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Effects of Anthropogenic Activities on the Surface Water Quality of Idim Esiere Ebom Stream in Calabar South Lga, Cross River State, of Nigeria

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ABSTRACT

The Idim Esiere Ebom Stream is a major source of freshwater in Garden street, Calabar South LGA of Cross River State, Nigeria, as well as a spring of potable water to the residents. However, there is the dearth of scientific information on the water quality of the stream; Thus, the need to evaluate its water quality. To this end, the effects of the physicochemical characteristics of the water quality and some heavy metals of the surface water and sediments of the Idim Esiere Ebom stream were studied. In this study, samples of the surface water and sediments were collected from 5 different stations of the stream monthly for 6 months (March-August) representing early wet (EW) season (March to May) and Peak wet (PW) season (June to August). The mean levels of the spatial and temporal distribution of Physicochemical parameters (pH, Temperature, Dissolved Oxygen, Salinity, Total dissolved Solids, Electric conductivity, Turbidity, Biochemical Oxygen Demand) of surface water and heavy metals (Iron, Copper, Lead, Chromium, Cadmium and Nickel) of the surface water and sediments were determined. The results from the analysis were compared with national and international standards. From the results obtained, it was observed that levels of most physicochemical characteristics and heavy metals exceeded the permissible limits. In conclusion, the anthropogenic activities into the stream has an impact in some stations of the stream.

Key words: Calabar, Water Quality, Sediments, Heavy Metals, Physicochemical Parameters.

1. INTRODUCTION

Water is vital to the existence of all living organisms. It is used by mankind for domestic activities (such as drinking, cooking, washing and bathing), agricultural activities, generation of power (Hydroelectric power plant) as well as recreational activities. However, this valued resource is increasingly being threatened as human population and large scale global industrialization that require more water of high quality for domestic and economic activities [1]. Global water resource security poses a serious threat to the world's population. Urban water issues in developing countries are complex and increasingly urgent. One of the biggest challenges for people in slum is getting affordable, safe water for drinking and other activities. In this densely populated urban slum, water borne diseases spread rapidly, especially with poor environmental sanitation that enhances the contamination of water. The quality of water is a function of either or both natural influences and human activities [2-3]. Rivers and streams are some of the most important freshwater resources for man. Unfortunately, these water bodies are easily contaminated by indiscriminate disposal of waste from commercial and industrial sources as well as a plethora of human activities which affect their physicochemical characteristics [4]. Surface water can be contaminated by some impurities like dust, smoke or gases from the atmosphere [5].

Owing to large quantities of effluent discharge into receiving waters, the natural process of self-purification of water become inadequate for the protection of public health. When the self-purifying capacity of the catchment area is exceeded, however, large quantities of these waste substances accumulate in water bodies, where they can harm aquatic life.

This self-purification process is an essential indicator for a healthy river and can be affected by dilution & dispersion, sedimentation, sunlight, oxidation, reduction etc. The exchange of discharge of domestic and industrial effluents is such that rivers or streams receiving such untreated effluents cannot provide the dilution necessary for good quality water sources.

The water itself evaporates and enters the atmosphere as pure water vapor. Much of it falls back into the water body as rains; what falls on the land is the precious renewable resource on which terrestrial life depends [6].

The prevention of river pollution requires effective monitoring of the physicochemical parameters [7]. There are maximum allowable concentration limits of water characteristics proposed by the World Health Organization (WHO)[8] which aid in assessing the quality of water.

Idim Esiere Ebom stream is a major stream of economic, agricultural and environmental significance in Calabar South LGA of Cross River State, Nigeria. The stream serves as a source of potable water to the residents of the community with a population of about 5000. The residents use water from the stream for other domestic activities for washing, cooking, irrigation as well as a source of livelihood fishing (from the downstream stretch of the stream).

Being the only fresh water source in the environment, the stream has been attracting some anthropogenic inputs which hitherto were alien. At present, there are a few auto-mechanic garages, deposits of metal scraps as well as livestock farms. So far, there are no scientific records on the status of the stream. With increasing anthropogenic activities within the vicinity of the water body, this research study aims at establishing baseline data of the water body with the intent of periodic monitoring of its status.

