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A COMPARISON OF THE BOATING AND SWIMMING MICROBIAL WATER QUALITY OF CALABAR RIVER AND CROSS RIVER ESTUARY, NIGERIA

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Abstract
Calabar River Estuary is often used by both locals and tourists for boating and swimming making it necessary to assess the microbial recreational water quality of this water body. Five sampling stations were established – 3 in Calabar River and 2 in the Estuary. Calabar River stations were inshore while the estuarine stations were outshore. Sampling was fortnightly and twice on sampling days to cover flood and ebb tides. Water samples were analyzed for total coliform, fecal coliform and intestinal Enterococci. The highest count of intestinal Enterococci (191cfu/100ml) was recorded in station 3 during flood tide in July. Station 2 had the lowest count (17cfu/100ml) of intestinal Enterococci and this was in November during the dry season and during low tide. The 95th percentile of the highest and lowest count of intestinal Enterococci was 190/100ml and 14/100ml respectively. The highest total coliform count (1900cfu/100ml) was recorded at station 3 in July during flood tide while the lowest (163cfu/100ml) was recorded also station2 during ebb tide in November. Almost the same scenario was observed for fecal coliform. The highest count (250cfu/100ml) was recorded at station 3 in July during flood tide while the lowest count (27cfu/100ml.) was recorded at station 2 in February during ebb tide. Statistical analysis using t- test indicated that there is no significant difference in microbial water quality between Calabar River and the Estuary. All the sampled stations met the WHO, and EC standards for safe recreational waters.

Key Words: *Boating, Swimming, Water quality, Total coliform, Fecal coliform, Enterococci*

Introduction

Rivers have always been the focus of human settlement and recreation. The banks of Calabar River and Estuary are not an exception. Residential, recreational, tourist and industrial developments and roads take place here. The catchment often supports a range of land uses such as housing, agriculture and forestry. All these activities can pollute waterways. Waste discharges, accidental spills, urban and agricultural runoff, and groundwater flow carry a wide range of pollutants which impact water quality (UNEP, 2001).

According to Arnolds and Gibbons (1996), a recognized major source of microbial contamination to surface waters is storm water runoff. Storm water runoff contributes to a significant pollution load in coastal waters as well as in urbanized

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areas. Rain falling on impervious surfaces, including pavement, roofs, sidewalks, patios, bedrock outcrops and compact soil are washed off and carried along into the rainfall runoff and into surface waters. In Wisconsin, for example, the highest levels of *Escherichia coli* in runoff were detected in residential and commercial areas (Bannerman *et al.*, 1993). The bacteria were also from roof, parking lot, driveway and sidewalk sources.

On the other hand, public health and especially the health of beach goers are severely threatened by the disposal of raw sewage to the storm water that flows out into the River. Children, elderly people, and those with relatively lower resistance to infection by bacteria and other microorganisms are especially at risk (City of Sao Paulo, 1998). Adelegen (2004) writing on the history of water resources in Nigeria and the way forward concluded that water pollution has continued to generate unpleasant implications for health and economic development in Nigeria and the third world in general. Also, Asuquo (1999) working on anthropogenic pollution of surface waters of Calabar river concluded that the river is heavily contaminated by hydrocarbons and said the protection of the quality of coastal waters must be reasonably ensured. Similarly, in a prospective study to investigate the microbial water quality of Doula lagoon, Cameroun, Akoachere *et al*. (2008) concluded that the pressure of potential bacterial agents in the lagoon may pose a serious threat to the health and well being of users of the water body and called for urgent intervention. The Calabar River flows through the city of Calabar and into the Estuary. In the city, although there are municipal waste dumping and gathering facilities, solid waste are often left overflowing from dumpsters and spilling on the streets and in the gutters where they decay and may be washed off by surface runoff into nearby waters during the rains. Located at the proximity of the water body are also subsistent farmlands, government and industrial establishments. This is why this study became necessary so as to evaluate which section of the water body is most impacted microbiologically by these anthropogenic activities. The city of Calabar is fast becoming an attractive tourist destination which brings up the need to have a picture of the quality of the coastal waters in terms of its usage for recreation.

Study Area

The Calabar River takes its rise from Oban Hills of the South-Eastern Nigeria and meanders South-North, covering an estimated area of 1669km^2 before discharging into the Cross River Estuary at Calabar (CRBDA, 1982). The River Estuary is located between latitude 4^{0}54$^’$ and 5^{0}50’N and longitudes 8^0 and 8^{0}24$^’$E (figs.1and 2). It ranges in depth from less than 1m at the shores to about 10m along dredged navigational channels. The climate of the Cross River Basin has been described by Eze and Effiong (2010). The area has a wet season which starts in April and ends in September. Average rainfall is 1,830 millimeters and average temperatures range from 24°C to 30°C. Relative humidity is high ranging between 80% and 100%. The dominant vegetation in the study area is mangrove which gives way to the rain forest further north of Calabar. Human settlement with business and agricultural activities are concentrated on the east coast of the River leading to marked reduction in forest cover while the west is thickly forested with little human influence.

Sampling points were selected taking into consideration the anthropogenic activities going on at these sampling stations and also because this area is where the boating and swimming activities take place. Tourists often take boat rides in the River through Marina resort and into the Estuary thereby the need to compare the water quality of the River with that of the Estuary. They take dips in the water from the boats which make this investigation even more relevant. Five stations along the River were identified. Stations 1, 2, 3 are in Calabar River while stations 4 and 5 are in the Estuary (figs.1 and 2). Station 1 is directly beside a municipal urban drainage which drains water directly into the River. Station 2 is directly beside a holiday resort (Marina resort). Marina Resort attracts many visitors, among them tourists. Station 3 is directly beside a fish market. The locals often bathe here. There are also farming activities going on around here. Stations 4 and 5 are along the Estuary and are fishing areas.

Methodology

Sample Collection

Sampling was carried out fortnightly according to Fresenius *et al* (1988) using a research boat – Plankton Fischer. Water samples were collected, put in an ice box (temperature approx. 4^0C) and taken as soon as possible to the laboratory for analysis.

