in water occasioned with a resultant decrease in the oxygen content or carrying capacity of the water, clog up the waterways, leading to decreased oxygen content and therefore death of living organisms (Katoski, 1997).

Table 3 Nutrient Characteristics of Water from Okamini Stream in January

January				
Nutrient Parameters (mg/L)	**Stations**			**Mean±SD**
	1	**2**	**3**	
Nitrate	9.82	8.43	9.56	9.27±0.60
Sulphate	43.64	48.62	45.86	46.04±2.04
Phosphate	0.476	0.272	0.524	0.424±0.11
March				
Nitrate	9.91	8.57	9.42	9.30±0.55
Sulphate	47.33	50.29	47.56	48.39±1.34
Phosphate	0.361	0.513	0.501	0.458±0.07

4. Conclusion

The physicochemical parameters examined in the Okamini Stream in Obio/Akpor, Rivers State showed that the water is not suitable for consumption. However, the values obtained generally showed danger signals in the immediate, but there is the likelihood that the situation might get worse in the near future of the conditions around the stream are not put under serious check or complete removal.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest existed between the authors.

References

[1] Abdar MR. Physicochemical characteristics and phytoplankton of Morna Lake, Shirala (MS) India. *Biolife.* 2013; 1: 1 -7.

[2] Adewuyi GK, Badejo OT, Idowu FF, Ogunjobi GA, Gbopa AO. Analysis of physico-chemical parameters: an empirical study of Yewa River Ogun and part of Badagry Creek, Lagos, Southwest Nigeria. *International Journal of Hydrology*. 2017; 1(7): 202–211.

[3] Allison IR, Obunwo CC, Cookey GA, Bull OS. Determination of the water quality index (WQI) of a fresh water stream (Mini-Whuo) Eliozu, Rivers State, Nigeria. *Journal of Chemical Society of Nigeria.* 2020; 45(5): 825-834.

[4] Al-Zubaidi HAM. Effect of heavy metals in wastewater effluents of Textile factory-Hilla on the characteristics of Hilla River. *Journal of Kerbala University – Science*. 2012; 10(3): 5-16.

[5] Andrews JE, Brimblecombe P, Jickells TD, Liss PS, Reid B. An introduction to environmental chemistry. 2nd Edition. UK: Blackwell Science Ltd. 2004.

[6] APHA - American Public Health Association. Standard methods for the examination of water and waste water. 19th Edition. Washington, DC: APHA. 1995.

[7] Atwebembeire J, Bazira J, Kagoro G Yatuha J, Andama M, Bunny JL. The physico-chemical quality of streams and channels draining into River Rwizi, South Western Uganda. *Journal of Water Resource and Protection*. 2018; 10: 817-845.

[8] Banunle A, Fei-Baffoe B, Otchere KG. Determination of the Physico-Chemical Properties and Heavy Metal Status of the Tano River along the Catchment of the Ahafo Mine in the Brong Ahafo Region of Ghana. *Journal of Environmental and Analytical Toxicology*. 2018; 8(3): 574.

[9] Bertram J, Balance R. A Practical guide to the design and implementation of freshwater, quality studies and monitoring programmes. United Nations Environmental Programme (UNEP) and World Health Organization (WHO), E & FN Spoon Publishers. 1996; 172–177, 192–196.

[10] Cataldo DA, Maroon M, Schrader LE, Youngs VL. Rapid colorimetric deter- mination of nitrate in water by nitration of salicyclic acid. *Communication in Soil Science and Water Analysis.* 1985; 6(1): 71–80.

[11] Dorleku M. Groundwater contamination with toxic metals through small scale mining within the Lower Pra Basin. Master's Thesis, University of Ghana, Legon, Ghana. 2013.

[12] Edori OS. Physical and Chemical Characteristics of Water from Ede Onyima Creek, Okarki-Engenni, Rivers State, Nigeria. *Chemistry Research Journal*. 2020; 5(3): 144-154.

[13] Edori OS, Edori ES. Geochemical Index, Ecological Risk and Enrichment Factor of Heavy Metals in Sediment at Drainage Discharge Points into the New Calabar River, Rivers State Niger Delta, Nigeria. *The Pharmaceutical and Chemical Journal*. 2021a; 8(1): 9-17.

[14] Edori OS, Edori ES. Evaluation of Physicochemical Characteristics of Surface Water from Orashi River, Rivers State, Southern Nigeria. *Athens Journal of Sciences*. 2021b; 8(2): 105-122.

[15] Edori OS, Iyama WA, Amadi MC. Variation of Some Physicochemical Parameters of Surface Water of Elelenwo River, Rivers State, Niger Delta, Nigeria. *International Journal of Research and Scientific Innovation*. 2020; 7(5): 230-235.

[16] Edori OS, Kieri BSI, Festus C. Physicochemical Characteristics of Surface Water and Sediment of Silver River, Southern Ijaw, Bayelsa State, Niger Delta, Nigeria. *American Journal of Environmental Science and Engineering*. 2019; 3(2): 39-46.

[17] Edori OS, Nna PJ. Determination of Physicochemical Parameters of Effluents at Discharge Points into the New Calabar River along Rumuolumeni axis, Niger Delta, Nigeria. *Journal of Environmental and Analytical Toxicology*. 2018; 8(3).

