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Hydrochemical and Bacteriological Studies of Streams in Calabar South Local Government Area, Nigeria

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ABSTRACT: This paper presents the results of hydro-chemical and bacteriological analysis of water obtained from streams in Calabar South Local Government Area in Nigeria. Water samples were collected from five different streams in the local government area. The water samples were analysed for physic-chemical and bacteriological parameters. From the analytical results obtained, the different parameters tested were as follows: pH (3.81 – 5.35), TDS (2.28mg/l – 152.75mg/l), turbidity (0.12NTU – 44.07 NTU), DO (7.10mg/l – 10.40mg/l), BOD (0.35mg/l – 0.56mg/l), Fe (0.14mg/l – 0.91mg/l), Pb (0.03mg/l – 0.59mg/l), Zn (0.02mg/l – 0.87mg/l), Mn (0.76mg/l – 1.82mg/l), Cu (0.02mg/l – 0.18mg/l), THC (28 per 0.1 ml – 96 per 0.1ml), and total coliform count (23mg/l – 88 mg/l). Most of these parameters were highly objectionable for portable water sources. The bacteriological analysis showed isolation of specified bacterium from all the samples. It was observed that the water sources were quite unreliable for drinking when compared with the World Health Organization (WHO) Standards.

KEYWORDS: Water samples, Stream, Bacteriological, Physico-chemical parameters and Calabar South.

1.0 INTRODUCTION

Water is a chemical compound with each of its molecules containing two hydrogen atoms and one oxygen atom (Kumar, 1990). It is an essential constituent of all animals and vegetable matter and can be considered as the most important raw material of civilization since without it man cannot live and industries cannot operate (Duggal, 1996). Water pollution may lead to stream insanitation; the use of polluted water by communities for their daily requirements would mean taking unsafe water which may cause the sporadic outbreak of water borne diseases. Water pollution has resulted in organisms drying off at a very alarming rate and our drinking water has become affected, as in our ability to use water for recreational purposes (Udomessien, 2003).

Surface water degradation has become a matter of increasing National and Global concern as the impact of organic and inorganic contaminants continue to render vital water resources less suitable for their intended uses. The protection of the aquatic environment and its associated resources is one of the programmes of action enlisted in Agenda 21 of the United Nations geared towards achieving sustainable development (United Nations and Development, 1888). In many African countries, it has been reported that 80% of human's illnesses are attributed to contaminated water supplies (Calamari, D. and Naeve, H; 1994). In natural aquatic ecosystems heavy metals occur in low concentrations normally at the nanogram to microgram per litre level. In recent times however, the occurrence of metal contaminants especially the heavy metals in excess of natural loads, has become a problem of increasing concern. This phenomenon according to Calamari, D. and Naeve, H. (1994) has arisen as a result of rapid population growth, increased urbanization, expansion of industrial activities, exploration and exploitation of natural resources, extension of irrigation and other modern agricultural practices as well as the lack of environmental regulations.

The significance of water route in spread of diseases varies both with the diseases and the local circumstance (Adesiyum and others, 1983). Wolf (2001) added that harmful chemicals such as pesticides from agriculture and heavy metals like lead and mercury from industries can build in the food chain where they can reach toxic levels in fish and other sea animals. The effects of water pollution by chemicals include cancer, arthritis, skin irritation and eruption, heart diseases, central nervous system problems, skin rashes, kidney problems and bronchitis.

The objectives of this study are to create awareness of the dimension of water pollution and their respective consequences, to develop attitude of responsibility towards quality of water and to determine the present bacteriological and physico-chemical qualities of water sources available to the population at Calabar South local government area whose number, quality, sources and activities are ever increasing.

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The incidents of water borne diseases, and epidemics nationwide arising from drinking water of doubtful quality have become of great concern. The primary purpose of the guideline for drinking water quality is the protection of public health (WHO, 2006). As described by Horsefall and Spiff (1998), water quality standard is a measure, principle or rule established by authority set to protect the water resource for uses such as drinking water supply, recreational uses and aesthetics, agriculture (irrigation and livestock watering), protection of aquatic life and industrial water supplies.