Isolation of Indicator organisms

For the isolation of total and fecal coliform, the membrane filter technique was utilized using Endo medium. Approximately 2ml. of Endo medium was added to the pad contained in the dish. The dish was covered until the water sample has been filtered through the membrane. The filter was then placed on a filter holder and clamped in position below the funnel, and the water sample (100ml.) poured into the funnel and passed through the Millipore filter by the aid of a vacuum pump. The funnel was removed and the filter disk, handled with sterile forceps was then placed on the pad previously impregnated with the endo medium. Total coliform plates were incubated at 35^0C for 20 hours while fecal coliform plates were incubated at 44^0C for the same duration at which time the number of coliform colonies were determined. Presumptive, confirmed and completed tests were carried out (Pelczar *et al* 1977).

KF streptococcus agar was used to isolate intestinal *Enterococci*. Water sample (100ml) was passed through the 0.45µm membrane filter which retains the bacteria. The filter was placed on KF streptococcus agar (in triplicates) and incubated at 35^0C for 48h. Red and pink colonies were counted.

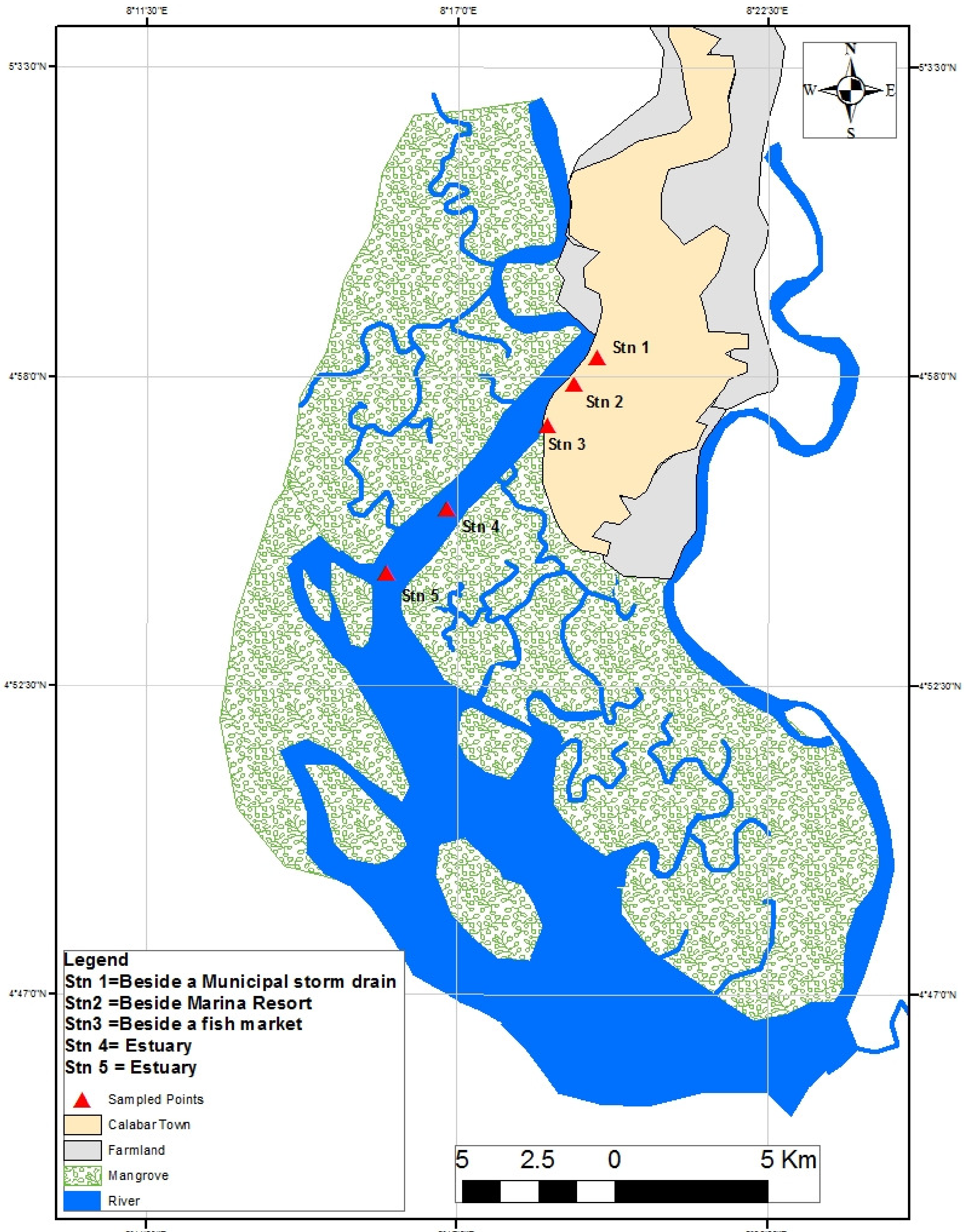

Figure 1: Map of Calabar showing sampled stations

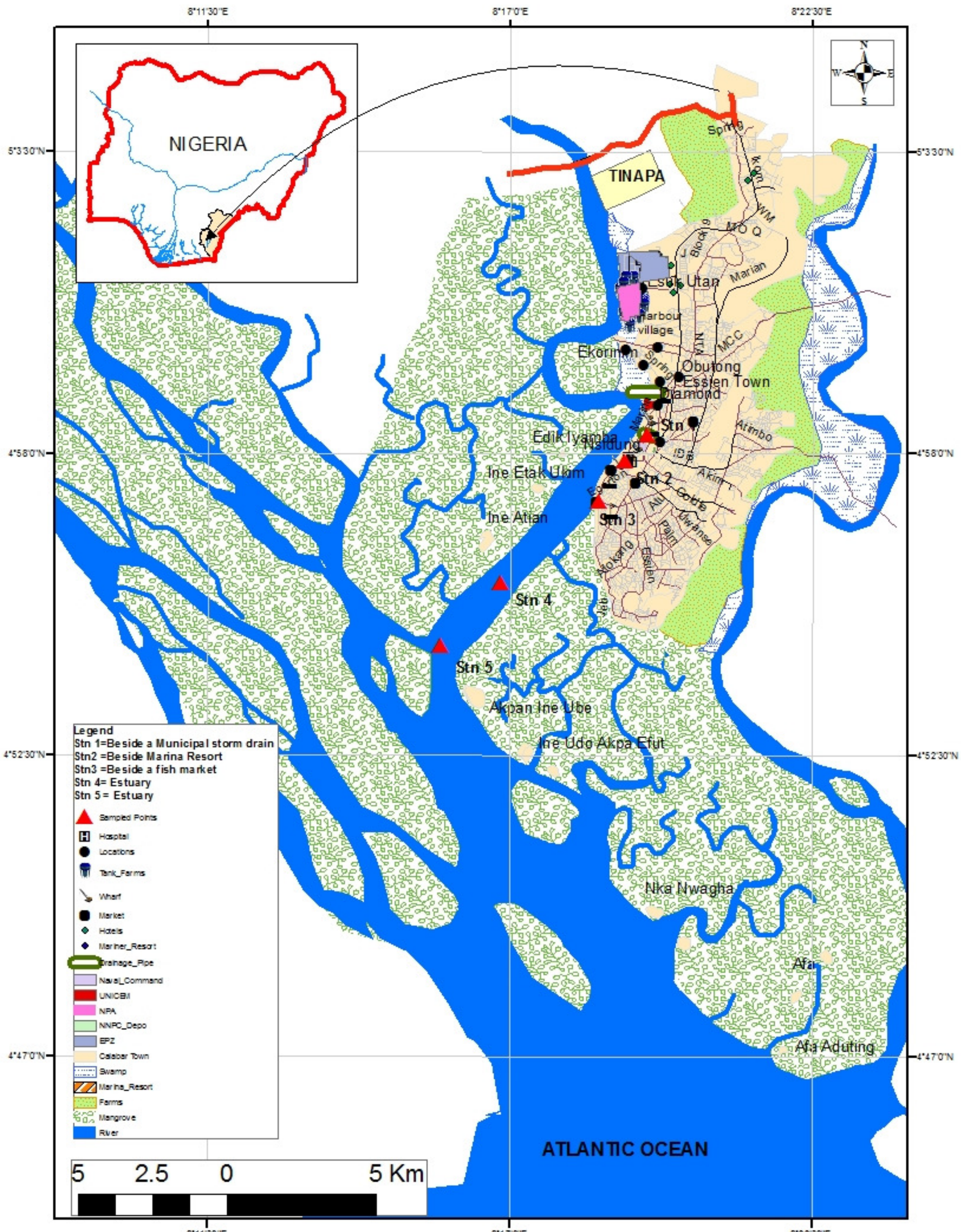

Figure 2: Map of Calabar indicating the immediate anthropogenic environment.

Result

Table 1: Total coliform count in water (cfu/100ml)

Month	Tide	St.1	St.2	St.3	St.4	St.5
Feb.'09	Ft.	509	475	598	426	404
	Et.	386	327	401	379	413
Mar.'09	Ft.	665	588	679	627	602
	Lt.	594	453	509	491	624
Apr.'09	Ft.	795	679	800	473	408
	Et.	798	550	751	480	301
May'09	Ft.	1681	1510	1601	1540	1500
	Et.	1563	1524	1599	1533	1490
June'09	Ft.	1714	1591	1813	1635	1499
	Et.	1312	1246	1401	1398	1579
July'09	Ft.	1874	1617	1900	1572	1696
