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THE RESPONSE OF BENTHIC FORAMINIFERA TO ENVIRONMENTAL CHANGES IN EPIE CREEK, YENAGOA, BAYELSA STATE

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ABSTRACT

Epie creek, located at the Southern part of Nigeria has been known for its use as sink for the disposal of untreated sewage and industrial effluents. Benthic foraminifera are increasingly been used as environmental bio-indicators of pollution. Their munity structure provides information on the general characteristics of the environment and some species are sensitive to specific environmental parameters. This study investigates recent foraminifera from sediment samples collected from ten (10) stations (ranging in depths from 1m to 4.2m) in the Epie creek from Igbogene to Tombia- Etegwe. The environmental factors that necessitate their existence such as temperature, pH, salinity and dissolved oxygen were measured during the sampling time. Metals were determined using atomic absorption spectrophotometer. Recognized benthic foraminifera species belonging to four (4) genera of three (3) families and four(4) suborder were identified. Five (5) benthic foraminifera taxa were identified from sediment samples which include Lenticulina stellata, Saccammina sp, Marginulina costata, Marginulina cf. planata and Trochammina sp. The stress tolerant specie, Trochammina ,sp. was common in the study area confirming a stressed environment.

Keywords: Epie Creek, Benthic foraminifera, Environmental Changes, bio-indicators

INTRODUCTION

The choice of Epie Creek for study was necessitated by the discharge of hazardous waste and effluents into the creek, and the over-dependence by the inhabitants on the creek for several purposes, ranging from domestic, agricultural, fishing, recreating and travelling. The Creek serves as a receiver of poorly managed wastes posing a great health threat to the various communities as dead fishes were seen floating on the creek as at the time of sampling (fig. 1).

The area has witnessed a great increase in activities due to sudden surge in population, the creek is a major sink to several wastes streams resulting from market activities, the unwholesome attitude of the inhabitants that defecate and the crude method of fishing using chemicals into the creek poses a great threat to the quality of water and sediments, and may have deleterious effect on the health of the inhabitants. Seiyaboh 2018, had noted that when water and sediment characteristics are impacted upon, the tendency that the aquatic organisms in such area can be impacted as well is very high.

Epie Creek is located in Yenagoa, is a non-tidal, fresh water serving as major surface water resource in Yenagoa metropolis in the Bayelsa state capital with several communities aligning the creeks.(fig. 1) .

Foraminifera are single celled protists that are present in a wide range of marine environments, they constitute the most diverse group of shelled microorganisms (Murray, 1991).

Foraminifera may be planktonic (float in the upper water column) or benthonic (live on the sea bottom) in their mode of life. There are two groups of benthic organisms, based on their habitat: epifauna and Infauna. Epifaunal live attached to a surface and infauna live within bottom sediments.

The application of benthic foraminifera in the study area outweighs other chemical and biological techniques, for pollution monitoring as they provide a good snapshot of environmental conditions, they respond quickly to small environmental changes. According to Pati and Patra , 2012), their use hinges on the following:

- Their tremendous taxonomic diversity gives them the potential for diverse biological responses to various pollutants. Different index species can be identified for pollution from diverse sources.
- Due to their relatively small size and great population density, statistically significant sample sizes can be collected quickly and relatively inexpensively for either assemblage assessment and for experimental studies, with minimal environmental impact.
- Their short reproductive cycle and rapid growth makes their community structure responsive to quick environmental changes.
- Living population and surface sediment assemblages can be used to assess the current state of benthic ecosystem.
- As the mineralized tests are readily preserved, fossil foraminifers can be studied from sediment cores to assess decadal, century and millennial scale changes in community structure at sites of interest, providing an historical record. This provides historical base line data even in the absence of background studies.
- Some species can be readily maintained in culture, so laboratory protocols can be established to determine responses of selected taxa to pollutants of concern. Field transplant studies can also be designed for them.
- They have biological defense mechanisms which protect them against unfavorable environmental factors, thus providing detectable biological evidence of the effects of pollution.

The inherent nature of benthics restricts their movements making them susceptible to pollution or unhealthy water conditions. Benthic communities are exposed to many stressors, including low oxygen levels, Excess sediment suspension in the water can block sunlight from reaching grasses growing at the bottom and chemical contaminants

Many chemical contaminants bind to bottom sediments, remaining there for years. Benthic species become contaminated when they feed and live in these toxic sediments.

