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Comparative Study of Sediments Samples from Brackish and Fresh Water in the Lower Niger Delta, Nigeria

Woke, G.N.[1]; Umesi, N[2]

[1, 2]*Dept of Animal and Environmental biology, University of Port Harcourt, Choba, Nigeria.*

***Corresponding Author:** Woke, G.N, Dept of Animal and Environmental biology, University of Port Harcourt, Choba, Nigeria.*

ABSTRACT

Brackish and freshwater of the New Calabar River, Port Harcourt, were investigated in order to determine whether the industrial effluent and other anthropogenic inputs had direct impacts on the water quality of the River. Sediments and water samples collected from Brackish and freshwater were indices used as environmental indicators for comparative studies. A total of 192 individuals with Capitella sp the most dominant were recorded in brackish water compared to 169 individuals with Tubificid sp the most dominant in freshwater respectively. The percentage composition of macroinvertebrates was: Polychaeta (36.6%), Crustacea and Insecta (18.18%) each, Oligochaeta, Gastropoda and Bilvalvia (9.09%) each for Brackish water compared to Oligochaeta, Hirudinea and Insecta (25%) each, Crustacea and Gastropoda (12.5%), each for fresh water respectively. Comparative water analysis showed that the mean temperature (27.77 ± 0.170C and 28.00 ± 0.180C), pH (7.12 ± 0.01 and 6.23 ± 0.03), TDS - total dissolved solids (2657.00 ± 24.4 mg/L and 19.84 ± 0.40 mg/L), TSS - total suspended solids (506.55 ± 9.26 mg/L and 9.90 ± 0.14 mg/L), Salinity (6269.95 ± 67.25 mg/L and 7.19 ± 0.04 mg/L), DO - dissolved oxygen (6.34 ± 0.06 mg/L and 6.09 ± 0.01 mg/L), BOD - biochemical oxygen demand (17.53 ± 0.11 mg/L and 51.06 ± 0.20 mg/L) for Brackish and fresh water respectively. Results showed a significant difference among the variables ($p < 0.05$) and some were above the WHO limits. The study revealed the need for continuous pollution monitoring and management programme of surface water in Rivers State and Nigeria as a whole.

Keywords: *Freshwater, Brackish Water, Sediment, Pollution, Biological Oxygen Demand.*

INTRODUCTION

The quality of life on earth is linked inextricably to the overall quality of the environment (Vidali, 2001), thus, the aquatic phase of the environment is an important segment of the total environment. This includes both ground and surface water (Kpee and Nwadinigwe, 2014). Water is essential compounds to the ecosystem (Manjare et al, 2010), a sine qua non for life in all its forms, having unique properties which enable aquatic system to be unusually resistant to extreme environmental) fluctuations, unlike terrestrial and atmospheric systems (Eja, 2002). Water has many uses including physiological, domestic, industrial, recipient of waste, agricultural, irrigation etc, the medium by which materials make their never ending odyssey through the ecosystem (Woke, 2011) demand to such a high level that all the available oxygen may be removed, consequently causing the death of all aerobic species e.g. fish (Maduka, 2004). Therefore, the stress encountered by the organisms in such ecosystems become magnified in the presence of pollutants as the organisms have to contend with sudden or prolonged alteration in the physico-chemical quality of their environment (Woke & babatude, 2009). It is now generally accepted that aquatic environment cannot be perceived simply as holding tanks that supply water from human activities. Rather, these environments are complex matrices that require careful use to ensure ecosystem functioning well into the future (UNEP GEMSP, 2000).

Sediments and some physico-chemical parameters of water from the brackish and fresh water regions of the New Calabar River are the indices used in carrying out this study. Thus, the present study was aimed at comparing the differences in sediments and water quality of the brackish and freshwater regions with reference to conventional national and international standards.

MATERIALS AND METHODS

Study Area

The study area is the New Calabar River which lies on the eastern arm of the Niger Delta (RPI, 2006). It is a tributary of River Niger and River Benue that form a Delta plain in the Niger Delta

area. The entire river course tranverses through five local government areas of Rivers State viz: Ikwerre, Obio/Akpor, Emohua, Degema, Asari-Toru, between longitude 006^0 53.086"E ($7^0$60'E) and latitude $04^0$53' 19.020"N ($5^0$45'N) in the coastal area of the Niger Delta, Nigeria (Fig. 1) it is one of the series of the Niger Delta Rivers which drain into the Atlantic Ocean and is connected to other rivers via Creeks in the coastal area of the Niger Delta (Ezekiel, 2001). At the source (Choba) the water is fresh and acidic but brackish at the month (Iwofe). Choba is the upstream part of the river where the water is fresh and tidal while Ogbakiri and Iwofe are downstream (Edun and Efiuvwevwere, 2012). However, the river is a major source of fish, shrimps and crabs, fringed by riverside swamp forest; houses, an abattoir, poultry, a fabrication company and a weekly market.