	Et	1790	1308	1798	1695	1477
Aug.'09	Ft.	1453	1329	1521	1195	1239
	Et.	1381	1193	1586	902	1006
Sept.'09	Ft.	1128	1083	1095	983	1001
	Et.	1140	986	1002	996	998
Oct.'09	Ft.	800	579	648	573	600
	Et.	721	400	480	382	472
Nov.'09	Ft.	460	200	640	600	520
	Et.	378	163	501	471	371
Dec.'09	Ft.	1660	1240	1440	1020	931
	Et.	1295	939	1401	926	560
Jan'2010	Ft.	795	679	800	627	601
	Et.	798	550	751	491	624

Table 2: Fecal coliform count in water (cfu/100ml)

Month	Tide	St.1	St.2	St.3	St.4	St.5
Feb. '09	Ft.	37	30	41	37	34
	Et.	32	27	35	35	36
Mar. '09	Ft.	53	45	59	42	47
	Et.	48	40	50	44	41
Apr. '09	Ft.	67	58	61	55	52
	Et.	69	54	59	51	53
May '09	Ft.	190	178	187	170	176
	Et.	183	180	181	164	160
June '09	Ft.	198	193	201	188	189
	Et.	190	194	197	183	191
July '09	Ft.	205	183	250	194	95
	Et.	187	184	189	173	82
Aug. '09	Ft.	181	179	194	165	176
	Et.	174	171	178	167	168
Sept. '09	Ft.	158	142	152	136	147
	Et.	149	137	154	130	144
Oct. '09	Ft.	130	141	126	118	124
	Et.	121	127	129	120	122
Nov. '09	Ft.	98	83	119	89	87
	Et.	91	76	129	72	77
Dec. '09	Ft.	200	172	182	164	147
	Et.	191	174	176	158	140
Jan. '09	Ft.	127	119	153	110	110
	Et.	113	106	138	112	112

Table 3: Intestinal *Enterococci* count in water (cfu/ml)

Month	Tide	St.1	St.2	St.3	St.4	St.5
Feb. '09	Ft.	52	49	59	44	42
	Et.	39	34	39	39	43
Mar. '09	Ft.	68	60	69	60	60
	Et.	58	46	52	47	62
Apr. '09	Ft.	78	66	81	49	44
	Et.	77	54	77	50	31
May '09	Ft.	169	152	158	152	148
	Et.	157	153	155	151	147
June '09	Ft.	172	160	180	165	153
	Et.	132	126	139	141	155
July '09	Ft.	188	163	191	159	171
	Et.	181	132	180	171	
						149
Aug. '09	Ft.	147	131	154	117	121
	Et.	140	118	160	91	123
Sept. '09	Ft.	114	108	111	98	101
	Et.	115	97	102	101	103
Oct. '09	Ft.	80	59	66	59	63
	Et.	73	39	49	39	49
Nov. '09	Ft.	47	21	63	60	52
	Et.	39	17	48	48	54
Dec. '09	Ft	167	125	144	102	95
	Et.	131	95	139	90	59
Jan. 10	Ft.	78	66	82	64	58
	Et.	79	54	76	51	53