Because of their short cycles, preservation in marine sediments, diversity and abundance, sensitivity to rapid changing of environmental conditions and easy collection with minimal impact to the environment, benthic foraminifera are recognized as exceptional bio indicators (Murray, 2006; Carnahan et al., 2009)..

Benthic communities are exposed to many stressors, including low oxygen levels, excess sediment and chemical contaminants and they respond differently to slight environmental changes such as heavy metal (cadmium, mercury, arsenic, lead, zinc, cobalt) pollution, treatment stations, artificial inlets, agricultural and urban sewages (Ruiz *et al*., 2012). This is the crux of the present study as currently no study has been conducted to establish the effect of pollutants on aquatic micro organisms, as this will no doubt form the bases for further studies on the creek.

The aim of the present research therefore is to report the impact and/or the response the pollutants have on living benthic foraminifera. To achieve this, sediments and water samples were collected from the creek for sedimentological and geochemical analyses.

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Location of the study area

Epie Creek is located in Yenagoa metropolis of Bayelsa State between latitudes 4°50' to 5°23'N and longitudes 6°15'E to 6°30'E (fig.1).It traverses through the stretch of Yenagoa (Igbogene axis) to Swali being one of the major essential surface waters in Bayelsa State. The creek has a link with other areas such as Taylor and Ikoli creeks. The creek serves as a recipient channel for domestic, commercial and poorly managed industrial wastes. The major activities on and around the creek are fishing, dumpsite and water transportation.

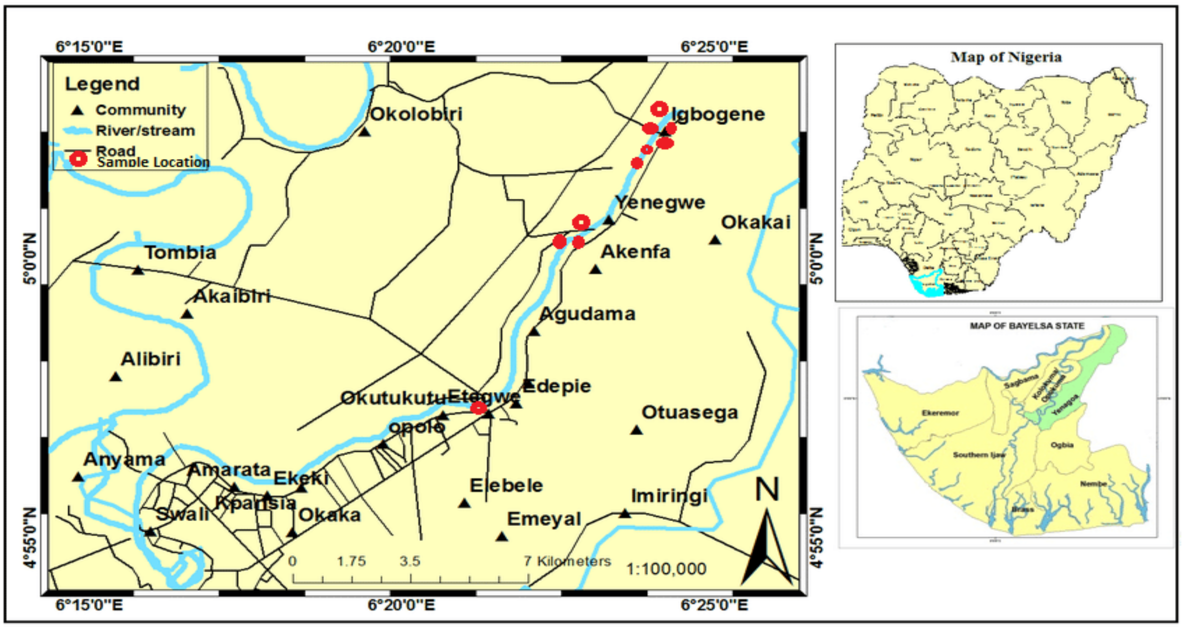

Fig 1: Map of Yenagoa showing situation of sampling stations along the Epie creek

Climate and Vegetation

The climate of the area is tropical and has wet and dry seasons. The setting is characterized by almost all year round rainfall. The mean monthly temperature range is 25^{o}c to 31^{o}c while the mean maximum monthly temperature range is 26^o C to 31^o C. The first rainy season is from March to July with the peak in June. This is then interrupted by a short period of about two to three weeks in August (termed as 'August break') with minimal or no rainfall. This is followed by a shorter rainy season from September to November. Dry season begins from December to February. The vegetation type in the state is the lowland rainforest type mainly in the North and mangrove swamp forest type in the south.