1.1 The Study Area

Calabar South local government area of Cross River State constitutes the study area. The landscape is dominated by two major rivers, the Calabar River in the north – west and the Great Kwa River in the eastern part. The area lies between latitudes 04^0 55' 30'' N and 04^0 58' 30'' N and longitudes 08^0 15' 30'' E and 08^0 21' 00'' E with an annual rainfall of 200mm to 350mm. The temperature of the area is generally high; the annual mean maximum and minimum temperatures are 31^0C and 23^0C respectively with mean relative humidity of 84mm. It experiences two seasons, the wet and dry season. The wet season lasts from April to September with a peak in June and July; the dry season is from October to March.

According to the result of the 2006 population census, Calabar South local government area has a total population of one hundred and ninety one thousand, six hundred and thirty (191,630) people. The state map showing the location of the local government area within Cross River State is shown in Plate 1.

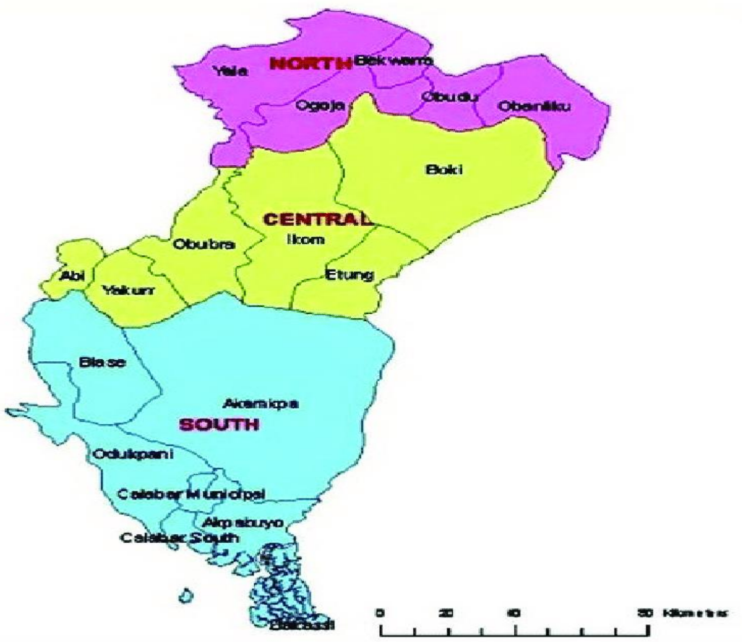

Plate 1: Cross River State Map Showing Different Local Government Areas

2.0 LITERATURE REVIEW

The provision of safe and potable water to rural and urban communities in the world is a necessary condition for development. This is one of the central objectives of the World Health Organization (Pollard et al 2006). Safe drinking water and adequate sanitation are essential for human health.

Ground, surface and rain water are the major sources of water for the populace. Surface water is often the most appropriate source of water for drinking and other domestic uses as it does not contain high mineral content. However, surface water is often contaminated by people and animals who defecate in or near the water source. Eighty percent of diseases in the third word are due to poor water quality and sanitation. There are many disease causing microbes and chemicals found in contaminated and polluted water which are harmful to human beings when they are consumed in drinking water (WHO, 2006).

According to Okafor, 1985, the sanitary quality of water is the relative extent of the absence of suspended matter, colour, taste, unwanted dissolved chemicals, bacteria, inactive or faecal pollution and other aesthetically offensive objects. In general, certain requirements must be met for water to be fit for human consumption. If these requirements are met, then the water could be described as “wholesome”, “potable”, or simply “good water” (Eja, 2002). The results of water quality measurements must be crosschecked with the established standards. In other words, man’s ability to control the quality of water is based on regularly making a series of physico-chemical and bacteriological tests, results of which are compared with established standards and a deviation from these standards calls for remedial actions. This is the essence of water quality control (Eja, 2002).

In order to maintain water quality, guidelines for drinking water was set up by the World Health Organization (WHO). A guideline value represents the level (a concentration or number) of a constituent that ensures aesthetically pleasing water and does not result in any significant risk to the health of the consumers (WHO, 1984, 1985 and 2006). Tables 1 and 2 show the drinking water quality standards from the World Health Organization which is similar to the Nigerian Federal Ministry of Environment's Standards.

Table 1: World Health Organization's and Federal Ministry of Environment's Drinking Water Standard.