Table 4: 95th Percentile of intestinal *Enterococci* count

Month	Tide	St.1	St.2	St.3	St.4	St.5
Feb.'09	Ft.	50	45	58	42	41
	Et.	36	32	35	36	41
Mar.' 09	Ft.	65	57	68	56	59
	Et	57	42	50	42	62
Apr. '09	Ft.	77	66	75	47	37
	Et.	73	65	74	48	27
May '09	Ft.	162	151	154	148	143
	Et.	156	152	150	149	144
June '09	Ft.	166	159	176	158	151
	Et.	127	125	136	135	147
July '09	Ft.	186	160	190	154	170
	Et.	177	131	172	159	147
Aug. '09	Ft.	196	128	152	112	119
	Lt.	139	117	155	89	122
Sept. '09	Ft.	107	100	107	96	96
	Lt.	114	95	100	97	102
Oct. '09	Ft.	79	49	58	58	56
	Et.	71	34	44	36	46
Nov. '09	Ft.	46	14	61	56	51
	Et.	38	14	47	46	49
Dec. '09	Ft.	166	123	143	101	89
	Et.	125	90	132	89	50
Jan. '10	Ft.	70	65	80	55	53
	Et.	72	50	75	49	52

Table 5: Variation in microbial water quality between the near-shore and estuary waters of Calabar River Estuary

Parameter	T	df	Sig.
Total Coliform count	1.458	46	0.152
Fecal Coliform count	1.258	46	0.215
Intestinal *Enterococci*	1.359	46	0.181

Discussion

Total coliform count in Calabar River ranged from 163-1900cfu/100ml while count in the Estuary ranged from 301-1696cfu/100ml (table 1). Fecal coliform count in Calabar River ranged from 27-250cfu/100ml while count in the Estuary ranged from 34-194cfu/100ml (table 2). The highest total coliform count was recorded in station 3 which is in Calabar River during the wet season at flood tide (figure 3). For fecal coliform the highest count was also recorded in station 3 in Calabar River during the wet season at flood tide (figure 5). Omoigberale *et al* (2013) investigated seasonal variation in the bacteriological quality of Ebutte River in Edo state, Southern Nigeria and reported that bacterial counts were highest in the wet season and the least total viable count were recorded in the dry season month of January. Human activities in this station as hitherto described may also have played a significant role in the higher number of both total and fecal coliforms at station 3. Edun and Efiuvwevwere (2012) in their work on bacterial profiles and physico-chemical parameters of water samples from different sites in the new Calabar River, Nigeria reported that the different sites had different bacterial and physico-chemical parameters profile and attributed this to the anthropogenic and industrial activities of the sites.

The lowest counts for both total and fecal coliform were recorded in station 2 (figures 2 and 4). This could be attributed to the fact that the station is directly beside Marina resort which is very well kept with no negative human activities such as using the environment there as a toilet as in station 3. Although the lowest counts of both total and fecal coliform were recorded in Calabar River, Stations 4 and 5 in the estuary had relatively lower total and fecal coliform counts (tables 1 and 2). The highest total and fecal coliform count for these estuarine stations were 1696cfu/ml (table 1) and 194cfu/ml (table 2) respectively while the highest in Calabar River were 1900cfu/ml and 250cfu/ml respectively for total coliform and fecal coliform.

According to extracts from the WHO (2003) and EC (2002) guidelines, the number of total coliform in bathing waters should not be more than 10,000 cfu (Colony forming units) in 100ml of the water. Also, the number of fecal coliform in 100ml of the water should not be more than 2,000cfu in this study, all the stations satisfied the above stated standards.