2. STUDY AREA

The study area (figure 1.1) is Idim Esiere Ebom stream which is geographically located approximately between co-ordinates N 04^0 57^1 0.13 and E 008^0 18^1 32.4. The stream is located in Calabar South Local Government Area of Cross River State, Nigeria. The study area experiences marked dry (November – March) and rainy (April – October) seasons but the study was carried out during the early wet season (March – May) and peak wet season (June – August). The area has a population of about 5000 with quite a number of farms and flora such as palm fruits, some herbaceous plants and flowers around the stream. A boat building company is also situated close to the stream where boats of all sizes are produced. The major economic activities in the area are fishing, farming, canoe making and poultry farming. Domestic activities such as drinking, cooking, washing and bathing are carried out in and around the stream as well as recreational activities.

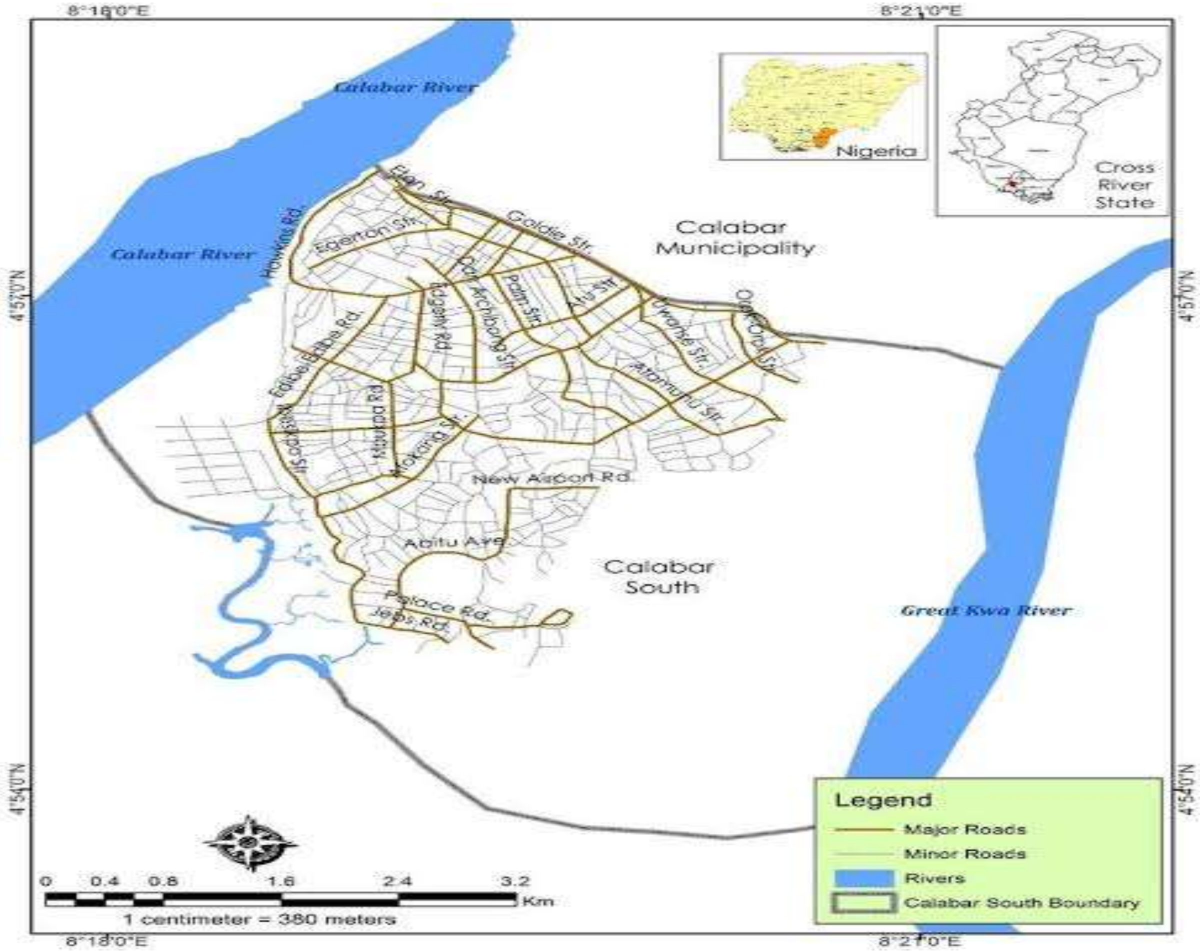

Figure 1.1: Map of the study area and co-ordinates

3.METHODOLOGY

The methods employed are categorized into three (3) such as pre-field, field and post-field activities. The pre-field stage involved recognissance tour of the sampling stations where Five (5) sampling stations were recognized based on the accessibility and

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activity at some point of the stream stretch. All sample containers were properly washed, dried and labelled prior to sampling. pH meter was calibrated with buffer of pH 4, 7 & 10.