Parameter	Drinking Water Quality as per		
	EQS Standard	WHO Standard	EC Standard
pH	6.0 – 8.5	6.5 – 8.5	6.5 – 8.5
TDS (mg/l)	1,000	1,000	1,000
Iron (mg/l)	0.3 – 1.0	0.3	0.2
Sodium (mg/l)	200	200	175
Chloride (mg/l)	150 - 600	250	250
Sulphate (mg/l)	400	400	25
Flouride (mg/l)	1.0	1.5	1.5
Arsenic (mg/l)	0.05	0.05	0.05
Ammonium (mg/l)	0.5	1.5	0.5
Nitrate (mg/l)	10	10	10
Phosphate (mg/l)	6.0	-	5.0
Potassium (mg/l)	12.0	-	10
Endrin (mg/l)	0	0.2	0.2
Heptachlor (µg/l)	0	0.1	0.1
DDT(µg/l)	0	1.0	0.1

Source: WHO, 2006

Table 2: Drinking Water Quality Standards

Parameters	**Maximum WHO Permissible Limit**
Al	0.2mg/l
Ca	75mg/l
Fe	0.3mg/l
NO_2	50mg/l
pH	6.5 – 8.0
TDS	1000mg/l
E. Coli	0
Total Coliform count	10
Faecal streptococcus	0
Clostridium perfringens spore	0
Colour	15 TCU
Turbidity	5 NTU
Odour	Objectionable
Taste	Unobjectionable
Temperature	Ambient
Aluminum (Al)	0.2 mg/L
Arsenic (As)	0.01 mg/L
Barium	0.7 mg/L
Cadmium (Cd)	0.003 mg/L
Chloride (Cl)	250 mg/L
Chromium (Cr6+)	0.05 mg/L

Conductivity	1000 µS/cm
Copper (Cu+2)	1 mg/L
Cyanide (CN-)	0.01 mg/L
Fluoride (F-)	1.5 mg/L
Hardness (as CaCO3)	150 mg/L
Hydrogen Sulphide (H2S)	0.05 mg/L
Iron (Fe+2)	0.3 mg/L
Lead (Pb)	0.01 mg/L
Magnesium (Mg+2)	0.20 mg/L
Manganese (Mn+2)	0.2 mg/L

Source: WHO, 2006

3.0 MATERIALS AND METHODS

3.1 Sample Collection And Preparation

In order to get fair and adequate representations of the various streams, their sample site, elevation and coordinates are presented in Table 1. Surface water samples were randomly collected between 7.00am and 9.30am fortnightly from the upstream, mid-stream and downstream respectively from the stations in May, June and September 2011 while operating from a dug-out canoe. The samples were collected in 1 litre polythene bottles with screw caps at approximately 30cm below the water surface. The bottles were treated with 5% nitric acid and rinsed with distilled water before use. The samples were fixed with 5% nitric acid to minimize the adherence of heavy metals to the walls of the bottles.

Water samples were transported to the laboratory in an ice chest within 24 hours and were stored at -5^{0}C in a Haier Thermocool freezer prior to further analysis. Heavy metals analysis was carried out with a Buck Scientific WGP 210 Atomic Absorption Spectrometer using element specific hollow cathode lamps in difficult condition by flame absorption mode. Blank solution was handled as detailed for the samples. All values were expressed in mg/l. The bacteriological analysis was carried out using the spread plate technique and the multiple tube techniques method and the number of colonies on each plate were counted and recorded per 100 ml of sample. The sample sites are presented in Table 4.

Table 4: Sample Sites Codes and their GPS

S/No.	Sample Code	Sample Site	Elevation	Coordinates
1.	S_1	Uwanse stream	7m	04^0 56' 11.7''N 08^0 20' 34''E
2.	S_2	Crutech stream 1	8m	04^0 55' 29.8''N 08^0 19' 56.2''E
3.	S_3	Crutech stream 2	8m	04^0 55' 29.5''N 08^0 19' 56.2''E
4.	S_4	Ewa Henshaw stream	8m	04^0 56' 34.1''N 08^0 18' 34.7''E
5.	S_5	Hawkins stream	2m	04^0 57' 00''N 08^0 18' 32.5''E

***Crutech –** Cross River University of Technology site

4.0 RESULTS AND DISCUSSION

4.1 Results

The concentrations of the investigated parameters varied in water from May, 2011 to September, 2011 respectively as shown from Table 5 to Table 16.

