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Evaluation of Surface Water and Sediment Physico-chemical Properties of Amadi-Ama Creek, Port Harcourt

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ABSTRACT

A pollution status assessment of Amadi-Ama Creek, Port Harcourt, was carried out to determine its water and sediment physico-chemical properties due to the vulnerability of Niger Delta freshwater ecosystems to pollution. A quantitative descriptive research design was used to sample areas of likely impact of contamination along the axis of the creek at low tide during the rainy season. *In situ* measurements of water temperature, salinity, dissolved oxygen (DO), and pH were taken. The grab sampling technique was used to collect water samples, whereas sediment samples were collected with an Ekman Grab. Water and sediment samples were code-labeled, placed in an ice-lined thermos cooler, and used for analysis. Results obtained showed - water temperature (29.1±1.2 - 32.4±0.7 °C), pH (6.6±1.8 - 9.6±0.7), DO (8.1±1.5 - 10.6±2.2 mg/L), BOD (8.4±1.9 - 21.0±0.5 mg/L), nitrate (0.51±0.09 - 0.88±0.2 mg/L), phosphate (0.013±0.04 - 0.016±0.001 mg/L). Sediment pH (6.2 – 7.5), organic carbon (0.17 - 2.01 %), nitrate-nitrogen (4.72 - 9.20 mg/kg), total Kjeldahl nitrogen (0.03 - 0.26 mg/kg), and phosphate content ranged from 2.70 – 8.73 mg/L. Sediment cations: calcium ion (0.53 – 1.67 mg/kg), magnesium ion (0.61 – 3.22 mg/kg), and potassium ion (0.28 – 2.80 mg/kg). Based on the water BOD, calcium and magnesium ions; sediment phosphate, nitrite and ammonium nitrogen concentration levels, it is recommended that measures should be taken to control anthropogenic release of organic matter and nitrogen-containing wastes to prevent water quality deterioration and protect the resource for continued benefit to humanity.

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INTRODUCTION

Surface water bodies, including creeks, are important sources of water for many communities, particularly for rural settlements in developing countries. They are important for the practice of fishing and a source of water for irrigation, edible and medicinal plants, and other resources from the aquatic environment. They are also transportation routes between riverine settlements and communities (Ekweozor *et al*., 2017). Lakes, streams, rivers, etc., serve as natural facilities for recreational sporting activities as well as sinks for waste management (Shiklomanov & Rhoda, 2003). Ecologically, surface waters are habitats for hydrophytes, aquatic fauna, and natural flood protection structures, etc.

Amadi-Ama Creek, a tributary of the Bonny Estuary, is an important surface water resource in Trans-Amadi, Port Harcourt. Fishing, water transport, car-washing, sand mining, popularly called dredging, and waste management, etc., are some activities carried out along the Creek. However, these activities are known to impact water quality (Khebiza *et al*., 2006; Gyawali *et al*., 2012). For instance, surface water pollution has also been reported to result from industrial activities (United Nations Environmental Programme, 2011) through the release of fossil fuels or incompletely burnt fuel, particulates, and oil by outboard engines that navigate waterways (Science for Environment Policy, 2007), and the inflow of urban stormwater. The Niger Delta surface water bodies are exposed to these activities and processes and, therefore, are prone to water quality degradation and subsequently pollutions.

Water physico-chemical properties provide metrics for measuring water quality and pollution (Marshall & Moses, 1994). They are the basis for the determination of pollution in aquatic systems and their suitability to support life and for human use. Hence, their importance in assessment and monitoring of surface water resources was emphasized in the "Enhancement of Fisheries of Small Water Bodies" conference held in Harare (Marshall & Moses, 1994). Environmental concerns have led to intense assessments of surface water bodies in the Niger Delta because of their social, economic, and ecological importance. Some such assessments include the Kolo Creek (Aghoghovwia & Ohimain, 2014), Ikoli Creek (Ogamba *et al*., 2015), Nwaja Creek (Adesuyi *et al*., 2015), and Sagbama Creek (Seiyaboh *et al.*, 2017), etc.

