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Assessment of Elemental and Microbial Quality of Lake Efi in Bayelsa State, Central Niger Delta, Nigeria

Tariwari C.N. Angaye[1]* and Cosboy E. Mieyepa[2]

1- Toxicity Research Group, Department of Biological Sciences, Niger Delta University, Bayelsa State, Nigeria.
2- Department of Environmental Resource Management, Faculty of Environmental Engineering, Imo State University, Nigeria.

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Abstract

Efi lake of Bayelsa state, Nigeria, is emerging as a resource in the Niger Delta. It holds a great mythological significance, as well as a means of livelihood. This study assessed the Elemental and Microbial quality of the lake. Water Samples of the lake were collected upstream, midstream and downstream in March 2015, and similarly analyzed following standard protocol. Results showed that, compared to iron which ranged from 0.034 - 0.74 mg/l, copper, mercury and lead were below detection limits, while Cadmium (0.00 - 0.057 mg/l), Chromium (0.00 - 0.137 mg/l) and Zinc (0.00 - 0.231 mg/l) occurred in very low concentrations ($P < 0.05$). The physicochemical parameters showed that temperature, pH, conductivity and TDS ranges as; 28.36 - 30.10^{o}C, 6.55 - 7.20, 48.13 - 68.93 µS/cm, 54.25 - 102.92 mg/l respectively; while turbidity, DO and Nitrate ranges as 7.87 - 17.29 NTU, 9.07 - 19.52 mg/l and 1.34 - 2.82 mg/l respectively ($P < 0.05$). Total heterotrophic bacteria and fungi were 0.44 - 1.159 X 10^6 and 0.46 - 0.86 X 10^4 Cfu/ml respectively. Furthermore, the total and feacal coliforms were 76.72 - 260.23 and 53.67-157.02 MPN/100 ml MPN/100 ml respectively. The results generally indicate mild anthropogenic activities in the lack. Hence, robust government and communal laws should be enforce to protect this potential eco-tourist area.

Keywords: Niger Delta, Efi Lake, microorganisms, physico-chemistry, Heavy metals

1 Introduction

A delta is could be defined as that portion of a country's land mass through which its rivers systems are discharged to the ocean. The Niger Delta is a wetland characterized by high level of precipitation and multiple flooding. Its river system are deltaic with three basic tributaries [1]. These tributaries are *River-Forcados* to the west in Delta state, *River-Orashi* located eastward and *River-Nun* (central i.e. between orashi and forcardos), in Bayelsa state. These three rivers form a triangular delta originating from a major parent tributary at *Ebueto*. The Niger delta has four ecological zones (coastal barrier island, mangrove swamp forest, freshwater swamp and lowland rainforest). Core States in the Niger Delta includes; Delta, Bayelsa, Rivers and Akwa Ibom. It is a geopolitical region located on the southern part of the Nigerian map. With more than 40 different ethnic groups, its population is estimated to be over 20 million.

Lake Efi is emerging as one of the potential eco-tourist zone of bayelsa state, Nigeria. Located in a community called Kalama, in Sabagreia town of Kolokuma/Opokuma Local Government Area. The origin of the lake holds a basking mythological history, which originated over three centuries ago. After a fierce argument between two fishermen (from Kalama and Gbarain communities), on the ownership of the lake. They both agreed on a competitive (win and claim) venture doctored by the Kalama man. The terms agreed was that the first between the two to make fire around the lake will solely retain owner the lake. The terms agreed made the Gbaraun man to quickly dash home to fetch fire from his community which is closer to the lake. The Gbaraun man was outsmarted that prior to his arrival, the Kalama man made fire from sticks around the lake, with the aid of his gun powder. The lake is pristine due to its self-purifying mechanism, and it host diverse species ranging from fish, turtle and crocodile. The lake is surrounded by forest and is about 2km square area in size. It has been managed by a conditional fishing festival only observed every decade [2].