In the field activity, The GPS co-ordinates were recorded for each sampling station. The sample containers were rinsed with sterile distilled water, after which they were rinsed with the stream water at the point of sample collection before being used to collect samples. Sampling was carried out from the downstream reach to the upstream reach. At each sampling station, surface water and sediment were collected. The samples for the physicochemical parameters and heavy metals to be analysed in the laboratory, was collected in sterile plastic containers and vial respectively. It was there after transported to the lab for immediate analysis in an ice packed cooler to maintain a temperature of 4^0C. Samples for heavy metals were preserved with 1ml concentration of Nitric acid.

Amber bottle each was used to collect samples for dissolved oxygen (DO) and biochemical oxygen demand (BOD). Sediment samples were collected by scooping during low tides with the use of a plastic shovel. The sample collected was kept in a clean and dried polyethylene bag for heavy metals analysis in the laboratory.

At each station in the stream, pH, temperature, dissolved oxygen, electrical conductivity, total dissolved solids, turbidity and salinity were measured in-situ using appropriate pieces of equipment. biochemical oxygen demand samples were collected into amber bottles and analyzed following Winklers method. The level of Six (6) Heavy Metal such as iron (Fe), copper (Cu), chromium (Cr), cadmium (Cd), lead (Pb) and nickel (Ni) were also determined spectrophotometerically for surface water and sediments. The sediment samples were then ground and sieved into fine particles and the level of iron, copper, cadmium, lead and nickel was measured following standard procedures. The results of the findings are present below:

4. RESULTS

Table: 1.1 Mean physicochemical parameters of surface water

	Stations				
Parameters	**1**	**2**	**3**	**4**	**5**
pH(EW)	5.07	6.2	6.39	6.51	6.76
pH(PW)	6.22	6.73	6.95	6.95	7.27
pH (mean)	**5.65**	**6.47**	**6.67**	**6.73**	**7.01**
T(EW)	29.8	33.2	31.5	30.87	30.8
T(PW)	27.6	32	28.5	27.5	27.3
T(mean)	**28.7**	**32.6**	**30.0**	**29.2**	**29.05**
EC(EW)	158.6	342.4	375.3	374	371.7
EC(PW)	107.7	200	209.3	205	206
EC (mean)	**133.1**	**422.9**	**292.3**	**289.5**	**288.86**