Relief and Drainage

Bayelsa State is a lowland state characterized by tidal flats and coastal beaches.The fact that the area lies between the upper and lower delta plain of the Niger Delta suggests a low lying relief. There are numerous streams of varying volumes and velocities in the area which include the Rivers Nun and Ikoli.

GEOLOGY OF THE STUDY AREA

Bayelsa State is located within the lower delta plain believed to have been formed during the Holocene of the Quaternary period by the accumulation of sedimentary deposits. The major geologic characteristic of the area is sedimentary alluvium.

Stratigraphy of the Niger Delta

The Niger Delta is divided into three major stratigraphic units (fig 1), the Akata (shale), Agbada (sandstone and shale) and Benin (sandstone) formations (Reijers, 2011).

Akata Formation

The upper Akata Formation is Paleocene in age. It is believed to be a primary source rock, providing Type 2and 3 kerogen and a potential target in deep water offshore and possibly beneath currently producing intervals onshore. The formation was formed during low stands in relative sea level and anoxic conditions. The clays are typically over - pressured due to the absence of enough porous sediment during compaction and are about 9000 feet vertical depth below mean sea level. It is estimated to be up to 7000 meters thick.

Agbada Formation

The Agbada Formation dates back to Eocene. It is the major oil producing formation in the Niger Delta Complex Basin, and overlies the Paleocene Akata Formation, which is the principal hydrocarbon source rock and forms the second of the three strongly diachronous Niger Delta Complex formations. It is a marine facies defined by both fresh water and deep sea characteristics. The basin was deformed by large synsedimentary faults, roll over anticlines and diapirs; hydrocarbon accumulations are largely controlled by growth faults.

The hydrocarbons in this layer of rock became subaerial and were covered in a marsh type environment rich in organic content. It is estimated to be 3700 meters thick.

Benin Formation

The Benin Formation is Oligocene and younger in age. It is composed of continental flood plain sands and alluvial deposits. It is estimated to be up to 2000 meters thick.