The quality of water in communities aligning coastal settlement is essential to their relative health and sustenance. In Bayelsa state, the river of some riverine communities unfortunately act as a waste dump sites [3]. The wastes streams discharged into the water bodies may include organic and inorganic waste such as; heavy metals, elemental ions, oil and grease and other wastes of organic origin [3, 4], originating from point and non-point sources as leachates swept by runoffs [4]. Although the contamination of a river may be determined by its flow intensity and dilution capacity [3], however the persistent

Corresponding Author: Tariwari C.N. Angaye, Toxicity Research Group, Department of Biological Sciences, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria. E-mail: maktarry@yahoo.com;
Tel: +234-703-7889-063.

anthropogenic activities over a period of time may influence the contamination rate.

The viability of microbes linked to water-borne diseases is made possible by persistence sewage discharged into water bodies. Significant level of heterotrophic bacteria have been reported in surface water of the Niger Delta. They include [3]. They species includes; *Staphylococcus aureus, Escherichia coli, Bacillus, Pseudomonas, Proteus, Enterobacter, Streptococcus, Salmonella, Shigella, Vibrio* species [5]. Also microbes like the *Salmonella Typhi* [6, 7], as well as the *Pseudomonas* and *Escherichia* genera have been reported on the Wilberforce axis of River Nun [8]. Notwithstanding, Efi Lake is a means of livelihood and potential eco-tourist zone of Bayelsa state; as such it has become necessary to assess the Elemental and Microbial quality of Lake so as to circumspect it envisaged sustainability.

2 Materials and Methods

2.1 Study area

Sampling was carried out in Efi Lake located in Kalama community of Sabagreia town in Kolokuma/Opokuma LGA, Bayelsa State Nigeria. It is located on latitude and longitude N05^{o} 02^{l} 49.1^{ll} and E006^{o} 14^{l} 40.3^{ll} respectively. The major occupation of the sabagreia people is farming and petty trading. Efi Lake is a resource, which holds a great mythological history, and diverse aquatic macrophytes, and some endangered species. The study area has a tropical humid warm climate with two prevailing seasons. They are the rainy season (March to October), with an annual precipitation of over 2000mm and the dry and dusty seasons (November to February).

2.2 Sample collection

A total of six sample was collected in the month of February 2015, two from each sampling points (i.e. upstream, midstream and downstream). The water sample were collected aseptically with sterile microbiological bottles and preserved in ice packs. Other physicochemical parameters were determined in-situ using potable meters. The samples were immediately digested with few drops of nitric acid and stored in ice pack where applicable, and transported to the laboratory for the analysis of ex-situ parameters (i.e. heavy metals).

2.3 Laboratory analysis

2.3.1 Microbial Quality Assessment

The enumeration of total heterotrophic bacteria (THB) and fungi (TF) were carried out using serial dilution and aerobic pour plate technique as described by several authors [3, 9, 10]. Serially diluted aliquots of the water samples were ascetically plated into Nutrient Agar and Sabouraud dextrose agar respectively for THB and TF respectively. The plates were maintained for an incubation period of 24-48 at 37°C for THB, while the TF was maintained at 48-72 at 37°C. The viable colonies were enumerated and expressed as colony forming units per millilitres (i.e. cfu/ml). Total coliform (TF) and fecal coliforms (FC) were assessed using Multiple Tube Fermentation Technique expressed as MPN (Most Probable Number) APHA 9222C.

2.3.2 Elemental Assessment

All analysis were carried out following standard protocol [11]. The pH, temperature, dissolved oxygen and conductivity were measured using EXTECH Multi- probe meter (DO700). Total dissolved solid was measured using TDS meter. Nitrate was analysed using Colorimetric method. The heavy metals were analysed using Perkin Elmer 5100 PC AA Spectrometer Atomic Absorption Spectrophotometer (AAS).

2.4 Statistical analysis

All statistical analysis for the purpose of this research were carried out using SPSS software (SPSS Inc, Chicago; version 16). A one-way analysis of variance was carried out at P = 0.05, and Duncan's multiple range test (DMR) was used to discern the source of the observed differences.