Table 5: P_H Values

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		1	2	3				
S_1	mg/l	5.32	5.32	5.35	5.35	5.32	5.55	0.02
S_2	,,	4.45	4.43	4.51	4.51	4.43	4.46	0.04

S_3	,,	3.51	4.15	3.67	4.15	3.51	3.78	0.33
S_4	,,	3.87	3.79	4.19	4.19	3.77	3.94	0.22
S_5	,,	3.83	3.81	3.80	3.83	3.80	3.81	0.01

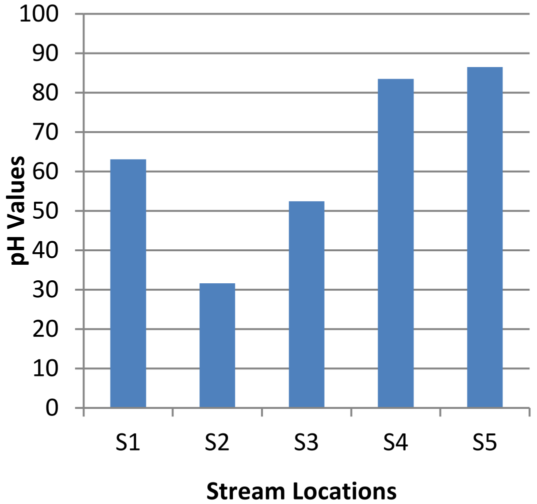

Fig. 1: pH Values at Different Locations

Table 6: Total Dissolved Solids (TDS) mg/l

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		1	2	3				
S_1	mg/l	84.44	98.61	6.31	98.61	6.31	63.12	49.71
S_2	,,	29.12	47.45	18.33	47.45	18.33	31.63	14.72
S_3	,,	2.28	128.18	26.85	128.18	2.28	52.44	66.74
S_4	,,	2.48	95.16	152.75	152.75	2.48	83.46	75.81
S_5	,,	94.9	76.83	87.69	94.9	76.83	86.47	9.09

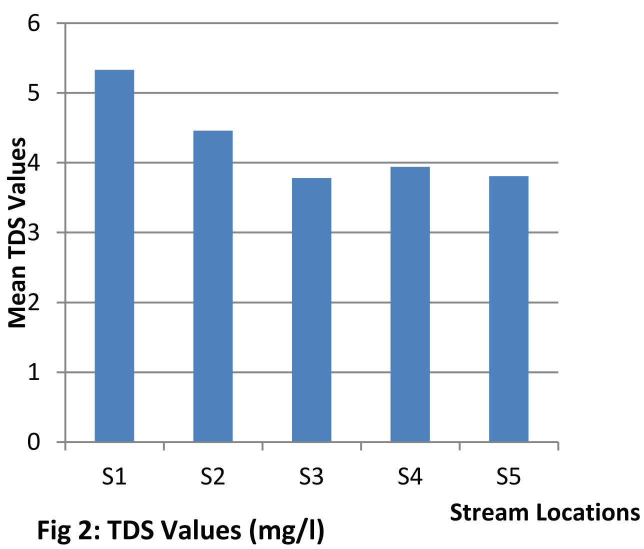

Fig 2: TDS Values (mg/l)

Table 7: Turbidity

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	NTU	0.67	0.60	4.59	4.59	0.60	1.95	2.28
S_2	,,	0.17	0.21	44.07	44.07	0.17	14.80	25.3
S_3	,,	0.12	0.15	25.84	25.84	0.12	8.70	14.8
S_4	,,	0.07	0.07	3.68	3.68	0.07	1.27	2.08
S_5	,,	0.07	0.09	8.63	8.63	0.07	2.93	4.94