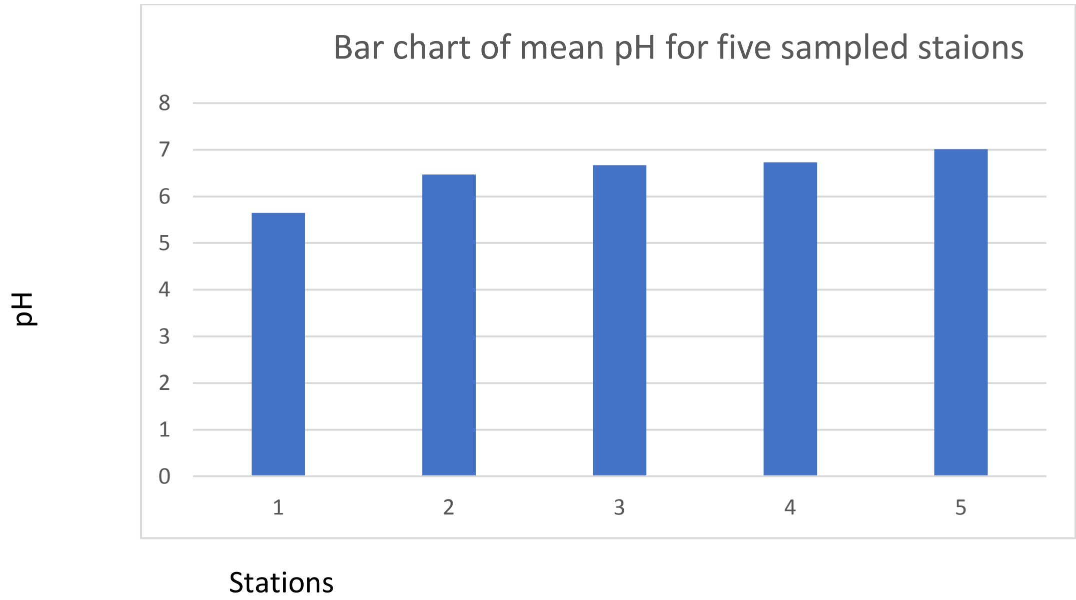

Figure 2 Bar Chart of p^H for different samples

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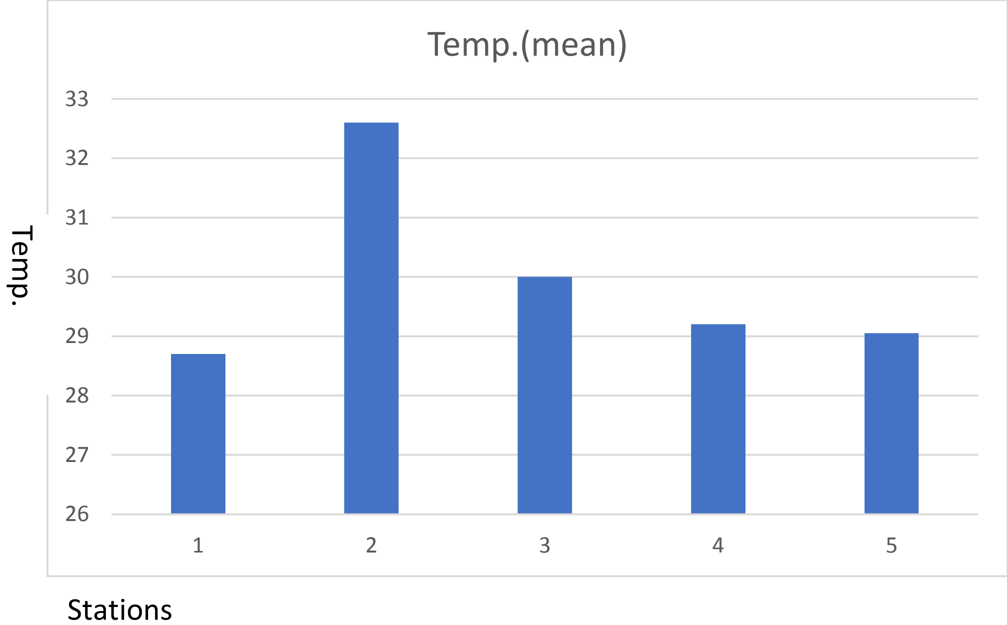

Figure 3. Bar Chart of Mean temperature for different samples

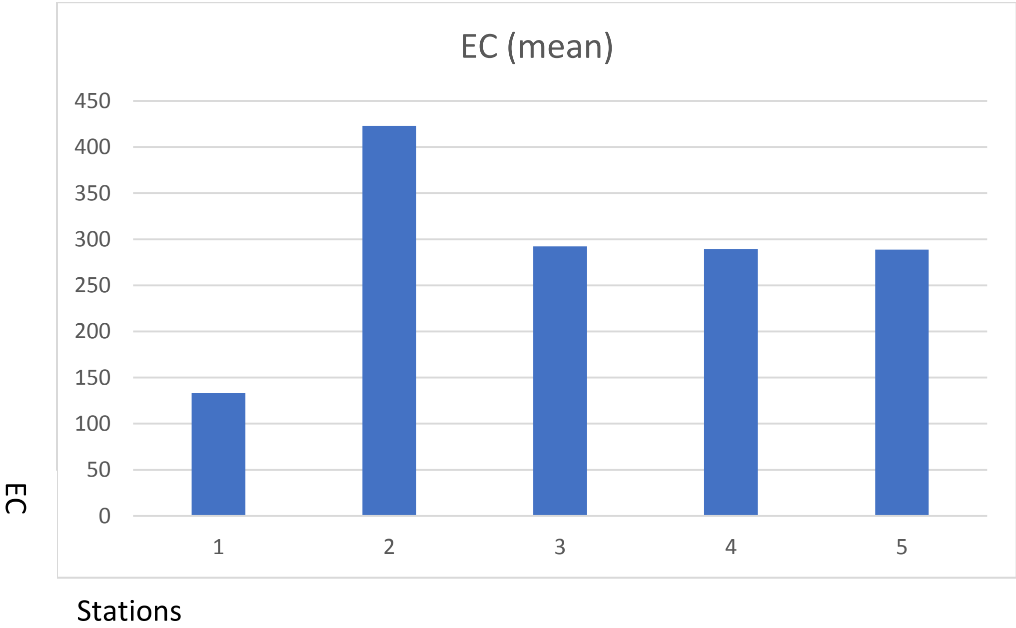

Figure 4. Bar Chart of Mean EC for different samples

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Table 1.2: Temporal variation between the two season of the mean physicochemical parameters level of surface water