3 Results and Discussion

Table 1 presents the level of endemic microbes in the lake which includes; Total Heterotrophic Bacteria (THB), Total Fungi (TF), Total Coliform (TC) and Feacal Coliform (FC). The density of THB and TF ranged from 0.441-1.159 X 10^6 and 0.459-0.848 X 10^4 Log cfu/ml (P<0.05). The level of coliform, according to WHO should be zero for potable water, although result of Efi lake indicated significant level of total (76.72-260.23 MPN/100 ml), and faecal (53.67-157.02 MPN/100 ml) coliforms. THB levels of with mean densities of 6.434±0.039 and 6.387±0.055Log cfu/ml have been reported in lower and upper Nun River of the Niger delta, as well as Ogobiri (6.414±0.078Log cfu/ml) and Akaibiri (6.394±0.070Log cfu/ml) axis of river Nun [3]. Due to the detected level of microbes in the lake the water is, direct consumption of water is discouraged. On the other hand, depending on the endemic biota, mild and tolerable level of microbes might sustain aquatic life, provided the threshold limit of pathogenic microbes is not exceeded. For instance, bacterial, viral and fungal diseases have been reported in fish as a result of exceeding level of water contamination [12, 13].

Table 2 presents the physicochemical properties of Efi Lake of Sabagreia, a potential tourist centre and means of livelihood of the Kolokuma clan in Bayelsa state Nigeria. Result showed that the temperature of the water ranged from 28.36-30.10^{o}C. Standard temperature that sustain life should be ambient. Extreme temperatures might aid exotic/alien species invasion, or even synergicidel with regards to other elemental or physicochemical activities. The pH from all sampling points (i.e. upstream, midstream and downstream), which ranged from, 6.55-7.20 complied with WHO and Standard Organisation of Nigeria (SON) permissible limits (6.5 – 8.5), with significant difference upstream, midstream and downstream (P<0.05). Several authors have reported the pH of surface water as; 7.4 – 7.57 and 6.9 – 7.33 in dry and wet season respectively for Epie creek [14], 6.95 – 7.50 for lower Kolo creek [15], 7.17 for upper river Nun [16], 6.8 – 8.5 for Nkoro River [17] as well as 6.5-7.11 and 6.5-6.73 for Rivers igedi and Nun respectively [3].

Table 1: Microbiological Quality assessment of Efi Lake

Sample Code	THB, X 10^6 (Cfu/ml)	TF, X 10^4 (Cfu/ ml)	TC (MPN/100 ml)	FC (MPN/100ml)
USI	1.159±0.449c	0.742±0.173c	260.232±5.629d	157.032±3.280c
US2	0.698±0.442b	0.585±0.517b	167.122±11.871b	200.302±5.582d
MS1	0.749±0.112b	0.559. ±0.414ab	76.717±8.787a	140.312±10.111a
MS2	0.794±0.110b	0.549±0.299ab	90.050±0.032a	140.152±9.905a
DS1	0.648±0.109b	0.459±0.328a	205.222±2.882c	85.903±3.377b
DS2	0.441±0.252a	0.848±0.192d	250.362±23.005d	53.667±6.498a
WHO	-	-	0	0
SON	-	-	0	0

Each value is expressed as mean ± standard error (n = 3). Different letters in each column indicate significant differences at P< 0.05 according to the Duncan Statistics. ***Keys:*** *Upstream (US), Midstream (MS), Downstream (DS).*

The conductivity of Efi lake ranged from 48.13 - 68.93 µS/cm with significant difference (P<0.05), upstream, midstream and downstream. The values reported in this study, complied with WHO and SON permissible limits of 1000 µS/cm. This value corroborates the range of values reported by other authors who studied surface water of Bayelsa like; Amassoma and Agudama-Ekpetima rivers, which are downstream and upstream river Nun with conductivity values of 56.075±0.591 and 64.950±0.681µS/cm respectively [3], 82.30 – 102.0 µS/cm for Kolo creek [15], 76.23 umhos/cm for Igbedi creek [18], 87 – 95 umhos/cm during the construction of Tombia bridge [18]. Puyate and Rim-Rukeh [19], also reported conductivity with values in the range of 18.9 – 156.4 µS/cm.

