

Physicochemical and microbial assessment of some creeklets associated with urban runoff in Yenagoa metropolis

Abstract

Urban runoff have become a major source of surface and ground water pollution in most developing nations, where municipal waste streams are uncharacterized or segregated. Bayelsa state, is a wetland located in the Southernmost and Central part of Niger Delta, in Nigeria. This study evaluated the physicochemical and Microbial quality of recipient creeklets of urban runoff in Yenagoa Metropolis, being the Capital city of Bayelsa state. Water samples were collected from 6 randomly selected creeklets, and analyzed following standard protocol. Results of physicochemical parameters were reported as; temperature (27.96 ± 0.30 - $29.01\pm 0.27^\circ\text{C}$), pH (6.60 ± 0.52 - 6.81 ± 0.56), Dissolved oxygen (3.80 ± 0.48 - $8.90\pm 0.27\text{mg/l}$), Turbidity (17.94 ± 0.05 - 31.97 ± 0.83 NTU), conductivity (67.67 ± 0.13 - $55.31\pm 0.42\mu\text{S/cm}$), and Total dissolved solid (TDS), ranging from 51.20 ± 0.66 - $111.50\pm 0.29\text{mg/l}$ ($P<0.05$). While the levels of nitrite range from 1.45 ± 0.03 - 3.94 ± 0.53 mg/l, Total heterotrophic bacteria and fungi were 0.65 ± 0.11 - $1.35\pm 0.71\times 10^6$ and 0.46 ± 0.33 - $0.77\pm 0.62\times 10^4\text{Cfu/ml}$ respectively. Furthermore, the total and faecal coliforms were 161.18 ± 9.30 - 256.14 ± 4.90 and 81.15 ± 9.90 - 169.11 ± 3.71 MPN/100ml respectively. The results generally indicated significant levels of contamination of the creeklet due to anthropogenic activities. As such, Government, NGOs and all stakeholders should formulate mitigable measures to check anthropogenic activities.

Keywords: niger delta, Creeklet, microorganisms, physicochemistry, urban runoff

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Introduction

Water is an essential resource to biodiversity largely because all organism depend on water for survival and sustenance. As documented in literature, the quality of river water plays a vital role to the relative public health and sustenance of any given community or ecosystem.¹ For instance, anthropogenic activities have the tendency to release toxic organic and inorganic leachates from waste stream which are transported by urban runoff to contaminate water bodies.^{2,3} Persistent inflow of waste stream from urban runoffs have largely affected the ambient water quality of aligning water bodies. It has been observed that in some communities of most developing countries surface water still serve as a means for waste disposal, especially in riverine communities.³ Persistent anthropogenic activities over a period of time may influence the contamination rate.

The contamination of water bodies from leachates of urban runoff due to unregulated and illicit dumping of unsegregated and untreated treated waste stream have been reported by several authors.¹⁻⁶ Some of the envisaged adverse of such contaminated runoff water on such water bodies includes but not limited to; nutrient enrichment, deterioration of the water qualities, and destruction of spawning grounds for aquatic and marine life, general fish kill.² Furthermore, the quality of any water body is largely dependent on its intended purpose. Even the spread of water-borne diseases like typhoid, cholera, diarrhoea from contaminated water have been documented in literature by several.^{1,7-9} Consequent upon the environmental hazards associated with organic and inorganic leachates of waste streams associated with urban runoff and its toxicity to the ecosystem; it has become necessary to investigate the potential hazards associated with urban runoffs.

Materials and methods

Study area

Yenagoa metropolis is the capital city of Bayelsa state of Nigeria, which is located on the southernmost part of Nigeria. It is a wetland consist of several network of creeklets which is linked to a major parent creek called Epie creek. The study area is a tropical humid hot climate with two prevailing seasons, being wet and dry seasons. The wet season which ranges from April to October is relatively cool and rainy, while dry season which is relatively hot and dusty ranges from November to March.¹

Sampling

The sampling points are randomly selected dumpsites within the metropolis and the central dumpsite located on the outskirts of the metropolis. A total of 6 creeklet water samples (control inclusive), were collected in triplicates from 5 creeklets (Amarata, Okutukutu, Etegwe, Akenpai, Agudama), and one control station outside the metropolis. Samples for physicochemistry were monitored *insitu*, while samples for microbiological analysis were packaged in sterile Mc-cathney bottles and transported to the laboratory in ice pack.

Techniques for physicochemical analysis

Physicochemical parameters like; pH and Total dissolved Solid (TDS) were measured *insitu* using portable digital multi-probe meter (EXTECH-DO700). In the same vein, Salinity and conductivity were measured *insitu* using EXTECH-EC400 multi-probe meter, while turbidity and Total Suspended Solid (TSS) were assessed with the EXTECH-TB400 Turbidity meter and Envco-1500 TSS Meter respectively.