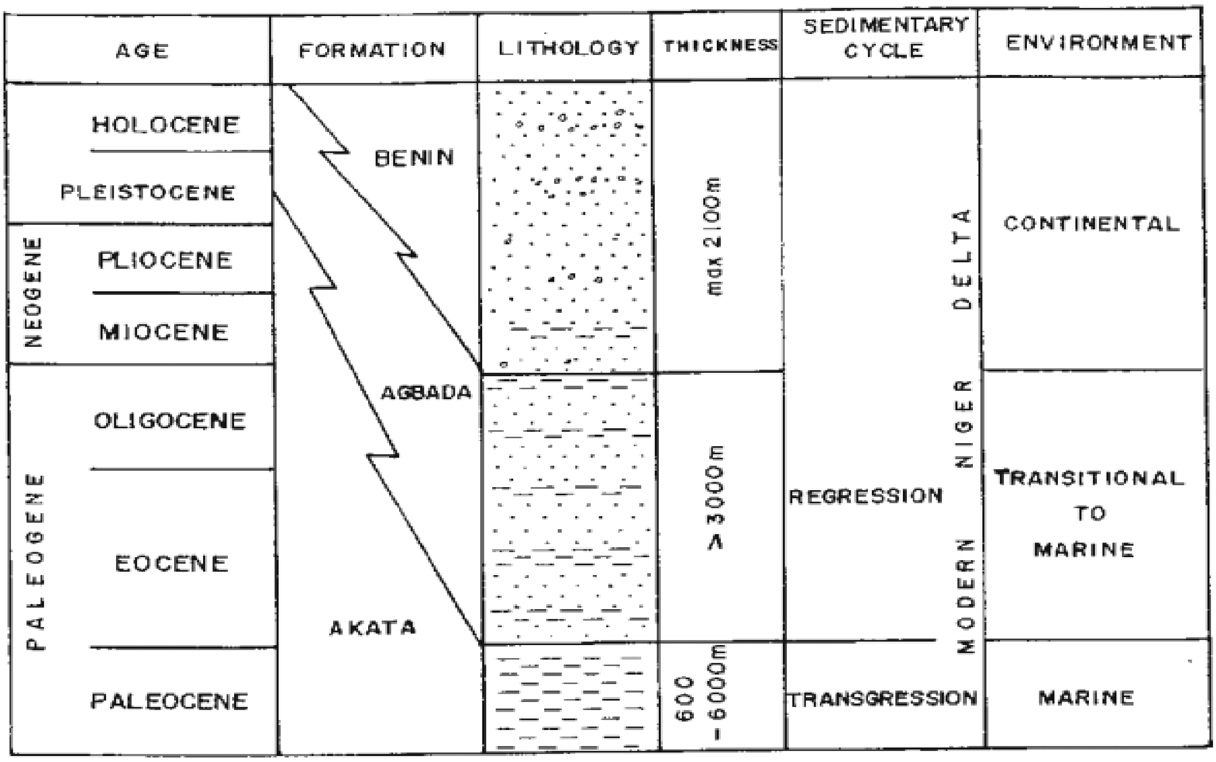

Figure 2: Stratigraphic successions in the Niger Delta (Obaje, 2009)

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MATERIALS AND METHODS

The following materials were utilized, a grab sampler, plastic containers, Global positioning system (GPS), Rose Bengal solution used to distinguish live from dead Benthonic Foraminifera, Formalin solution for the preservation of the samples, Measuring tape, Extech pH/conductivity meter was used in the measurement of conductivity and pH., Smart DO meter was used in measuring the amount of gaseous oxygen dissolved in water sample, Indelible marker and a field notebook

Sediment Sampling

Sediment samples were collected from ten(10) stations along the Epie creek (fig. 1). Sample location coordinates were determined using Global Positioning System (GPS). Sediment samples were collected using a grab sampler at each station and stored in polythene bags. The top portions of the sediment samples in various labelled polythene bags were immediately preserved after collection with formalin solution.A; constant volume of sediment was taken from each sample, washed over a sieve and stained with Rose Bengal solution for at least 48hrs to distinguish stained (living) from unstained (dead) benthic foraminifera.

The water samples were collected from the sampling stations in clean plastic containers (rinsed thoroughly with habitat water at each sampling point before collection).Each sample was collected by submerging the receiving container into the water body.

Table 1: Positions of sampling stations

Stations	Depth(m)	Longitude(^oE)	Latitude(^oN)
L1	1.00	6°24’2.156”	5°1’59.104”
L2	2.00	6°24’3.412”	5°2’1.451”
L3	3.00	6°24’4.120”	5°2’4.781”
L4	2.00	6°24’5.851”	5°2’6.600”
L5	1.60	6°23’25.050”	5°1’8.543”
L6	4.20	6°23’15.650”	5°1’10.081”
L7	1.70	6°23’10.670”	5°0’26.781”
L8	1.10	6°22’39.900”	5°0’4.484”
L9	1.00	6°22’41.695”	5°0’6.621”
L10	1.00	6°21’15.660”	4°57’15.600”

Laboratory Preparation for Foraminifera study

The sediment samples for foraminifera analysis were washed gently through a 63um sieve with tap water in order to remove silt and clay. They were then dried in an oven at temperature 60°C and weighed. The residual fractions obtained after washing were re-dried at the same temperature of 60°C and weighed to determine by difference, the mud fraction. The stained foraminifera were handpicked and separated from the sediment for faunal analysis. Also, the benthic foraminifera were taxonomically identified using a stereomicroscope.