The Dissolved oxygen (DO) ranged from 9.07-19.52mg/l with significant difference upstream, midstream and downstream (P<0.05). Although DO level was not specified by WHO and SON, however low level of DO may be toxic to some aquatic organism [20], especially if lower than 2.0mg/l [12]. Agedah et al [3] reported DO levels of 10.200±0.283 and 14.225±0.263mg/l for Igbedi and Ogobiri which are along the river Nun axis. Some other rivers in Bayelsa had DO in the ranges of 4.8mg/l – 7.2mg/l [18], 5.0 – 7.92 mg/l for Kolo creek [15], 1.38 – 9.06 and 1.76 – 5.68 mg/l for dry and wet seasons of Epie creek respectively [14].

The level of total dissolved solid (TDS) ranged in the lake ranged from 54.25 - 102.92 mg/l with significant difference (*P*<0.05) amongst the sampling points. Notwithstanding, our values are comparable to previous studies of surface water in Bayelsa state. Aghoghovwia and Ohimain [15] reported TDS value of 41.5 – 51.0 mg/l in Lower Kolo creek. The TDS values of Amassoma and Igbedi were also reported as 28.180±0.048 and 32.550±0.666mg/l respectively [3]. Epie creek TDS values were 55 - 62 and 33 – 37.33 mg/l in dry and wet seasons respectively [14], and 62.1 – 67.9 mg/l for Tombia axis of the river Nun [21].

Table 2: General physicochemical parameters of Efi Lake

Sample Code	Temperature (^oC)	pH	EC (µS/cm)	TDS (mg/L)	Turbidity (NTU)	DO (mg/L)	Nitrate (mg/L)
USI	29.297±0.318b	6.780±0.042b	64.527±0.955e	92.753±0.723d	17.293±0.219e	11.063±0.145d	1.343±0.081a
US2	29.767±0.144b	6.853±0.060b	68.903±0.478f	102.922±0.365e	15.793±0.990d	9.490±0.091b	2.820±0.115d
MS1	28.703±0.059a	6.557±0.018a	61.413±0.120d	660.500±1.415b	9.623±0.024b	17.187±0.124e	1.907±0.052b
MS2	28.356±0.099a	6.690±0.029ab	59.336±0.191c	54.253±0.764a	8.647±0.165ab	19.523±0.125f	2.253±0.179c
DS1	29.590±0.135b	7.460±0.078d	50.127±0.043b	64.250±0.171b	11.213±0.019c	9.077±0.186a	1.377±0.033a
DS2	29.303±0.111b	7.200±0.100c	48.130±0.026a	76.827±0.022c	7.877±0.052a	10.203±0.133c	1.630±0.125ab
WHO	Ambient	6.5 – 8.5	1000	500	5	-	50
SON	-	-	-	-	-	-	-

The turbidity of the water sample under study from Efi Lake ranged from 7.87-17.29NTU, with significant difference (*P*<0.05), amongst the sampling points. The highest turbidity value was indicated upstream (17.293±0.219), while the lowest was downstream (7.877±0.052). This study is comparable to a recent study, which reported turbidity values of 103.752±2.062 NTU upstream the river Nun axis of Agudama-Ekpetima, and 117.002±2.160NTU downstream river Nun [3]. Other authors who studied surface water in the Niger delta reported turbidity values 62.54 NTU in Igbedi creek [16], 5 – 64 NTU around Tombia bride Agudama Ikpetiama [21], 11.67 – 19.67 and 16.67 – 28.00 NTU, along the Epie creek in dry and wet seasons respectively [14], 35.0 – 40.5 NTU in Kolo creek [15]. The turbidity values of Efi Lake exceeds WHO and SON permissible limit (5NTU). The mild variation in turbidity values might be a reflection of anthropogenic activities of the inhabitants aligning the coastal settlement or abrasion effect on the bank of the lake [1, 3].

The Nitrate level in Efi Lake ranged from 1.34-2.82mg/l with significant difference (P<0.05), amongst the sampling points (i.e. upstream, midstream and downstream). The level of nitrate is higher compared to values of Epie creek with 0.02 – 0.27 mg/l for dry season and 0.14 – 0.28 for wet season [14]; Akaibiri River of 0.330±0.014mg/l and Igbedi River with 0.813±0.562mg/l [3], as well as the lower Kolo creek with values in the range of 0.1 – 0.24mg/l [15]. On the other hand, higher Nitrate levels within the range of 1.48 – 4.33 mg/l have been reported in some rivers of the Niger delta [19]. Notwithstanding, it was noteworthy that the Nitrate level of Efi Lake complied with the allowable limits of WHO and SON.