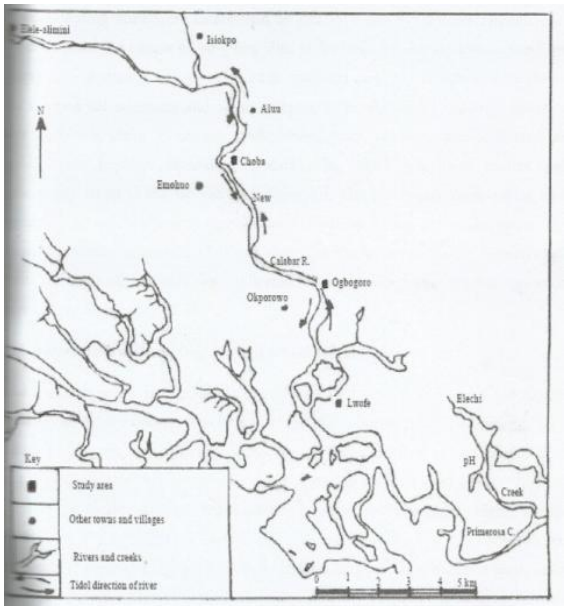

Fig1. *Map of the New Calabar River showing locations of the Brackish and Freshwater (Source: Edun and Efiuvwevwere, 2012).*

Sampling Stations

Two sampling sites were established as Brackish and freshwater respectively. The criteria for the choice of sampling sites at the brackish and freshwater were for comparative studies.

Sampling site (Brackish water) the brackish water is a tidal environment located around Ogbogoro and Iwofe communities where human population is high and industries are concentrated. The vegetation fringing the river at the left and right banks consists of mangrove plants such as *Rhizophora, Avicennia* and *Nypha fruticans* (Nypa palm); arising from a characteristic muddy substrate that produces a foul odor.

Sampling Site (freshwater)

The freshwater has a little tidal influence from the immediate tidal mangrove zone. It is located around Choba community where human and industrial population is low compared to the brackish water. The vegetation fringing the river at the right banks consist of mangrove plant such as *Nypha fruticans* (Nypa palm) etc. while the left bank consists of seaweeds and borders toward the market. An abattoir was seen and also public toilets which discharge waste into the river. Human activities like dredging, fishing, transportation are prevalent in the area.

Field and Laboratory Procedure

Water and sediment samples lasted from August to October, 2017. Sediment samples were collected with an Eckman's grab of 10cm diameter and 12cm long. Samples from each site were washed using 0.5m mesh sieve. The residue in the sieve was then emptied into a wide mouth labelled plastic container and preserved with 10% formalin to which Rose-Bengal was added. The preserved samples were transported to the laboratory for subsequent analysis. Benthic invertebrates were sorted out by transferring successive quantities of preserved residue into a white plastic tray. Each identified species or taxon was counted and the number recorded.

Water Sampling

Duplicate water samples were collected from brackish and fresh water along the New Calabar River in the morning hours between 9 to 11am with IL polyethylene bottles. The bottles were rinsed about 2 – 3 times with the river water before collection, in insitu measurement recorded before samples were immediately transported to the laboratory and analysed within 24 hours of collection. The physical and chemical parameters analysed were: temperature, pH, (TDS), (TSS), Salinity, (DO), (BOD) and (COD). The method used was as described by APHA, 1998.

Results and Discussion

A total of eleven (11) species belonging to ten (10) families of benthic invertebrates were identified in the brackish water compared to eight (8) species, belonging to seven (7) families in the freshwater (Table 1 and 2). The summary of the individual species and composition of benthic macro-invertebrates from brackish and freshwater are presented in Table 3. The results value obtained showed that brackish water has a

total number of 192 species as compared to freshwater that has only 169 species.

The results further showed that *Capitella* sp in brackish water have the highest number of 50 species as compared to none in fresh water with a mean density of $25m^3$. While in freshwater, *Tubificid* sp has the highest number of 60 species as compared to none in brackish water with a mean density of $30m^3$ (Table 3). Also, in terms of percentage composition polychaetes were dominant with highest species of four (4), having 36.6% while Crustaceans and Insect had two species of 18.8%, followed by Oligochaetes, astropods and Bivalves that had one (1) species and with composition of 9.09% in brackish water (Table 4), compared to freshwater where the Oligochaetes, Hirudineans and Insect were dominant with highest species of two (2) each, all having a similar percentage composition of 25.0%, Crustaceans and Gastropods had one (1) species each with percentage composition of 12.5% (Table 5) (Fig. 2).