Heavy metal analysis: The analyses were carried out at the Central Research Laboratory, Niger Delta University, Wilberforce Island, Bayelsa State

Exactly 100ml of water samples were placed in 250ml beaker, before adding 5ml of concentrated nitric acid solution, HNO_3. The acidified water was then placed on a six-hole water bath and was evaporated to dryness. 15ml of digested acid (1:3 HNO_3/H_2SO_4 Concentrated acid) was added and the mixture was heated on a hot plate to half the volume, twenty mils (20 ml) of distilled water added and mixed properly and filtered into 100 ml volumetric flask and the volume made up to mark with distilled water. These were prepared for atomic absorption spectrometry analysis (AAS).

AAS Analysis: The atomic absorption spectrophotometer was then switched on and the various lamps were set up, gases and appropriate lamp current were set up. The various analyses were done by aspirating the digested samples on AAS. The concentrations of the respective metals were recorded in mg/l units.

In this research only the concentrations of Cadmium (Cd), Chromium (Cr), Copper (Cu), Cobalt (Co), Lead (Pb), Zinc (Zn), Nickel (Ni), Mercury (Hg) and Arsenic(As) were evaluated.

Measurement of Physical parameters

The values of the physical parameters were measured insitu and recorded at the sample collection site. The Parameters measured are: Salinity, pH, temperature (T), dissolved oxygen (DO) and conductivity. Electronic devices capable of recording the parameters were used.

RESULTS

Five (5) species of benthic foraminifera were identified, belonging to four (4) genera of three (3) families. (Plate 1) One of the species belongs to the suborder Lagenina (Calcareous) and two each to Rotaliina (Calcareous) and Textulariina (Agglutinated) as shown below in Table 2.

They include *Lenticulina stellate* (fig. 3), *Saccammina* sp.(fig. 4), *Marginulina costata* (fig. 5), *Marginulina* cf. *planata* (fig. 6) *and Trochammina* sp..(fig. 7).Most of the samples were barren of foraminifera (Table 4.2).*Trochamminna* sp.is the most abundant species.

Ostracodes (fig. 8) were more than foraminifera at location five, (L5) while foraminifera are more at location three.

Table 2: Absolute Numbers and Distribution of total Benthonic Foraminifera fauna.

SAMPLE LOCATION	*Lenticulina Stellata*	Saccammina sp	*Trochammina* sp	*Marginulina* cf.*Planata*	*Marginulina costata*	*Total foraminiferal count*	*Ostracod*
L 1	Barren	1	2	1	Barren	4	1
L 2	Barren	Barren	Barren	1	Barren	1	1
L 3	Barren	Barren	6	1	Barren	7	Barren
L 4	Barren	Barren	2	1	Barren	3	2
L 5	4	4	Barren	Barren	2	10	5
L 6	1	1	Barren	Barren	Barren	2	Barren
L 7	Barren	Barren	Barren	Barren	Barren	Barren	Barren
L 8	Barren	Barren	Barren	Barren	Barren	Barren	Barren

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L 9	Barren	Barren	Barren	Barren	Barren	Barren	Barren
L 10	Barren	Barren	1	Barren	Barren	1	1
TOTAL	5	6	11	4	2	28	10

Table 3: Suborder, Family and Genera of foraminifera identified from Epie creek, Yenagoa

Suborder	Family	Genus	Species
Lagenina	Vaginulinidae	Lenticulina	*Lenticulina stellate*
Rotaliina	Vaginulinidae	Marginulina	*Marginulina costata*
Rotaliina	Vaginulinidae	Marginulina	*Marginulina* cf. *planata*
Textulariina	Saccaminidae	Saccammina	*Saccammina* sp.
Textulariina	Trochamminidae	Trochammina	*Trochammina* sp.

Heavy Metals

Basic statistics of the different heavy metals, Cadmium (Cd), Chromium (Cr), Copper (Cu), Cobalt(Co), Lead(Pb), Zinc(Zn), Nickel(Ni), Mercury(Hg) and Arsenic(As) are presented in Table 4.

Heavy metals in the field samples were determined and then compared with standard limits in order to establish whether the level of pollution was above locally and internationally accepted standard.

The concentration of cadmium, chromium, and zinc were the most significant across all sample locations while copper, mercury and arsenic were below the limits of 0.5, 0.001 and 0.01 mg/L respectively WHO (2008). Lead, was found higher in concentrations but they are within permissible limit of 0.01mg/l and was undetected in certain locations (L5, 6 and 8). Results obtained for Nickel was higher in concentration only at locations 5, 6 and 8 along the creek.