Conclusively, this study seeks to assess the water and sediment physico-chemical condition of Amadi-Ama Creek by analyzing samples collected from it. This study will add to the expanding study of Niger Delta water bodies and provide data on the Creek for future reference and monitoring. It will also provide information for environmentalists and policymakers for management of the ecosystem based on ecological management principles for conservation purposes. This assessment will provide information for recreational users of the creek on its safety or otherwise, backed by empirical data.

MATERIALS AND METHODS

Amadi-Ama Creek is a tidal estuarine ecosystem with freshwater input from its surroundings. It has its headwater upstream in the Rumuobiakani and Mini-Ewa areas of Obio/Akpor Local Government Area, and connects to the Bonny Estuary. It has shorelines with intertidal mudflats covered with dense vegetation of *Rhizophora* species interspersed with white mangrove species (*Laguncularia racemosa*), black mangrove (*Avicennia germinans*), and *Nypa fructicans* at most areas. There were also disused scrap metal pipes, fibre plastics of speed boats, and public toilets at some points. The water had floating plastics transported into it by stormwater.

The Creek is located in Trans-Amadi, an area of Port Harcourt metropolis popularly called Trans-Amadi Industrial Layout, which is in Port Harcourt Local Government Area of Rivers State. This area has GPS latitudes of 04^0 47’ 05.1’’ to 04^0 47’ 39.0’’N and longitudes 07^0 01’ 54.2’’ E - 07^0 01’ 23.7’’ E. The Creek, as a tributary of the Bonny Estuary, empties into the Atlantic Ocean, which borders Nigeria’s territory at the south. The entire area is located in the region of Nigeria called the Niger Delta (Figure 1).

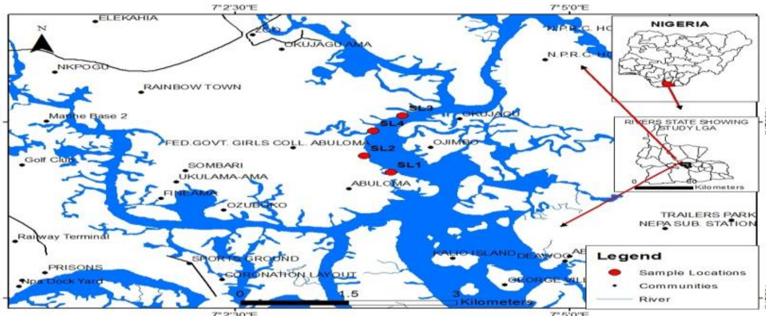

Figure 1: Map of Trans-Amadi, Port Harcourt, showing Amadi-Ama Creek

The zone of likely impact was used to locate four sample locations (SL) 10 m from the low-tide point at the shoreline into the pelagic zone with potential human impact along the axis of the creek (Figure 1). Some features of the sample locations are given in Table 1. Sampling was carried out at low tide following standard procedures and using appropriate instruments.

Table 1: Sampled Locations and Their Features

Sample Location	Location Code	Location Coordinates	Features Around Location
Somiari/Fimie	SL-1	4^0 47’ 05.1’’N 7^0 01’ 54.2’’E	Public/community dumpsites/toilets at the shores; dense mangrove vegetation at the shore; and Dredging activities.
Amadi-Ama	SL-2	4^0 47’ 27.5’’N 7^0 01’ 29.4’’E	Public/community dumpsites/toilets at the shores; Van Oord is located opposite the village.
NLNG Base	SL-3	4^0 47’ 39.0’’N 7^0 01’ 22.6’’E	Heavy water transport boats for water transportation.
Bourbon Interoil/Prodeco	SL-4	4^0 47’ 36.2’’N 7^0 01’ 23.7’’E	Dense mangrove vegetation. Bourbon InterOil Nigeria Limited and Prodeco International Limited premises across the shore.