Table1. *Benthic Macro Invertebrates Collected from Brackish water, New Calabar River*

Phylum	Annelida
Class	Polychaeta
Family	Nereidae
	Nereis succinea
	Namalycastis indica
Family	Eunicidae
	Marphysa sp
Family	Capitellidae
	Capitella sp
Class	Oligochaeta
Family	Naididae
	Allonais sp
Phylum	Arthropoda
Class	Crustacean
Family	Grapsidae
	Sesarina alberti
Family	Diogenidae
	Clibanarus africans
Class	Insecta
Family	Chironomidae
	Endochironomus sp
Family	Syrphidae
	Tubifera sp
Phylum	Mollusc
Class	Gastropoda
Family	Potamididae
	Tympanotomus fuscatus
Class	Bilvalvia
Family	Tellinoidae
	Tellina sp

The mean values and standard deviation of the physico-chemical parameters of brackish and freshwater are presented in (Table 6). The mean temperature value for brackish water was 27.77 ± 0.17^0C while that of freshwater was 28.00 ± 0.18^0C, the difference in temperature values were not statistically significant ($p > 0.05$), followed by pH mean values in brackish water 7.12 ± 0.01 and freshwater 6.23 ± 0.03, TDS mean value 2657.00 ± 24.04 mg/L and freshwater 19.84 ± 0.40 mg/L. Indeed, it was observed that the brackish water was more turbid than freshwater. Furthermore, mean dissolved oxygen (DO) in brackish water was 6.34 ± 0.6 mg/L while that of freshwater was 6.09 ± 0.01 mg/L. BOD value was 17.53 ± 0.11 mg/L in brackish water as compared to freshwater 19.99 ± 0.022 mg/L.

Values for COD were higher in brackish water than in fresh water with a mean of 59.18 ± 0.04 mg/L in the former and 51.06 ± 0.20 mg/L in the later respectively. Salinity in the brackish water was higher (mean value 6269.95 ± 67.25 mg/L), as compared to the freshwater with mean value of 7.19 ± 0.04 mg/L. It was also observed that salinity fluctuated in both water bodies.

Table2. *Benthic Macro Invertebrates Collected from Fresh Water, New Calabar River*

Phylum	Annelida
Class	Oligochaeta
Family	Tubificidae
	Tubificid sp
Family	Euriudae
	Libyodrilus sp
Class	Hirudinea
Family	Hirudinidae
	Hirudo medicinalis
	Limnobdella australis
Phylum	Arthropoda
Class	Crustacean
Family	Palaemonidae
	Desmocaris trispinosa
Class	Insecta
Family	Chironomidae
	Chironomons larvae
Family	Nepidae
Phylum	*Ranatra* sp
	Mollusca
Class	Gastropoda
Family	Lymneidae
	Lymnea natalensis

Table3. *Summary of Individual Species and Composition of Benthic Macro Invertebrates from Brackish and Freshwater of the New Calabar River*

Class	**Species**	**Brackish water**	**Fresh water**	**Mean**
Polychaeta	*Nereis succinea*	8	-	9
	Namalycastis indica	15	-	7.5
	Marphysa sp	41	-	20.5
	Capitella sp	50	-	25
Oligochaeta	*Allonais* sp	6	-	3
	Tubificid sp	-	60	30
	Libyodrilus sp	-	14	7
Hirudinea	*Hirudo medicinalis*	-	21	10.5
	Limnobdella australis	-	10	5
Crustacea	*Sesarina alberti*	2	-	1
	Clibanarus africana	4	-	2
	Desmocaris trispinosa	-	9	4.5
Insecta	*Endochironomons* sp	20	-	10
	Tubifera sp	30	-	15
	Chironomons larvae	-	30	15
	Ranatra	-	10	5
Gastropoda	*Tympanotonins fascatus*	3	-	1.5
	Lymnea natalensis	-	15	7.5
Bilvalvia	*Tellina* sp	3	-	1.5

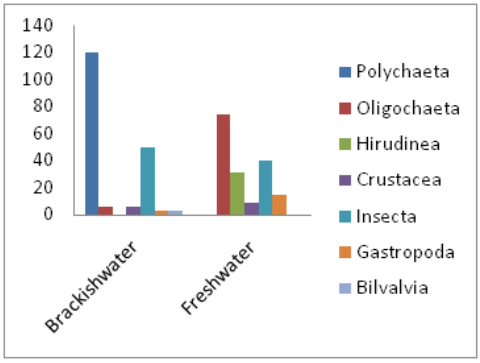

Fig2. *Spatial variation in brackish and freshwater of the New Calabar River*

Table4. *Percentage Composition of Benthic Macro Invertebrates from Brackish Water*

Class	Total No. of family	Total No. of species	Percentage composition
Polychaeta	3	4	36.36
Oligochaeta	1	1	9.09
Hirudinea	Not detected	Not detected	0
Crustacean	2	3	18.18
Insecta	2	2	18.18
Gastropoda	1	1	9.09
Bilvalvia	1	1	9.09
Total	**10**	**11**	**99.99**