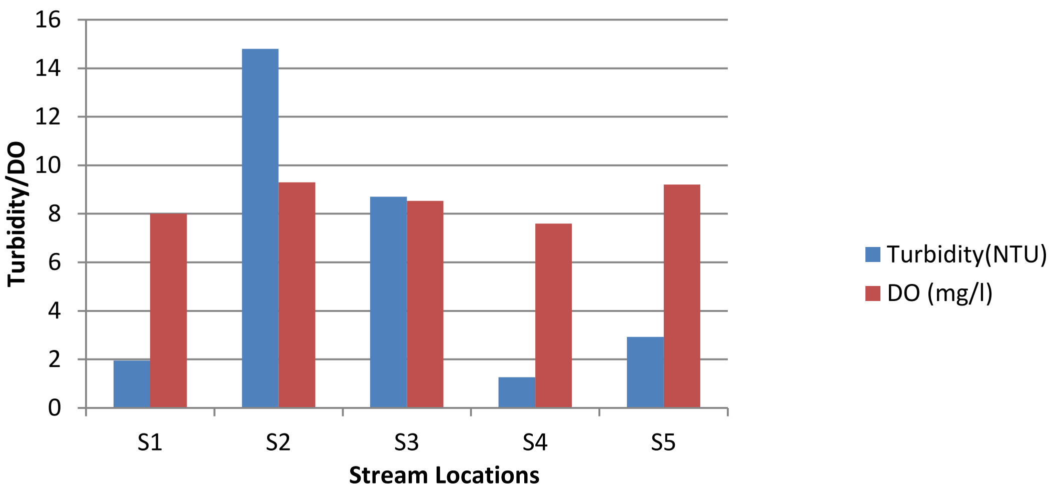

Fig. 3: Turbidity and Dissolved Oxygen (DO)

Table 8: Dissolved Oxygen (DO)

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	mg/l	9,90	9.70	9.70	9.90	9.70	9.77	0.46
S_2	,,	7.10	10.40	10.40	10.40	7.10	9.30	1.91
S_3	,,	8.80	8.40	8.40	8.80	8.40	8.53	0.23
S_4	,,	9.60	6.60	6.60	9.60	6.60	7.60	1.73
S_5	,,	10.20	8.80	8.80	10.20	8.80	9.21	0.81

Table 9: Biochemical Oxygen Demand (BOD)

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	mg/l	0.35	0.54	0.22	0.54	0.22	0.37	0.16
S_2	,,	0.47	0.55	0.27	0.55	0.27	0.43	0.14
S_3	,,	0.41	0.46	0.30	0.46	0.30	0.39	0.08
S_4	,,	0.42	0.56	0.25	0.56	0.25	0.41	0.16
S_5	,,	0.56	0.52	0.19	0.56	0.19	0.42	0.20

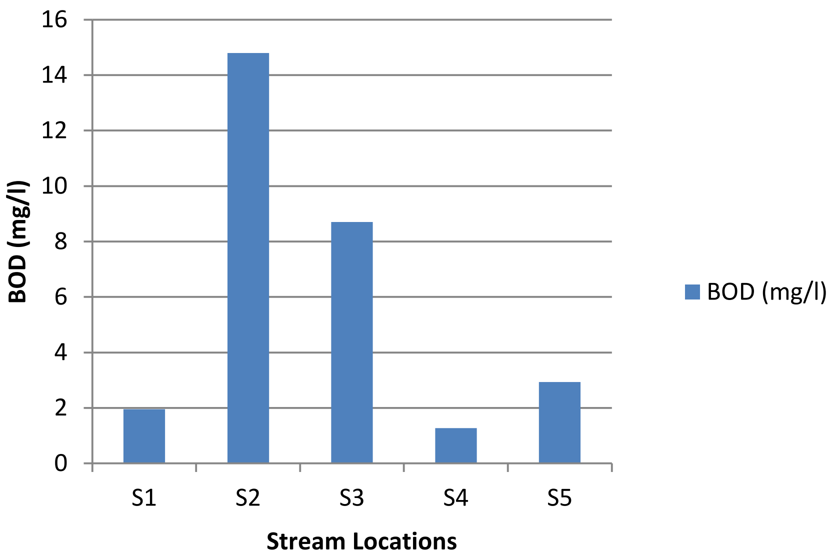

Fig. 4: BOD (mg/l)

Table 10: Iron (Fe)

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	mg/l	0.14	0.32	0.97	0.97	0.14	0.48	0.43
S_2	,,	0.54	0.91	0.56	0.56	0.91	0.67	0.21
S_3	,,	0.76	0.85	0.58	0.85	0.50	0.73	0.14
S_4	,,	1.02	1.02	0.37	1.02	0.37	0.79	0.37
S_5	,,	0.81	0.51	1.21	1.21	0.51	0.84	0.35

Table 11: Lead (Pb)