Techniques for microbial analysis

The microbial inoculation and density enumeration of the soil samples was carried out using serial dilution and pour plate technique as described by several authors.^{10,11} About 1.0ml aliquots of the water samples was dispense into the 9.0ml of sterile distilled water in plugged test tube and agitated for even distribution, making a dilution factor ranging from 10^{-1} to 10^{-7} was achieved from the first diluent. About 1ml of each diluent from the respective test tubes were aseptically pipetted into the individual labelled sterilized Petri dishes. The inoculation was carried out in a laminar flow, the inoculated plates were inverted prior to their transfer to the incubator. The media used for the study were Nutrient Agar for Total Heterotrophic Bacteria (THB) at 35°C for 24–48 hours, Sabouraud dextrose agar for Total Fungi (TF) 28±2°C for 72–96 hours. Furthermore, MacConkey broth for was used for the culture of Total and Feecal Coliforms 37°C for 24–48 hours.¹²

Statistical analysis

All statistical analysis for the purpose of this research were carried out using SPSS software (SPSS Inc, Chicago; version 20). One-way analysis of variance was used for mean separation at $P=0.05$, While Duncan's multiple range test (DMR) was used for the source of differences.

Results and discussions

Table 1 presents the physicochemical properties of the creeklets in Yenagoa Metropolis of Bayelsa state Nigeria. Result showed that temperature of the creeklet water sample ranged from 27.96±0.30–29.01±0.27°C. The temperature recorded in this study were within ambient range. As established in literature optimal temperature is required for the sustainability of biodiversity, as extreme temperature might oblige the proliferation of exotic/alien species.¹ The temperature values of this study is comparable to values reported by other authors, in the study area for Epie creek 27.3–29.3°C,² and 28.36–30.10°C for Efi lake.¹ The pH values of this study ranged from 6.60±0.52 - 6.81±0.56, which was within the stipulated limits of the WHO (6.50–8.50). Notwithstanding, the pH of this study is comparable to values reported by other authors, in the study area for Efi lake 6.55–7.20,¹ 7.4–7.57 in dry season and 6.9–7.33 in wet season for Epie creek,² 6.95–7.50 for lower Kolo creek,¹³ 7.17 for upper river Nun,¹⁴ 6.8–8.5 for Nkoro River¹⁵ as well as values ranging from 6.5–7.11 for Igedi river and 6.5–6.73 for River Nun.³ Acidic or alkaline pH indicates elemental contamination of water bodies, which have the propensity to adversely affect biodiversity. The result of this study indicates optimal pH.

The spatial levels dissolved oxygen (DO) amongst the creeklet ranged from 3.80±0.48–8.90±0.27mg/l, with significant difference ($P<0.05$) amongst the sampling stations (Table 1). Although, there is no specified level for DO. But ambient or tolerant DO level varies for depending on the affected organism. For instance, low level of DO may be toxic to some aquatic organism,¹⁷ especially if lower than 2.0mg/l.¹⁶ Also DO solubility can be affected by high temperature as such there is an inverse correlation between temperature and DO.² Comparatively,³ reported DO levels of 10.200±0.283 and 14.225±0.263mg/l for Igbedi and Ogobiri around the river Nun which was higher than values of this study. However, the DO level reported by Seiyaboh et al.¹⁸ ranging from 4.8mg/l–7.2mg/l was in tandem with

values of our study. Efi Lake had DO levels in the range of 9.07–19.52mg/l.¹ DO levels of 5.0–7.92mg/l was reported for Kolo creek,¹³ 1.38–9.06 and 1.76–5.68mg/l for dry and wet seasons of Epie creek respectively.²

The turbidity levels of the water sample from the creeklet ranged from 17.94±0.05–31.97±0.83 NTU, with the most and least turbid values in Agudama and Etegwe stations respectively (Table 1). Notwithstanding, the control station indicated a lower turbidity values compared to stations in the study area ($P<0.05$). The turbidity values recorded in this study is comparable to values reported by other authors in; upstream and downstream of Nun river of Agudama Iketiama with values of 103.752±2.062 and 117.002±2.160NTU respectively.¹⁸ Other authors who studied surface water in the Niger delta reported turbidity values 62.54 NTU in Igbedi creek,³ 5–64 NTU around Tombia bridge Agudama Iketiama,²¹ 7.87–17.29NTU in Efi lake,¹ Epie creek in dry (11.67–19.67) and wet (16.67–28.00 NTU) seasons,² and Kolo creek with values of 35.0–40.5 NTU.¹³ While the control station indicated the lowest value, the conductivity of the creeklets ranged from 67.67±0.13–55.31±0.42µS/cm (Table 1); with Agudama and Etegwe Stations having the highest and lowest values respectively ($P<0.05$). Our values is comparable to 48.13–68.93µS/cm obtained for Efi Lake.¹ As documented values of Amassoma and Agudama-Ekpetima were 56.075±0.591 and 64.950±0.681µS/cm.¹ Other conductivity values were reported for Kolo creek 82.30–102.0µS/cm for,¹³ Igbedi creek 76.23µmhos/cm,¹⁴ Tombia bridge construction area 87–95µmhos/cm,¹⁸ as well as values of 18.9–156.4µS/cm reported by Puyate and Rim-Rukeh.