[18] Fellman JB, Hood E, Dryer W, Pyare S. Stream physical characteristics impact habitat quality for pacific salmon in two temperate coastal watersheds. *PLoS One*. 2015; 10(7): e0132652.

[19] Gregory R. Galvanic corrosion of lead solder in copper pipework. *Journal of the Institute of Water and Environmental Management.* 1990; 4: 112-118.

[20] Godfrey I. Physical and chemical characteristics of major aquatic ecosystems in the Victoria and Kyoga Lake basin. In: Ogutu-Ohwayo, R. and Ndawula, L Eds on Biodiversity of Lake Victoria: its conservation and sustainable use. Jinja, Uganda. 2000.

[21] Iyama WA, Edori OS. Water quality index estimate for Isiodu River water during dredging in Niger Delta, Nigeria. *Global Journal of Pure and Applied Sciences*. 2013; 19: 163-167.

[22] Iyama WA, Edori OS, Ikpe S. Study of pollution levels in Ahoada-Ihuaba axis of Sombreiro River, Ahoada Rivers State, Nigeria. *International Research Journal of Pure & Applied Chemistry.* 2014; 4(4): 378-387.

[23] Kamal D, Khan AN, Rahman MA, Ahamed F. Study on the physicochemical properties of water of Mouri River, Khulna, Bangladesh. *Pakistan Journal of Biological Sciences*. 2007; 10(5): 710–717.

[24] Karato SI, Wang D. Electrical conductivity of minerals and rocks. Physics and Chemistry of the Deep Earth. 2013; 145-182.

[25] Keith B. Physiochemical parameters of water. 2nd edition, Oxford University press. 2003; 3-6.

[26] Kinsiclounon GE, Edorh PA, Guedenon P, Senou M, Deguenon Y, Akpovi C, Loko F, Boko M, Gbeassor M, Creppy E E. Risks of contamination of drillings water with toxic metals accumulated in sediments of Nokoué Lake in Benin. *Merit Research Journal of Environmental Science and Toxicology*. 2013; 1(4): 91- 98.

[27] Kotoski EJ. Information on Phosphorus Amounts & Water Quality Environmental Impact. Spring Harbor Environmental Magnet Middle School. 1997; 1-4.

[28] Mehedi MY, Kamal D, Azam K, Khan YSA. Trace metals in coastal water along the ship breaking area, Chittagong, Bangladesh. *Khulna University Studies*. 1999; 1: 289-293.

[29] Nduka JK, Orisakwe OE, Ezenweke LO. Some physicochemical parameters of potable water supply in Warri, Niger Delta area of Nigeria. *Scientific Research and Essay*. 2008; 3(11): 547–551.

[30] Okeke PN, Adinna EN. Water quality study of Otamiri Otamiri-oche River in Owerri, Nigeria. *Universal Journal of Environmental Research and Technology*. 2013; 3(6): 641-649.

[31] Omaka ON, Nwabue FI, Itumoh EJ, Oroke EC, Igwe DO. Physicochemical parameters and nutrients variations of streams and rivers in Abakaliki, Ebonyi State, Nigeria. *Global Nest Journal*. 2014; 16(1): 114-123.

[32] Onyegeme-Okerenta BM, Obia C, Wegwu MO. Physicochemical properties of water quality of Imeh, Edegelem and Chokocho communities located along Otamiri-oche River in Etche Ethnic Nationality of Rivers State, Nigeria. *Journal of Applied Science and Environmental Managemen*t. 2016; 20(1): 113 – 119.

[33] Rahmanian N, Ali SHB, Homayoonfard M, Ali NJ, Rehan M, Sadef Y, Nizami AS. Analysis of Physiochemical Parameters to Evaluate the Drinking Water Quality in the State of Perak, Malaysia. *Journal of Chemistry*. 2015.

[34] Sharma N, Walia YK. Water quality investigation by physicochemical parameters of Satluj River (Himachal Pradesh, India). *Current World Environment*. 2017; 12: 174-180.

[35] Solomon RJ, Kehinde OA. Physicochemical properties of a flowing stream in Jabi, Abuja, Nigeria. *Direct Research Journal Biology Biotechnological Science*. 2017; 3(1): 24-29.

[36] Songa P, Rumohr J, Musota R. Policy and Institutional Framework Considerations in the Implementation of Catchment-Based Water Resources Management in Uganda: Highlights from the River Rwizi Catchment. *WIT Transactions on Ecology and the Environment*. 2015; 196: 15-26.

[37] Thirupathaiah M, Samatha C, Sammaiah C. Analysis of water quality using physicochemical parameters in lower Manair reservoir of Karimnagar district, Andhra Pradesh. *International Journal of Environmental Sciences*. 2012; 3: 369-378.

[38] United State Environmental Protection Agency (USEPA). Drinking water standard and health advisories. 2012; 3 – 4

[39] Vincent DA, Ugbomeh AP, Nwabueze E. The physico-chemical parameters of Kalaigidama and Basambio Creeks, Ke in Rivers State, Nigeria. *African Journal of Environment and Natural Science Research*. 2020; 3(2): 13-21.

[40] Wagner RH. Environment and man. New York: W.W. Norton and Company. 1974.