Stations /Parameters	1	2	3	4	5	WHO	Ttest	
pH(EW)	5.07	6.2	6.39	6.51	6.76	6.5 – 8.5	0.004	Significant
pH(PW)	6.22	6.73	6.95	6.95	7.27			
T(EW)	29.8	33.2	31.5	30.87	30.8	10 - 30	0.002	Significant
T(PW)	27.6	32	28.5	27.5	27.3			
EC(EW)	158.6	342.4	375.3	374	371.7	1200	0.002	Significant
EC(PW)	107.7	200	209.3	205	206			
TURB(EW)	22.3	36.3	16.3	16.7	13.7	5	0.025	Significant
TURB(PW)	23.7	37.7	35.3	34.7	29.3			
TDS(EW)	96.5	206.7	205.8	205.6	205.3	1000	0.001	Significant
TDS(PW)	58.4	106.7	103.8	103.5	105.4			
DO(EW)	2.71	7.63	8.13	7.09	6.82	7.5	0.298	Not Significant
DO(PW)	5.74	6.52	7.36	7.41	7.44			
SAL(EW)	0.06	0.52	0.67	0.63	0.63	0.04	0.007	Significant
SAL(PW)	0.02	0.13	0.09	0.08	0.04			
BOD(EW)	1.44	3.95	3.8	2.8	2.89	6	0.125	Not Significant
BOD(PW)	2.64	2.21	2.17	2.16	2.15			

Table 1.3: Spatial variation of the mean physicochemical parameters level of surface water

Stations /Parameters	1	2	3	4	5
pH	5.65±0.63	6.47±0.36	6.67±0.44	6.73±0.40	7.01±0.34
Temp. (°C)	28.7±1.73	32.6±4.34	30.0±1.84	29.2±2.30	29.05±2.52
EC (µs/cm)	133.1±30.74	422.9±113.96	292.3±98.33	289.5±103.42	288.86±102.89
Turb. (NTU)	23±4.98	37±5.44	25.8±14.88	25.7±14.25	21.5±12.80
TDS (mg/l)	77.45±23.42	363.5±69.84	361.8±70.64	346.4±74.24	345.85±74.41
DO (mg/l)	4.23±1.86	7.08±1.53	7.75±1.46	7.25±0.45	7.13±0.53
Sal. (PSU)	0.04±0.02	0.33±0.32	0.38±0.61	0.36±0.59	0.36±0.60
BOD (mg/l)	2.75±1.88	2.81±0.65	2.81±0.87	2.18±0.56	2.22±0.04

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Table 1.4: Temporal variation between the two season of the mean Heavy metals level of surface water parameters

Stations /Parameters	1	2	3	4	5	NESREA (mg/l)	Ttest	
Iron(EW)	<0.001	1.019	0.035	1.258	0.247	0.3000	0.21	Non-Significant
Iron(PW)	<0.001	0.548	1.247	1.083	1.229			
Copper(EW)	0.041	0.101	0.099	0.039	0.120	0.0100	0.03	Significant
Copper (PW)	0.046	0.022	0.066	0.015	0.049			
Cadmium(EW)	<0.001	<0.001	<0.001	<0.001	<0.001	0.0903	<0.001	Significant
Cadmium(PW)	<0.001	<0.001	<0.001	<0.001	<0.001			
Chromium(EW)	<0.001	<0.001	<0.001	<0.001	<0.001	0.5000	<0.001	Significant
Chromium(PW)	<0.001	<0.001	<0.001	<0.001	<0.001			
Lead(EW)	<0.001	<0.001	<0.001	<0.001	<0.001	0.0100	<0.001	Significant
Lead(PW)	<0.001	<0.001	<0.001	<0.001	<0.001			
Nickel(EW)	<0.001	<0.001	<0.001	<0.001	<0.001	1.0000	<0.001	Significant
Nickel(PW)	<0.001	<0.001	<0.001	<0.001	<0.001			