A Standard for cobalt was not available and therefore it was difficult to make conclusion whether the levels obtained were high or low.

Table 4: Concentration of trace metals in mg/L from Epie-creek, Yenagoa along with WHO and SON (2008) standards

SAMPLE CODE	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Cobalt (Co)	Lead (Pb)	Zinc (Zn)	Nickel (Ni)	Mercury (Hg)	Arsenic (As)
WHO LIMIT	0.003	0.05	0.5-2.0	-	0.01	0.01	0.02	0.001	0.01
SON LIMIT	0.003	0.05	1.0	-	0.01	5.0	-	0.001	0.01
L 1	0.030	0.109	0.021	0.081	0.359	0.123	0.238	-0.002	-0.013
	0.028	0.111	0.020	0.080	0.360	0.125	0.240	-0.003	-0.012
	0.032	0.110	0.019	0.079	0.361	0.127	0.242	-0.001	-0.014
L 2	0.031	0.102	-0.000	0.120	0.440	0.109	0.121	-0.001	-0.015
	0.033	0.104	-0.001	0.119	0.442	0.111	0.120	-0.002	-0.013

	0.035	0.100	-0.002	0.121	0.441	0.110	0.119	-0.001	-0.011
L 3	0.031	0.101	0.027	0.129	0.106	0.182	0.014	-0.017	-0.036
	0.029	0.098	0.025	0.130	0.105	0.180	0.013	-0.015	-0.034
	0.030	0.102	0.023	0.128	0.104	0.184	0.015	-0.013	-0.033
L 4	0.031	0.105	0.016	0.034	0.347	0.379	0.039	-0.021	-0.012
	0.031	0.103	0.014	0.035	0.345	0.380	0.040	-0.020	-0.013
	0.031	0.101	0.015	0.033	0.343	0.381	0.041	-0.019	-0.011
L 5	0.035	0.069	0.028	0.038	ND	0.146	0.198	-0.005	-0.018
	0.036	0.070	0.027	0.036	ND	0.148	0.200	-0.006	-0.016
	0.034	0.071	0.026	0.034	ND	0.150	0.202	-0.004	-0.014
L 6	0.034	0.126	0.019	0.110	ND	0.189	0.172	-0.002	-0.008
	0.032	0.122	0.020	0.108	ND	0.190	0.174	-0.001	-0.006
	0.030	0.124	0.021	0.112	ND	0.191	0.176	-0.003	-0.004
L 7	0.035	0.089	0.010	0.036	0.428	0.112	0.098	-0.003	-0.004
	0.035	0.090	0.008	0.032	0.430	0.110	0.094	-0.004	-0.002
	0.036	0.091	0.006	0.034	0.426	0.108	0.096	-0.002	-0.003
L 8	0.030	0.092	0.024	0.037	ND	0.264	0.114	-0.005	-0.008
	0.031	0.090	0.025	0.033	ND	0.266	0.113	-0.004	-0.006
	0.029	0.088	0.023	0.035	ND	0.262	0.111	-0.003	-0.007
L 9	0.042	0.100	0.009	0.087	0.278	0.231	0.015	-0.018	-0.007
	0.040	0.102	0.005	0.086	0.280	0.230	0.013	-0.017	-0.003
	0.044	0.098	0.007	0.088	0.276	0.229	0.014	-0.019	-0.005
L 10	0.029	0.126	0.008	0.085	0.336	0.296	0.026	-0.003	-0.001
	0.030	0.125	0.007	0.083	0.333	0.294	0.022	-0.001	-0.000
	0.031	0.124	0.006	0.081	0.337	0.295	0.024	-0.002	-0.002

Physical Parameters

Physical parameters as measured in the study area, during the sample period, are summarized in Table 5. The water temperature and salinity values range from 29.4^{o}c to 33.4^{o}c and 25.8 to 64.4 respectively, and the pH from 6.08 to 7.01.Conductivity has a relationship with dissolved solids. When the water contain high ions and the salinity increases, the conductivity level is more likely to increase.