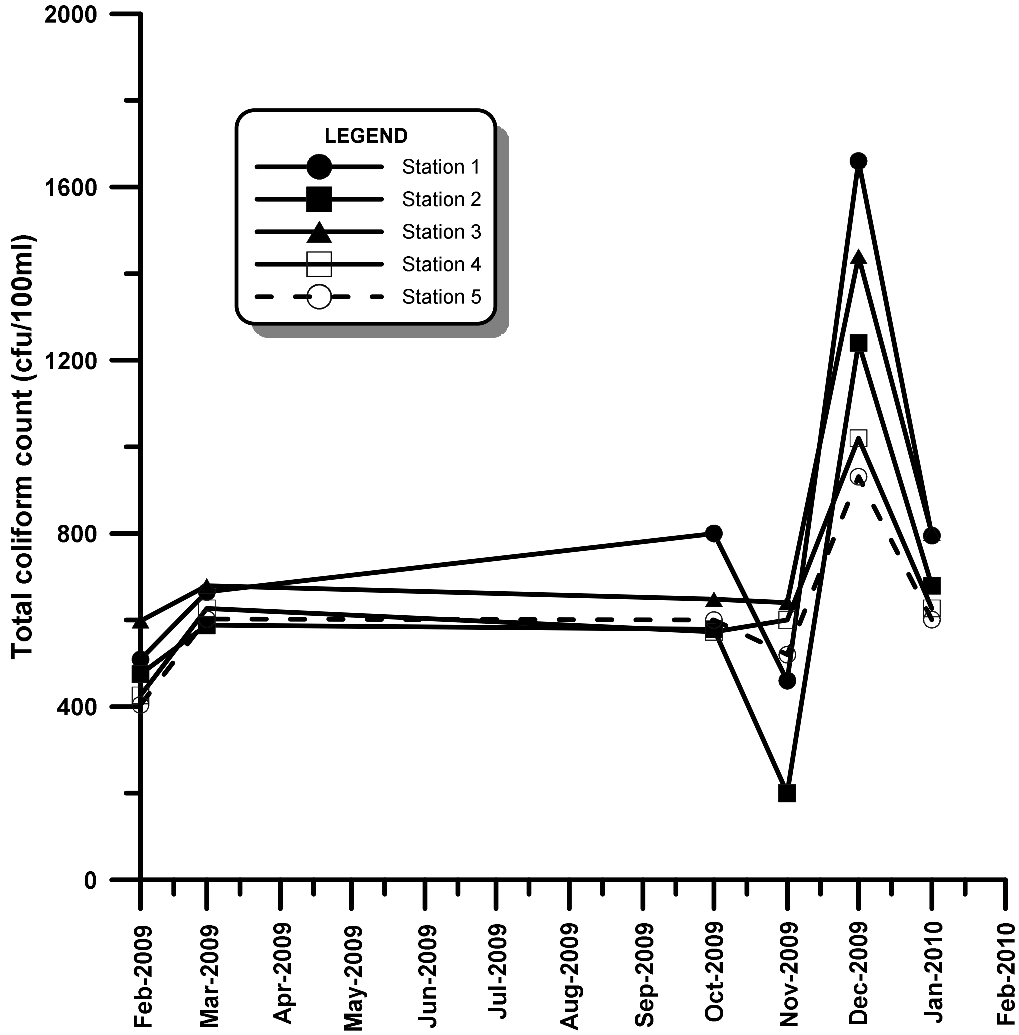

Figure 2: Plot of total coliform during dry season months at ebb tide

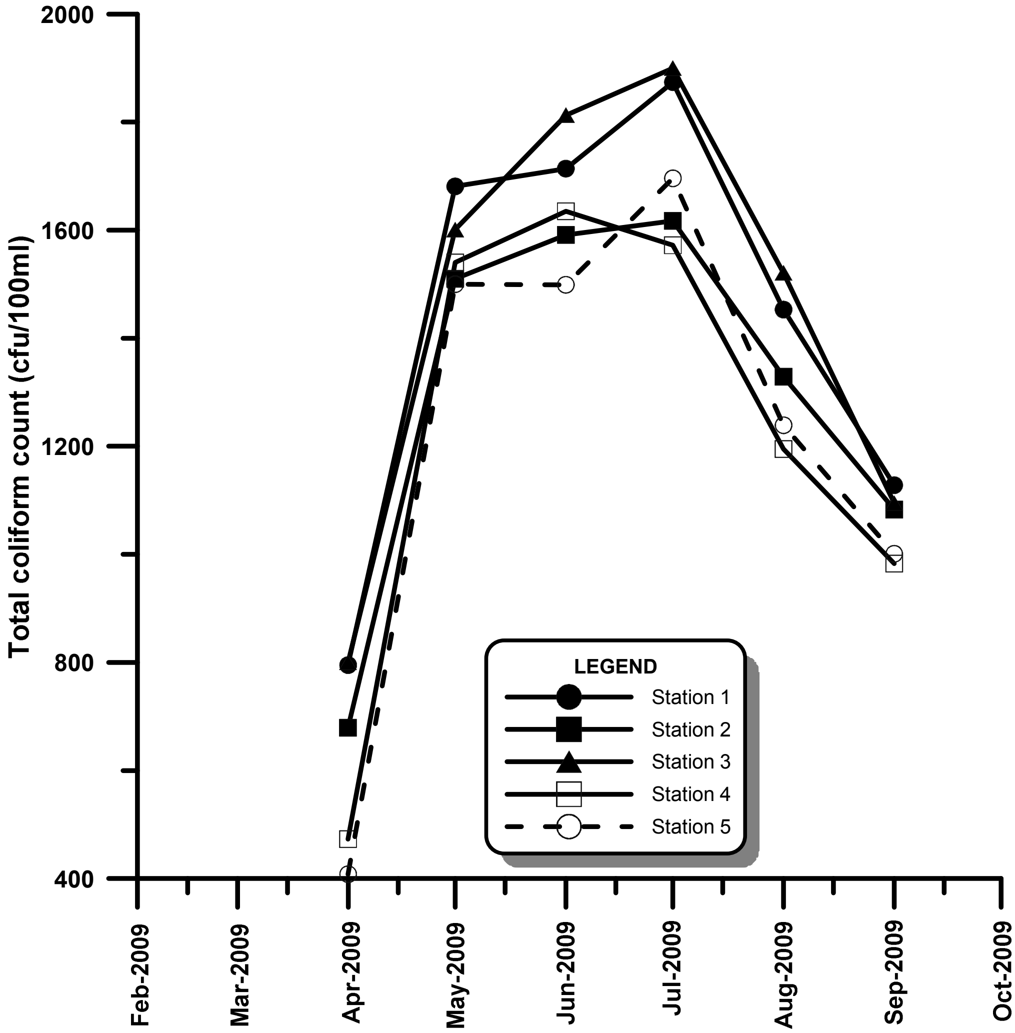

Figure 3: Plot of total coliform count during wet season months at flood tide