Table 1.5: Spatial variation of the mean Heavy metals level of surface water parameters

Stations /Parameters	1	2	3	4	5
Iron	<0.001	1.567±0.33	1.282±0.86	2.341±0.13	1.476±0.69
Copper	0.087±0.01	0.123±0.06	0.165±0.02	0.054±0.01	0.169±0.05
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	<0.001	<0.001	<0.001	<0.001	<0.001

Table 1.6: Temporal variation between the two season of the mean Heavy metals level of sediments parameters

Stations /Parameters	1	2	3	4	5	DPR/FMEnv	Ttest	
Iron(EW)	39.23	37.21	43.53	40.93	31.92	20.00	0.33	Non-Significant
Iron(PW)	38.17	38.68	37.21	36.18	37.50			
Copper(EW)	5.07	3.28	4.63	6.47	1.15	35.00	0.10	Non-Significant
Copper (PW)	5.31	4.64	4.22	7.54	5.89			
Cadmium(EW)	0.52	0.45	0.72	0.26	0.40	0.03 – 0.3	0.07	Non-Significant
Cadmium(PW)	0.87	0.44	0.63	1.15	0.91			
Chromium(EW)	1.90	1.00	4.21	4.99	1.40	0.5	0.02	Significant
Chromium(PW)	2.91	5.39	6.53	7.22	9.02			
Lead(EW)	4.66	2.81	1.97	6.35	3.18	2 – 20	0.00	Significant
Lead(PW)	12.83	7.94	6.68	14.25	13.20			
Nickel(EW)	0.63	6.90	1.71	6.52	0.58	0.8	0.01	Significant
Nickel(PW)	3.04	8.99	7.88	9.41	8.84			

Table 1.7: Spatial variation of mean Heavy metals level of sediments parameters

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Stations /Parameters	1	2	3	4	5
Iron	38.7±0.75	37.95±1.04	40.37±4.47	38.55±3.36	34.71±3.95
Copper	5.19±0.17	3.96±0.96	4.43±0.29	7.01±0.76	3.52±3.35
Cadmium	0.70±0.25	0.45±0.01	0.68±0.06	0.71±0.63	0.66±0.36
Chromium	2.41±0.72	3.20±3.10	5.37±1.64	6.11±1.58	5.20±5.39
Lead	8.74±5.78	5.38±3.63	4.33±3.33	10.3±5.59	8.19±7.11
Nickel	1.84±1.70	7.95±1.48	4.80±4.36	7.97±2.04	4.71±5.84

5. DISCUSSION

The temporal and spatial mean level of the physicochemical parameters measured from the surface water sample, heavy metals from the surface water sample and sediments presented in **tables 1.1 – 1.6.** The mean levels of the spatial distribution of some physicochemical characteristic in surface water were as follows: pH 6.5±0.43. [9] observed that the decomposition of dead and decaying organic matter in water bodies have the potential to increase the pH of a water body. According to the WHO guidelines drinking water quality, exposure to both high and low pH values causes irritation to the eyes, skin and mucous membrane for humans.

Temperature range of 29.91±2.55 was observed from this study. The early wet season values were high as a result of the heat from the dry season which ends in early March, as this period can also be regarded as late dry season/early wet season. The values for the peak wet season were seen lower than the early wet season due to the heavy rainfall and little sunlight during this season. Extreme temperature in water bodies have the potential to decrease the DO, kill aquatic organisms, increase the rate of chemical reaction in the stream such as the decomposition of dead and decaying organisms, increase taste, odour and colour, extremely high or low temperatures have a negative impact on water bodies [10].

For this study, electrical conductivity (EC) range of 285.3±89.87 was observed. The high level of electrical conductivity in station 2 (422.9±113.96) is due to the degree of anthropogenic activities such as waste disposal, sewage inflow and washing of clothes and vehicles by the residents of the area. The values of EC in the peak wet season were relatively low as compared to the early wet season and this was as a result of rainfall hence diluting the level of soluble salt in the water body. The value of electrical conductivity in the sampling stations did not exceed the permissible limit of 1200 $\mu S/cm$ set by WHO, hence not a threat.