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		1	2	3				
S_1	mg/l	0.03	0.08	0.04	0.08	0.03	0.05	0.03
S_2	,,	0.34	0.05	0.04	0.34	0.04	0.14	0.17
S_3	,,	0.41	0.34	0.02	0.34	0.02	0.32	0.11
S_4	,,	0.36	0.59	0.03	0.59	0.03	0.33	0.28
S_5	,,	0.55	0.40	0.01	0.55	0.01	0.32	0.28

Table12: Zinc (Zn)

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	mg/l	0.02	0.02	0.71	0.71	0.02	0.15	0.21
S_2	,,	0.51	0.49	0.87	0.87	0.49	0.62	0.21
S_3	,,	0.47	0.44	0.79	0.79	0.44	0.57	0.19
S_4	,,	0.44	0.28	0.91	0.91	0.28	0.54	0.33
S_5	,,	0.27	0.48	0.66	0.66	0.27	0,47	0.19

Table 13: Manganese (Mn)

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	mg/l	0.76	1.66	1.37	1.66	0.76	1.26	0.46
S_2	,,	1.06	0.83	1.74	1.74	0.83	1.21	0.47

S_3	,,	0.81	0.61	1.82	1.82	0.61	1.08	0.65
S_4	,,	0.85	0.85	1.48	1.48	0.86	1.06	0.36
S_5	,,	0.86	0.85	1.48	1.48	0.86	1.06	0.36

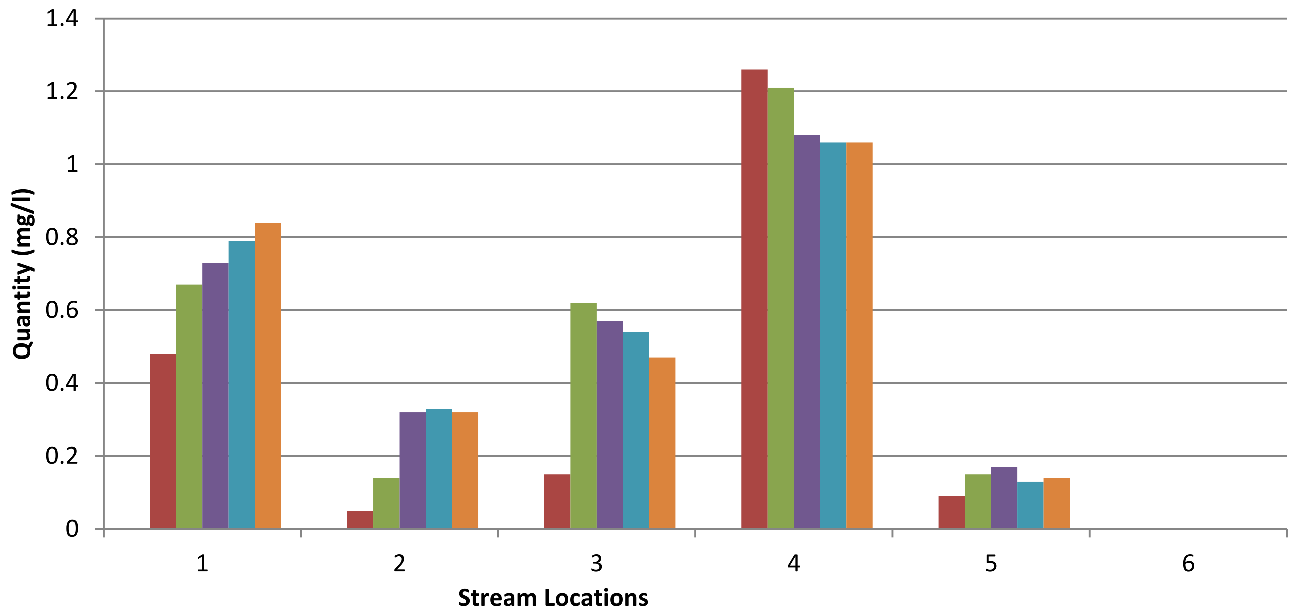

Fig. 5: Metal Contents (mg/l)

-Iron, - Lead, - Zinc, anganese, - Copper

Table 14: Copper (Cu)