The level of total dissolved solid (TDS) reported in this study ranged from 51.20±0.66–111.50±0.29 mg/l, with Etegwe and Akenpai stations having the highest and lowest values respectively ($P<0.05$). In addition, the control station indicated the lowest level of TDS. Our values are comparable to values reported by other authors. In Efi lake values ranged from 54.25–102.92mg/l.¹ Other authors reported TDS values for Kolo Creek 41.5–51.0 mg/l,¹³ Amassoma and Igbedi axis 28.180±0.048 and 32.550±0.666mg/l respectively,¹ Epie creek 55–62 for dry season and 33–37.33mg/l in wet seasons respectively, as well as values of 62.1–67.9mg/l in Tombia axis of the river Nun. Table 2 presents the level of microbes associated with the creeklet including; Total Heterotrophic Bacteria (THB), Total Fungi (TF), Total Coliform (TC) as well as the levels of Feecal Coliform (FC). The levels of enumerated THB and TF ranged from 0.65±0.11–1.35±0.71X10⁶ and 0.46±0.33–0.77±0.62 X10⁴ cfu/ml respectively ($P<0.05$). Furthermore, the coliform levels were 161.18±9.30–256.14±4.90 and 81.15±9.90–169.11±3.71MPN/100ml for TC and FC respectively ($P<0.05$). The qualitative assessment of water is largely dependent on its intended use. For instance, the levels of microbes in portable water must be zero, as recommended by WHO. Notwithstanding, our values reported is comparable to values of Efi lake ranging from 76.72–260.23MPN/100ml for TC, and 53.67–157.02MPN/100 ml FC.¹ The values of THB were 6.434±0.039 and 6.387±0.055Log cfu/ml for lower and upper Nun Respectively, and 6.414±0.078Log cfu/ml 6.394±0.070Log cfu/ml for Ogobiri and Akaibiri respectively.³ The levels of microbes detected in the creeklet water indicated significant level of microbial contamination, which can be source of reservoir for the transmission of water borne diseases. In addition exceeding level of microbial density can harm aquatic life, especially fish kill that has been documented in literature.^{16,19–21}

Table 1 Results of the physicochemical properties of the creeklets

Sample Code	Temp. (°C)	pH	DO (mg/l)	Turbidity (NTU)	EC (µS/cm)	TDS (mg/l)
Amarata	28.14±0.21b	6.63±0.10b	8.90±0.27d	24.15±0.32e	61.91±0.41e	90.42±0.31d
Okutukutu	27.96±0.30ab	6.81±0.56b	5.01±0.13b	27.04±0.69d	64.51±0.71f	111.50±0.29e
Etegwe	28.11±0.38a	6.61±0.71a	7.48±0.12e	17.94±0.05b	66.30±0.31d	314.34±2.08b
Akenpai	29.01±0.27b	6.81±0.09ab	7.40±0.42f	28.91±0.56ab	67.67±0.13c	51.20±0.66a
Agudama	26.98±0.62a	6.60±0.52d	3.80±0.48a	31.97±0.83c	55.31±0.42b	89.98±0.67b
Control	27.56±0.31b	6.89±0.11c	11.09±0.10c	4.10±0.08a	47.22±0.03a	44.42±0.31c
WHO	Ambient	6.5–8.5	-	5	1000	500

Table 2 Results of microbiological quality assessment of the creeklets

Sample Code	THB, X 10 ⁶ (Cfu/ml)	TF, X 10 ⁴ (Cfu/ml)	TC (MPN/100 ml)	FC (MPN/100ml)	Nitrate (mg/l)
Amarata	1.35±0.71c	0.92±0.45c	256.14±4.90d	169.11±3.71c	1.45±0.03a
Okutukutu	0.81±0.60b	0.50±0.71b	250.18±9.30b	161.10±4.17d	2.79±0.41d
Etegwe	0.68±0.31b	0.58±1.21ab	175.41±6.12a	90.31±0.11a	3.94±0.53b
Akenpai	1.27±1.43b	0.77±0.62ab	197.21±0.27c	81.15±9.90d	2.51±0.41c
Agudama	0.65±0.11b	0.46±0.33a	217.09±2.88c	97.67±2.70b	3.42±0.81a
Control	0.49±0.41a	0.80±0.19d	134.14±5.11d	78.52±4.12a	0.41±0.02ab

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.

Conclusion

The research investigated the physicochemical and microbiological assessment of some creeklet associated with urban runoff. Unfortunately, results indicated significant level of microbial contamination due to anthropogenic activities. On the other hand, most physicochemical parameters indicated mild level of contamination, as they complied with regulatory limits. The significant level of microbes is an indication that the creeklet water is unfit for consumption and most domestic and aesthetic purpose. The leachability of toxic leachate of urban runoff is largely implicated in the pollution of surface water. As such, we therefore urge government and all stakeholders to formulate policies to check the anthropogenicity of urban runoff, due to the fragility of the study area as a wetland prone to flooding.

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Conflict of interest

The author declares that there is no conflict of interest.

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