Turbidity recorded for this study range from 26.6±10.47. The mean values for turbidity in station 2 was a bit higher than the other stations due to suspended particles from **station 1**. This is as a result of the domestic activities like washing that takes place at the **station 1** and flows into **station 2**, hence making some part of the station turbid and reducing the transparency of the stream at this station. All the values exceeded the WHO permissible limit of 5NTU hence is a threat;

Total Dissolved Solids range of 299.0±62.51 was recorded. It was observed that the peak wet season had low values as compared to the early wet season. This is as a result of rainfall diluting the organic salts and organic matters. Total Dissolved Solids (TDS) mainly consist of inorganic salts such as carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron etc and small amounts of organic matter. An increase in TDS can cause oxygen depletion in the stream, hence, a threat on the fauna and flora present in the water body. All the values did not exceed the WHO permissible limit hence not a threat.

Dissolved Oxygen of 6.69±1.17 was observed. Plants use oxygen to produce food while animals use it to survive hence, the absence of oxygen in water can lead to the death of flora and fauna in the ecosystem. During the decomposition process, oxygen is being consumed and this could lead to oxygen depletion in water body. On the other hand, an excess of this oxygen can cause suffocation to fishes, hence, it is important to have an oxygen balance in the water body. Dissolved Oxygen is the maximum concentration of oxygen that can dissolve in water. It is an important parameter to assess the waste assimilative capacity of a water body [11].

Salinity was recorded as 0.29±0.43. The peak wet season mean value was relatively lower than that of the early wet season as a result of the rainfall which had diluted the dissolved salts particles present in the stream. High salinity level in the stream can cause dehydration to the fauna and even humans which can eventually lead to death and can also cause the stream to be unfit for domestic use.

Biochemical oxygen demand (BOD) was recorded to be 2.55±0.8. The level of BOD obtained from the sampling stations were less than the WHO Standard (6NTU). BOD is the measure of the extent of pollutant in the water body. BOD is the amount of

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dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials.

Temporal variation of the physicochemical characteristics in water for pH values recorded for early wet and peak wet as 6.19±0.66 and 6.82±0.39 respectively; Temperature for early wet and peak wet was recorded as 31.23±1.26°C and 27.62±0.50°C respectively; Electrical conductivity for early wet and peak wet was recorded as 324.40±93.70$\mu S/cm$ and 185.60 ± 43.70$\mu S/cm$ respectively;. Turbidity for early wet and peak wet was recorded as 21.06±9.10 and 32.14±5.63; Total dissolved solids 183.98±48.91 and 95.56±20.8; Dissolved solids 6.48±2.16 and 6.89±0.75; Salinity 0.50±0.25 and 0.07±0.04; Biochemical oxygen Demand 2.98±1.00 and 2.27±0.21 at early wet and peak wet seasons respectively.

The mean level for heavy metals in the surface water recorded in the five (5) stations were as follows – Iron mean values for early wet and peak wet season were 0.64±0.59mg/l and 1.03±0.33mg/l respectively; Copper mean values for early wet and peak wet were 0.08±0.04mg/ and 0.04±0.02mg/l respectively; It was observed that Cd, Cr, Pb and Ni were not detected in all the stations except Fe and Cu. In station 1, Fe was not detected in both seasons but was detected in other stations.

Temporal variation of the heavy metals for Iron mean values for early wet and peak wet was 38.56±4.38mg/l and 37.55±0.96mg/l respectively; Copper mean values for early wet and peak wet was 4.12±2.01mg/l and 5.52±1.30mg/l respectively; Cadmium mean value for early wet and peak wet was 0.47±0.17mg/l and 0.8±0.27mg/l respectively; Chromium mean value for early wet and peak wet 2.70±1.78mg/l and 6.21±2.27mg/l respectively; Lead mean level for early wet and peak wet 3.79±1.73mg/l and 10.98±3.42mg/l respectively; Nickel mean level for early wet and peak wet 3.27±3.18mg/l and 7.63±2.63mg/l respectively.

6. CONCLUSION

From the results of the study, the pH of the surface water at **station 1** was acidic, with low DO. Turbidity, DO and Salinity were above the WHO limit which might be as a result of the anthropogenic activities carried out around the stream. The level of Cadmium, Chromium and Nickel in the sediment were above the DPR/FMEnv set limit and this might be as a result of the run-off from the Mechanic workshop situated close to the stream and also the washing of vehicles close to the stream. Some physicochemical parameters (turbidity, DO and salinity) still exceeded permissible limits. In conclusion, the anthropogenic activities into the stream has an impact in some stations of the stream.

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