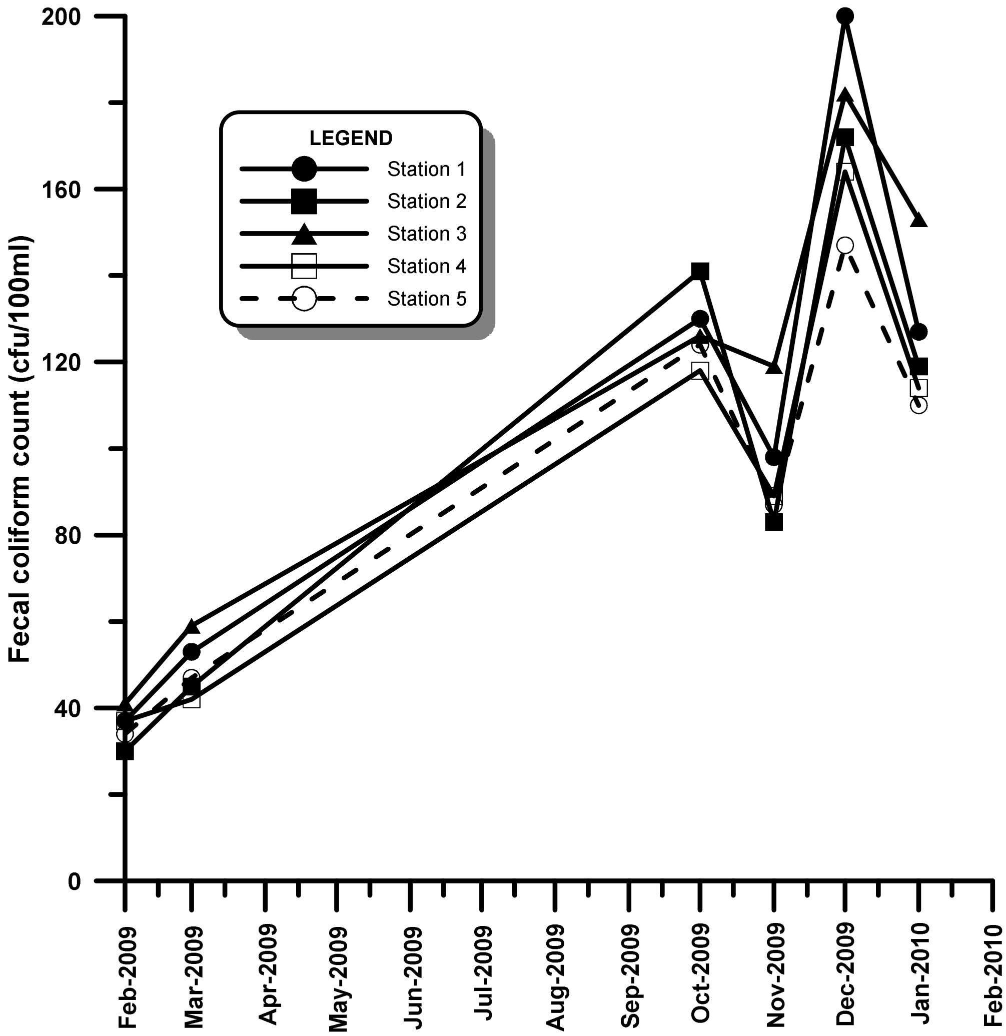

Figure 4: Plot of fecal coliform count during the dry season at ebb tide

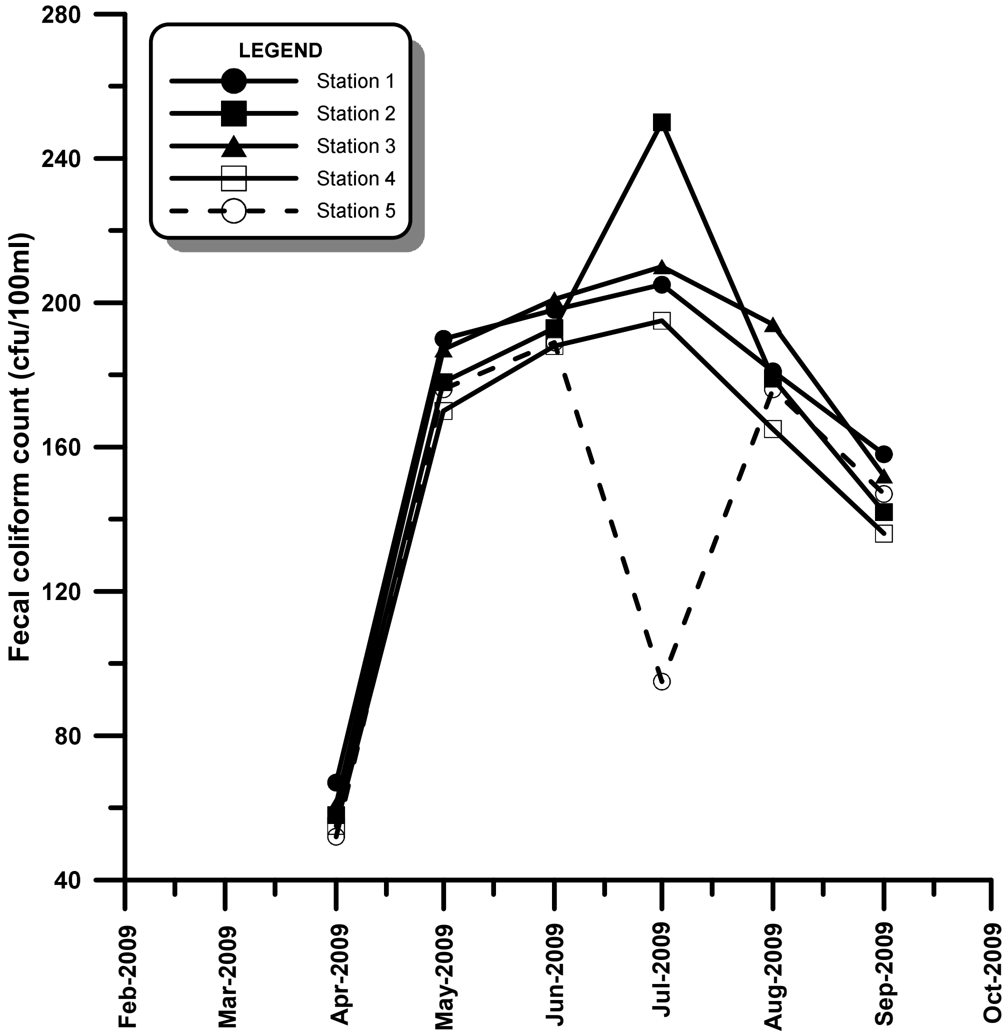

Figure 5: Plot of fecal coliform count during wet season months at flood tide.