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	mg/l	0.02	0.18	0.19	0.19	0.02	0.09	0.09
S_2	,,	0.10	0.18	0.16	0.18	0.10	0.15	0.04
S_3	,,	0.17	0.18	0.17	0.18	0.17	0.17	0.00
S_4	,,	0.18	0.10	0.10	0.18	0.10	0.13	0.05
S_5	,,	0.12	0.12	0.18	0.18	0.12	0.14	0.03

Table 15: Total Heterotrophic Count (THC)

Sample Code	Unit	Sampling Periods			Max.	Min.	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	Per 0.1 ml	166	60	83	83	66	69.7	11.93
S_2	,,	72	78	59	78	59	69.7	9.71
S_3	,,	45	56	76	76	45	59.0	15.72
S_4	,,	36	41	101	101	36	59.3	36.17
S_5	,,	28	32	96	96	28	52.0	38.16

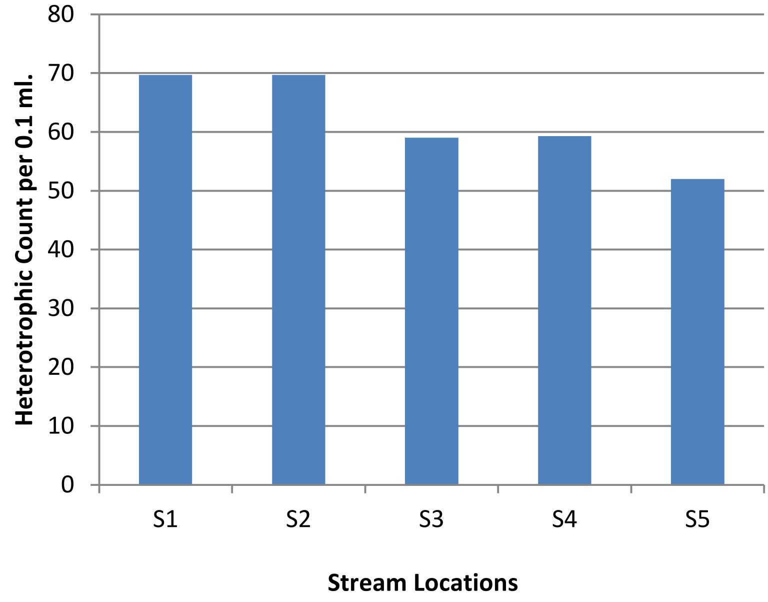

Fig. 6: Total Heterotrophic Count (per 0.1ml)

Table 16: Total Coliform Count (TCC)

Sample Code	Unit	Sampling Periods			Max.	Min	Mean	S.D
		May(1)	June(2)	Sept.(3)				
S_1	mg/l	38	40	47	47	38	41.6	4.72
S_2	,,	55	60	46	60	46	53.6	7.09
S_3	,,	40	42	53	53	40	45.0	7.00
S_4	,,	28	23	88	88	23	46.3	36.10
S_5	,,	24	29	42	42	24	31.6	9.29

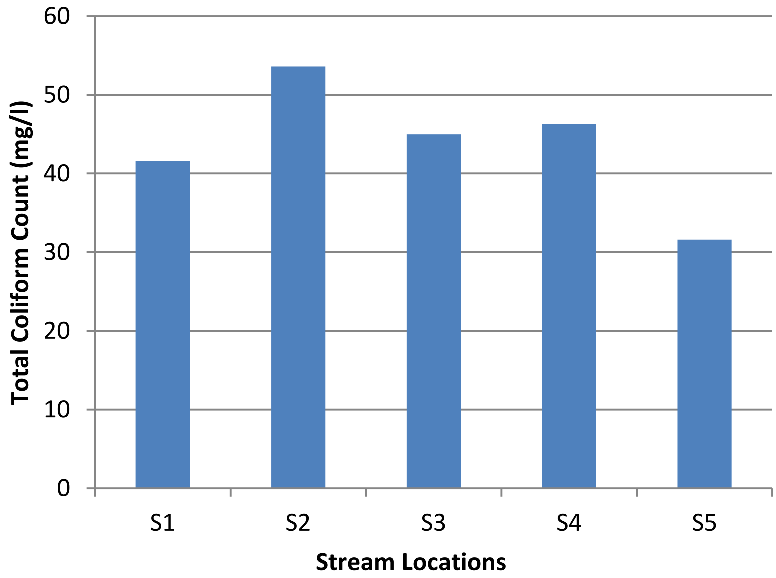

Fig. 7: Total Coliform Count (TCC) mg/l

4.2 Discussion

The World Health Organization, WHO (2008) Standard is used as the criteria in assessment of the quality of water from each location under investigation. From the results obtained, as shown on Tables 5 to 16, the state of the water is discussed as follows:

The pH value is an important factor in maintaining the bicarbonate and carbonates system, and is also reported to play an important role in formation of algal bloom (Anderson, 1982). For the period of investigation, the mean seasonal pH varied from

3.78 to 5.33 with the maximum and minimum pH values of 5.35 and 3.83 in stream 1 and 5 respectively. The pH results as shown in Table 5 (and Fig. 1) compared with Table 1 indicate that all the water samples are acidic. The acidic nature of the water may be attributed to high turbid materials and wastes from sub surface runoff water and river discharge characteristics, the high input of acidic waste materials through subsurface runoff from cottage industries in the area as well as free CO_2 from the atmosphere. However, all pH values were not within the WHO permissible limit of 6.5 – 8.5, hence the water sample have acidic tendency and may not be suitable for consumption.

Table 6and Fig. 2 show the mean seasonal variations in the various streams and the standard deviation of the total dissolved solids obtained during the period of investigation. The mean Total Dissolved Solids (TDS) values for all the samples ranged from 31.63mg/l to 86.47mg/l. These values were found to be far lower than the WHO, 2006 permissible limit of 1000mg/l.

The level of dissolved oxygen in water may serve as an indicator of the microbial activity in the water. As shown in Table 8 and Fig. 3 the maximum concentration of dissolved oxygen ranged from 6.60mg/l to 10.40mg/l with a minimum mean value of 7.60mg/l (SD = 1.73) obtained at stream 4 while the maximum mean value of 9.30mg/l (SD = 1.91) was obtained at stream 2. The results indicate that the oxygen concentration changes monthly.

The mean seasonal variation of turbidity ranged from 0.07NTU to 44.07NTU. The mean values recorded in Table 7 (and Fig. 3) were found to be lower at all locations except S_2, and S_3 than the WHO limit of 5.0 NTU. The high turbidity may be due to high water table within the zone of aeration.

A high BOD signifies the presence of a large amount of organic pollution (Agunwamba, 2000). Table 9 (and Fig. 4) shows the mean value of BOD concentration obtained during the period of investigation. The range was from 0.19mg/l to 0.56mg/l. The maximum mean value of 0.43mg/l occurred in stream S_2 while the minimum mean value of 0.37mg/l value occurred in stream S_1. These values were lower than the WHO permissible limit; this shows that the strength of waste in the area is low.

The mean value and standard deviation of iron concentration in the water from the study area is shown in Table 10 (Fig. 5). The mean minimum and maximum values were 0.48mg/l and 0.84mg/l in stream S_1 for May and September. The values were above the WHO permissible limit. This may be due to the discharge of waste containing iron into the streams.

Table 11 (and Fig. 5) show the mean lead (Pb) concentration. The mean Pb concentration ranges from 0.05mg/l to 0.33mg/l with SD range of 0.03mg/l to 0.28mg/l respectively. The mean value exceeded the WHO maximum permissible level of < 30µg/l for drinking water.

Heavy metals such as Zinc, Copper, and Manganese are essential for the growth and well being of living organisms including man. However, they can exhibit toxic effects when organisms are exposed to levels higher than normally required. Tables 15 (Fig. 6) and 16 (Fig. 7) show the mean range for the values of total heterotrophic count and total coliform count in the area of study. The mean value ranges from 52.0 per 0.1ml to 69.7 per 0.1 ml for the heterotrophic count and the mean values of total coliform count ranges from 31.6 mg/l to 53.6mg/l. Both parameters were observed to be very high and are causative agents of water based and water borne diseases.

5.0 CONCLUSION

Water is the most vital resources in the world. It is also one of the most essential requirements for life, and as such its quality is of paramount importance to the consumers. Standard methods for water analysis has been implemented throughout all the analysis in this study, and the results obtained are precise and logical enough to give useful information in which the portability of drinking water sources within Calabar South local government area could be assessed. From the results obtained, water sources from some streams within the area are quite unsafe for drinking and for other domestic purposes. They are polluted when compared with the WHO Standards.

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