Results of the selected heavy metals assayed are presented in Table 3. Copper, mercury and lead were not detected in the lake; however, the level of cadmium varies as; 0.037-0.033 mg/l upstream, 0.00-0.014 mg/l midstream and not detected downstream. While chromium (0.017-0.023mg/l) and zinc (0.021-0.091mg/l) were only detected

upstream, the level of iron was highest amongst all tested metals (0.393-0.740 upstream, 0.101-0.204mg/l midstream and 0.094-0.143mg/l downstream). From the foregoing high level of iron has been detected in both surface and groundwater of Bayelsa state [22, 23]. Cadmium could be leaching can result from agricultural activities like fertilizer and pesticide application [24-26].

Table 3: Heavy metal analysis of Efi Lake

Sample Code	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Mercury (mg/L)	Lead (mg/L)	Zinc (mg/L)
USI	0.037±0.009b	0.017±0.032a	BDL	0.740±0.058b	BDL	BDL	0.021±0.009a
US2	0.033±0.033b	0.023±0.023a	BDL	0.393±0.293a	BDL	BDL	0.091±0.091a
MS1	BDL	BDL	BDL	0.204±0.204a	BDL	BDL	BDL
MS2	0.014±0.00a	BDL	BDL	0.101±0.101a	BDL	BDL	BDL
DS1	BDL	BDL	BDL	0.094±0.034a	BDL	BDL	BDL
DS2	BDL	BDL	BDL	0.143±0.143a	BDL	BDL	BDL
WHO Limit	NS	0.005	1.5	1.0	0.001	0.01	1.5
SON	-	-	1.0	1.0	-	-	-

Each value is expressed as mean ± standard error (n = 3). Different letters in each column indicate significant differences at P< 0.05 according to the Duncan Statistics; BDL= below detection limit

Intolerant dose of cadmium is toxic metal which can result to neurological, carcinogenic, mutagenic and renal dysfunction [24]. It results to severe consequences to aquatic which include instant mortality or other systemic dysfunction. [27]. Chromium contaminants may originate from paint pigments, cement, rubber, metal plating, leather tanning, and textile pigments [26]. The toxic impacts of chromium includes; dermal allergy, pulmonary, liver and kidney dysfunction [28-30]. Zinc could be a component arising from precarious or anthropogenic discharged of waste from mining activities, wood preservatives or the manufacture of paint, fertilizer, dye, rubber and ointments [31]. The accidental consumption of zinc results to adverse health effects [32].

Although the lake showed significant level of contaminants from microbiological origin. On the other hand, elemental analysis indicated that all detected heavy metals complied with their respective stated limits. Furthermore, the selected assayed metals in Efi Lake were observed to be either present in low concentration or below detection limit. Although iron which ranks highest amongst assessed heavy metals is due to the geology of the area [Angaye and oHimain]. Generally, the spatial variation of is attributed to the nature of the catchment area, industrial effluents, runoffs, leachates of agricultural activities or hydrogeological of the area [33]. Notwithstanding, it is likely that the pH of the lake, is a reflection of the levels of metals [34]. Also petroleum exploration activities in the Niger delta can also emit natural gases (carbon dioxide, oxygen, sulphur dioxide and nitrogen), with some envisaged elemental leachates to the environment. The communal monitoring of Efi Lake through time-gap fishing activities might have been responsible for the low level of contamination.

4 Conclusions

The communal time-gap exploitation festival Imposed by the people of the Sabagreia people reflects the mild anthropogenic incidence of the lake. Unfortunately, significant level of endemic microbial count makes the lake water unfit for drinking. Also the higher but compliant level of Iron amongst tested heavy metals is attributed to the hydrogeology of the area. The findings of this research will assist the people of Sabagreia on Potential hazard and aid relevant agencies on the need for developing the lake. Although anthropogenic activities on is limited, however our findings indicates that the level of contaminants could arise. As such were recommend further development of the lake as a tourist center as well as constant microbial and element quality assessment of the lake.

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