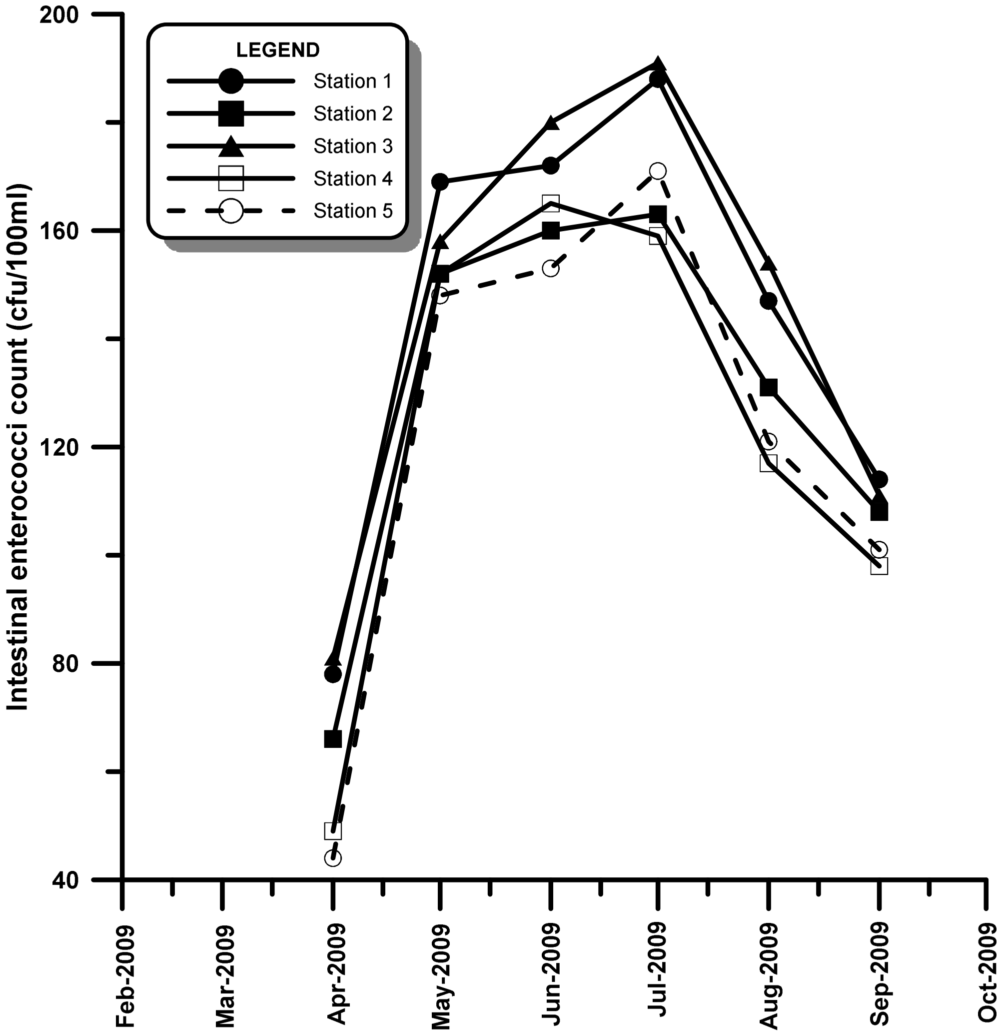

Figure 6: Plot of intestinal *Enterococci* count during the wet season months at flood tide

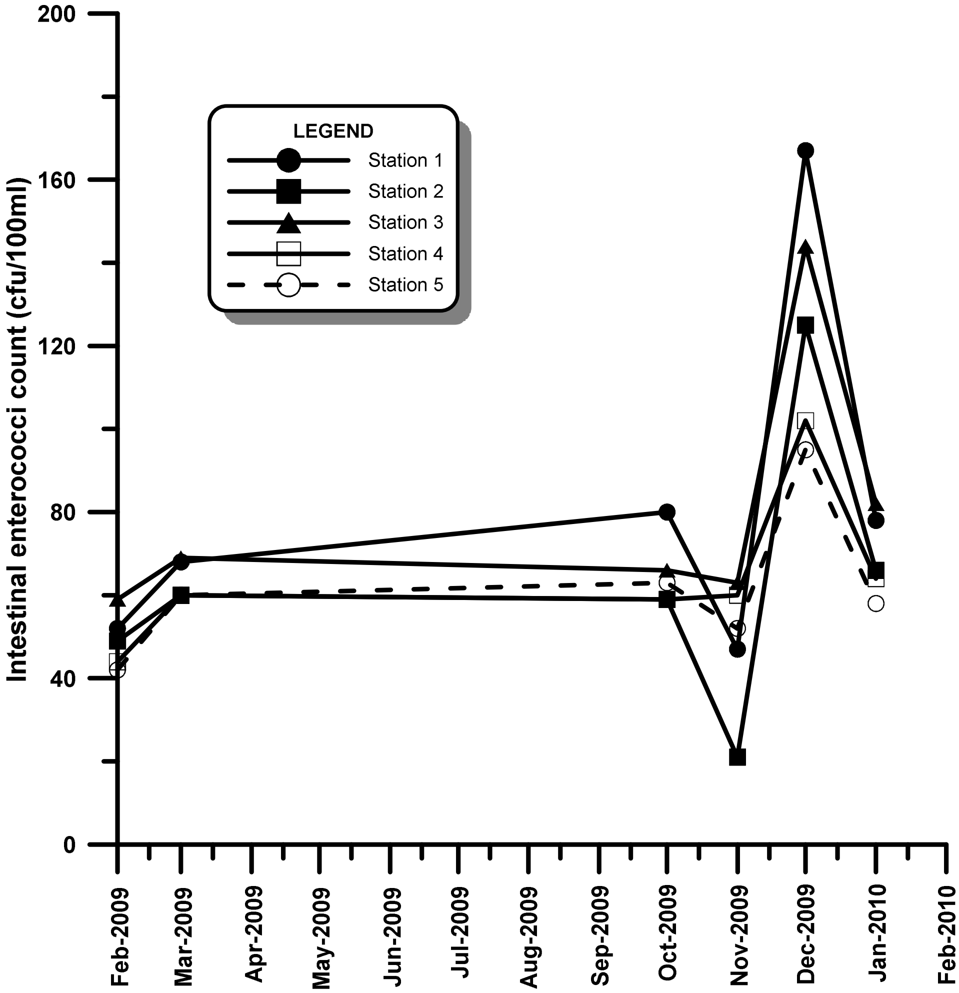

Figure 7: Plot of intestinal *Enterococci* count during dry season months at ebb tide

For intestinal *Enterococci*, the count in Calabar River ranged from 17 – 191cfu/ml while the count in the Estuary ranged from 31 – 171cfu/ml (table 3). Stations 1-3 were in Calabar River while stations 4-5 were in the Estuary. Although the highest count was recorded in Calabar River, a sampling station here (station 2) just like in the case of total and fecal coliform also recorded the lowest count of intestinal *Enterococci* during this study (17cfu/100ml). The 95th percentile value of intestinal *Enterococci* at this station was 14/100ml (table 4). As already mentioned, station 2 is directly beside Marina resort. The resort attracts visitors who sometimes take boat rides in the water. This is good news as it indicated that this was the safest point among the sampled stations for recreational activity in the water and is where tourists are often seen taking dips in the water while on boat rides.