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Table 5: Measurement of environmental factors operating in Epie-Creek, Yenagoa

Sample Location	pH	Temperature (^oC)	Total Dissolved Solid	Conductivity	Salinity (ppt)	Dissolved Oxygen (mg/L)	Depth (m)
L1	6.40	29.40	58.10	83.90	35.70	5.50	1.00
L2	6.42	30.50	42.40	60.30	27.80	6.20	2.00
L3	6.28	30.40	41.20	58.80	27.50	5.40	3.00
L4	6.28	30.50	39.40	54.80	25.80	5.10	2.00
L5	6.08	33.30	42.40	64.20	28.50	5.60	1.60
L6	6.15	33.40	43.40	62.00	28.40	5.30	4.20
L7	6.91	32.40	65.20	94.10	42.80	5.70	1.70
L8	6.94	33.10	65.50	96.50	43.50	5.70	1.10
L9	7.01	33.30	62.70	90.10	41.30	5.80	1.00
L10	7.00	33.40	96.60	141.40	64.40	5.90	1.00

DISCUSSIONS

The established range of temperature that is conducive for foraminifera to thrive is 20^{o}C to 30^{o}C (Bradshaw, 1955; 1957). The range of temperature obtained was between 29.40^{o}C to 33^{o}C. The increase in temperature could have been as a result of direct influence of solar radiation.

The pH of water is typically used to assess the acidity and alkalinity of the water. The recorded pH values of 6.08 to 7.01 indicate that the creek is slightly acidic and lesser in range than the recommended standard of 6.5-8.5 by World Health Organization. The variation could be associated to natural activities such as direct influence or different anthropogenic activities carried out along the creek. (Le Cadre et al., 2003).

The study is characterized by a low degree of heavy metal pollution as measured through geochemical analysis. Numerous studies dealing with the relationship between foraminifera and pollution have considered heavy metal content as a very important parameter acting in benthic foraminifera ecosystems. Studies carried out in the past on polluted environment have showed that a reduction in diversity and density as observed at the Creek can be attributed to environmental stress from pollution on benthic foraminifera communities. Although, it has been reported that an increase in pollution could lead to high number of individuals belonging to a few opportunistic species (Murray, 1973). In such cases, only low species diversity indicates polluted areas as shown from the study.. Benthic foraminifera species identified *in* the study area in order of increase in abundance are *Marginulina costata*, *Marginulina* cf. *planata*, *Lenticulina stellata*, *Saccammina* sp. *and Trochammina* sp. In the study area, it is believed that environmental conditions are not entirely stable to permit the accommodation of a large number of foraminifera species. As a result of the high dominance of the stress tolerant species, *Trochammina* sp., anthropogenic pollution is suggested in the zone of abundance of foraminifera and low species recovery implying a stressed environment.

This pollution produces numerous obvious effects such as local extinction of some species, changes in community structure, loss or modification of habitat, human health complications and diseases in both plants and animal species. It is therefore, very important to find ways of detecting and monitoring pollution in the creek overtime and make it a subject of active research.

SUMMARY AND CONCLUSION:

It was observed in the study area that heavy metal presence was low in few locations and high in other locations leading to an increase in stress- dominant species. The temperature conducive for foraminifera is between 20^{o}C to 30^{o}C , the range of temperature values obtained in the study area was between 29.40^{o}C to 33^{o}C making it impossible for most of the forms to exist except for the stress-dominat species . The genus *Trochammina* is both infaunal and epifaunal and a plant feeder. The genus is tolerant to such altered temperature range and also to low oxygen level. They are also known to cover a wide range of salinity (0 -60%)(Gebhart, 1997). Another genus *Saccamina* share similar attributes as *Trochammina*. The creek was found to be slightly acidic, this led to a reduction in diversity and density of the forms. The clearest response of foraminifera to environmental degradation is the increased percentages of abnormal specimens exceeding the background, the reduced size of the specimens and the increase of pollution tolerant species (Romano et al., 2009).

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PLATE 1 (Magnification ×40)

Fig. 3: ***Lenticulina stellata***

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Fig. 4: ***Saccammina*** **sp.**

Fig. 5: ***Marginulina costata***

Fig. 6: ***Marginulina cf planata***

Fig. 7: ***Ostracoda***

Fig. 8: ***Trochammina sp***

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