Table5. *Percentage Composition of Benthic Macro Invertebrates from Fresh Water*

Class	Total No. of family	Total No. of species	Percentage composition
Polychaeta	Not detected	Not detected	0
Oligochaeta	2	2	25
Hirudinea	1	2	25
Crustacean	1	1	12.5
Insecta	2	2	25
Gastropoda	1	1	12.5
Bilvalvia	Not detected	Not detected	Not detected
Total	**7**	**8**	**100**

DISCUSSION

It was inevitable to determine if anthropogenic inputs had any substantial adverse impact on the aquatic ecosystem, measured by indicator species in sediments and the physico-chemical characteristics of water in the study area (Johnson, 1995).

The low diversity of benthic fauna recorded in this study is not unusual for tropical waters. For instance, in Lake George, Uganda, the variation in horizontal distribution of benthos was attributed to the texture and stability of the substrate (Darlington, 1977), thus the bottom fauna were poor in species (Burgis *et al*, 1993, Woke & Wokoma, 2006). The significantly lower diversity of organisms during the rainy season was partly attributed to the indirect effect of the rains in the substrate. It was pointed out that during this period, the substrate is unstable, being either washed off or submerged, especially during the flood season (September to November).

The highest abundance of polychaetes is *Capitella* sp from brackish water which may be associated with coarse and sandy substration as well as silt clay fraction. The sandy substrate fraction of silt may have contributed to the increased mean density of *Capitella* sp. which is capable of settling quickly in disturbed environment and is able to survive toxic conditions other species cannot tolerate (Woke and Wokoma, 2007). Ajao and Fagade (2002) in a study reported the abundance of *Capitella capitata*, *Nereis* sp and *Polydora* sp are found in polluted areas of Lagos lagoon and they concluded that diversity indices indicated that the communities exhibited high dominance with a small number of species. The presence of these species implies that brackish water is highly polluted.

Table6. *Mean values ± SD of the physico-chemical parameters of the Brackish and freshwater*

Parameters	Brackish water	Fresh water	WHO[d]	Standards
Temp. ^{0}C	27.77 ± 0.17	28.00 ± 0.18		23 – 35[a]
pH	7.12 ± 0.01*	6.23 ± 0.03	6 – 9.5	6.5 – 9[a]
TDS (mg/L)	506.55 ± 9.26*	19.84 ± 0.40	1500	2000[c]
TSS (mg/L)	506.55 ± 9.26*	9.90 ± 0.14	50	30[a]
Salinity (mg/L)	6269.95 ± 67.25*	7.19 ± 0.04		
DO (mg/L)	6.34 ± 0.06	6.09 ± 0.01*	74	5[b]
BOD (mg/L)	17.53 ± 0.11	19.99 ± 0.02	100	50_c
COD (mg/L)	59.18 ± 0.04*	51.06 ± 0.20		

a: *(UNEP, 1999),* ***b:*** *(USEPA, 2006),* ***c:*** *(FEPA, 1991),* ***d:*** *(WHO, 2006)*

** The mean difference is significant at the 0.05 level*

Therefore high abundance of certain species of *Capitella* sp, *Tubifera* sp and *Endochironomons* sp in brackish water and Tubificid sp, *Chironomons larvae* and *Hirudo* medicinalis in the fresh water suggests conditions of environmental degradation evident from both water bodies. These species have been associated with aquatic pollution (Woke, 2011, Woke & Wokoma, 2007, Woke and Babatunde, 2009), a situation which has prompted an increasing environmental concern in the study area.

The measurable physico-chemical parameters considered in this study were Temperature, pH, DO, BOD, COD, TDS, TSS and Salinity. The concentrations of these parameters in the natural ecosystem very in response to pollutants as a result of anthropogenic activities. The significantly high TDS and TSS of the brackish water ($p < 0.05$) are implicative of high level of pollution of the brackish water when compared to freshwater relative to WHO standards which recommends 1500mg/L and 500mg/L for TDS and TSS respectively, while FEPA recommends a maximum of 2000mg/L for surface waters.

Comparison of the results to WHO and other standards desirable limits in drinking water shows that, although pH was tantamount in both water bodies, other parameters such as TDS, TSS, Salinity, COD, etc. were higher in the brackish water than in the freshwater. It is worthy to note that, although both water bodies exhibit patterns of environmental degradation, the brackish water was implicative of a higher pollution level compared to the freshwater.

The study reveals that the presence and high abundance of *Capitella* sp, *Tubifera* sp and *Endochironomons* sp in brackish water and *Tubificid* sp, *Chironomons larval* and *Hirudo medicinalis* in the fresh water is an indicative of increasing environmental degradation evident from both water bodies, thus making the water unfit for human consumption.

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