The highest count of intestinal *Enterococci* (191/100ml) was recorded at station 3 also during the wet season at flood tide (figure 6) while the lowest was recorded at station 2 in November (figure 7). The 95th percentile was 190/100ml (table 4). As already mentioned, station 3 has a lot of human activities going on. The station is beside a fish market. Moreover, many locals defecate into the water here and are often seen bathing in the River water here. There are also farming activities going on in the area surrounding this sampling station. Organic and inorganic fertilizers are freely used. This beach area is also where fishermen take off and land as they undertake their fishing activities. The local people are frequently cooking, washing cooking utensils and plates here. All these human activities may have contributed to the high intestinal *Enterococci* load at this sampling station. Station 4 and 5 which are in the Estuary had the lowest count of intestinal *Enterococci*. For example, the lowest count throughout the sampling period was recorded in station 5 (table 5). This could be attributed to the far distance between these stations and the land from where human activities impact microbial water quality. Mallin *et al.* (2000) had reported that the most important anthropogenic factor associated with bacterial abundance was percentage watershed – impervious surface coverage which consists of roofs, roads, driveways, sidewalks and parking lots. These surfaces serve to concentrate and convey storm water-borne pollutants to downstream receiving waters which explain why the inshore stations had more bacterial load than the estuarine ones. Their work again demonstrates the influence of human activities on the microbial profile of a water body.

The World Health Organization guidelines for safe recreational waters (WHO, 2003) recommend 95th percentile value of intestinal *Enterococci* per 100ml of water sample of 40 – 500 depending on the category of the water. WHO (2003) has four categories, A-D: In category A water, the 95th percentile value should not be more than 40/100ml. of water. This value relates to an average probability of less than one case of gastroenteritis in every 100 exposures. The acute febrile respiratory illness (AFRI) burden would be negligible. In category B water, the 95th percentile value of *Enterococci* should be 41-200/100ml of water. This value relates to an average probability of one case of gastroenteritis in 20 exposures. The AFRI illness rate at this upper value would be less than 19 per 1000 exposures, or less than approximately 1 in 50 exposures. Category C water is bathing water that has 95th percentile of 201-500/100ml. The value represents a probability of 1 in 10 to 1 in 20 gastroenteritis for a single exposure. Exposures in this category also suggest a risk of AFRI in the range of 19-39 per 1000 exposures, or a range of approximately 1 in 50 t0 1 in 25 exposures. Category D bathing water has more than 500/100ml. In this range, there is a greater than 10% chance of gastroenteritis per single exposure. The AFRI illness rate at this range would be greater than 39 per 1000 exposures, or greater than approximately 1 in 25 exposures. Above this level, there could be a major risk of high incidences of minor illness transmission (UNEP, 2001)

Conclusion

In this study, none of the sampled stations had 95th percentile of intestinal *Enterococci* of more than 200/100ml of the water which means sampled stations were in categories A and B and met the WHO standard (WHO,2003) for safe recreational waters as far as intestinal *Enterococci* count was concerned. As expected, it was observed that standards were better during the dry season (table 6). These standards are however for healthy adults and may not relate to children, the elderly or the immunocompromised, who could have lower immunity and might require a degree of protection

As indicated in table 7 the t-value of total coliform count was 1.458 at 46 degrees of freedom and 0.152 significant level. The t-value of fecal coliform count was 1.258 at 46 degrees of freedom and 0.215 significant value. By the same token, the t-value of intestinal *Enterococci* count was 1.359, at 46 degrees of freedom and 0.181 significant level. The table shows that none of the significant levels is less than or equal to 0.05 which concludes that there was no significant difference in microbial water quality between Calabar River and the estuary.

References

Adelegen, J.A. (2004). The history of environmental policy and pollution of water resources in Nigeria (1960-2004): the way forward. http://userpage.fu-berlin.de/ffu/akumwelt/be2004/download/adelegen-f.pdf

Akoachere, J.T.K., Oben, P.M., Mbivnjo, B.S., Ndip, L.L.M., Nkwelong, G. and Ndip, R.N. (2008). Bacterial indicators of pollution of the Doula lagoon, Cameroon: Public Health implications. *African Health Science*. 8(2): 85-89.

Arnold, C.L. and Gibbons, C.J. (1996). Inpervious surface coverage: The emergence of a key environmental indicator. *Amer. Planning Assn. J.*, 62: 243-258.

Asuquo, F.E. (1999). Physicochemical characteristics and anthropogenic pollution of the surface waters of Calabar River, Nigeria. *Global Journal of Pure and Applied Sciences,* 5(4): 595-600.

Bannerman, R.T., Owens, D.W., Dudds, R.B. and Hornewer, N.J. (1993). Sources of pollutants in Wisconson storm water. *Water Sci. Tech.*, 28: 241-259.

City of Sao Paulo (1998). Secretaris de Estado Meio Ambiente Balneabilidade das praisas paulistas.

CRBDA (1982). Inventory of natural site conditions, soils, slopes, hydrology, land use and vegetation throughout the area of operation of the authority. *Progress report* no. 4, 145p.

EC (2002). EC Bathing Water Directive 76/160/EEC and its proposed revision. http://www.europa.eu.int/water/water-bathing/index en. html.

Edun, O.M. and Efiuvwevwere, B.J.O. (2012). Bacterial profiles and physicochemical parameters of water samples from different sites of New Calabar River, Nigeria. Sustainable Agricultural Research. Vol. 1, no. 2.

Eze, B.E. and Effiong, J. (2010). Morphometric parameters of the Calabar River Basin: Implications for hydrologic processes. *Journal of Geography & Geology,* 2(1): 18-26.

Mallin, M.A., Williams, K.E., Esham, E.C. and Lowe, R.P. (2000). Effect of human development on bacteriological water quality in coastal watersheds. *Ecological Applications*, 10(4): 1047 – 1056.

Omoigberaele, M.N.O., Isibor, J.O., Izegaegbe, J.I. and Iyamu, U.I. (2013). Seasonal variation in the bacteriological quality of Ebutte River in Ehor community , Edo State, Nigeria. *Amer. Journ. of Res. Comm.* 1(7): 59-69.

Pelczar, M. J., Roger, D.R. and Chan, E.C.S. (1977). Microbiology. Fourth Edition. McGraw – Hill Inc.

UNEP (2001). Protecting the Oceans from land-based activities. Rep. Stud. GESAMP No. 71, 162pp.

WHO (2003). Guidelines for safe recreational water environments. Vol. 1. Coastal and Fresh Waters. 70-71.