Field sampling was carried out on the creek at the sample locations: surface water samples were collected with amber-coloured bottles by dipping bottles with the mouth up in water to fill and corking below the water surface. Immediately after water collection, the bottles were labelled and placed in a thermos cooler packed with ice blocks. Surface water samples for Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were fixed by adding drops of Winkler’s solution. This same procedure and method were used to collect water samples at the other locations. Sediment samples were collected with an Ekman Grab. A composite sampling technique in which three sediment samples were collected and bulked by thoroughly homogenizing to form the sample for a location. The sediment samples were immediately placed in sterile foil paper, labelled, and kept in the thermos cooler. Both water and sediment samples for each sample location were labelled with a location code to distinguish between sample locations and taken in the thermos cooler to the laboratory for analysis. *In situ* measurements of temperature, salinity, and pH of each sample location were taken on site.

Surface water temperature, pH, and salinity were measured by electrometric methods using a portable Hanna Multiparameter meter (HANNA HI 98194) with a probe. Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) were determined by Winkler’s Method. Nitrate content was determined by spectrophotometry with an Avanta GBC Scientific spectrophotometer after reacting the sample with sulphuric acid and Brucine reagent, and sample absorbance was read at 410 nm, while phosphate content was measured through the Stannous Chloride Method after reacting the sample with ammonium molybdate and its absorbance was read at 690 nm. Total hardness (TH) and magnesium ion (Mg^{2+}) content were determined by the ethylenediamine tetra-acetic acid (EDTA) titrimetric method, while Total Hardness (TH) was determined through complexometric titration using EDTA and calculated after determinations of magnesium and calcium ion concentrations in the sample with the formula of Yappert & DuPre (1997) given below.

Total Hardness, TH (mg/L as $CaCO_3$) = (Ca^{2+} + [Mg^{2+})

Sediment sample pH was determined by the same method as the water sample, and Organic carbon (OC) was determined through the Walkley-Black method. Average phosphorus was determined by the Bray P - 1 method. Nitrate-nitrogen (NO_3^--N) content was obtained by reacting the sample with phenoldisulfonic acid, and its concentration was determined through colorimetry, while nitrite-nitrogen (NO_2^--N) content was determined by the spectrophotometric method after reacting the sample with Griess-Ilosvay reagent as described by Thipwimonmas *et al.* (2001). Ammonium-nitrogen (NH_4^+-N) content was determined by the spectrophotometric method after Nesslerization as described by Golterman (1991), while total nitrogen (TN) was determined by the Kjeldahl method.

Sediment Ca^{2+}, Mg^{2+}, and K^{+} were determined by flame photometry with an atomic absorption spectrophotometer (Elico's SL-243).

From the data obtained from the determinations, descriptive statistics (mean, standard deviation) were calculated. One-Way Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) at the $p = 0.05$ level of significance with Statistical Analysis Software (SAS) 9.4m4 were run using Windows 8. Results obtained are presented in composite tables alongside the Federal Ministry of Environment (FMEnv, 2001) standard limits for water bodies for fisheries and recreation purposes.

RESULTS AND DISCUSSION

Table 2 displays the values of surface water physico-chemical properties at the assessed sample locations. Surface water temperature ranged from 29.1±1.2 °C to 32.4±0.7 °C with the highest temperature recorded at SL-4 and the lowest at SL-3. The temperature profile across all four sample locations is compliant with the regulatory standard limit, which provides an upper permissible thermal threshold of < 40.0 °C for surface water ecosystem protection for fisheries and recreation. Clearly, the temperature result seems natural as it is consistent with characteristic high surface water temperatures of the tropical region and corresponds with the findings of Otene and Iorchor (2013), who studied seasonal changes in water physico-chemical properties of this creek and reported temperature values of 30.6 ^{0}C. However, despite the general compliance, the significantly higher temperature observed at SL-4 (32.4 °C) may have resulted from localized input of stormwater runoff or the absence of riparian vegetation cover, which exposes the water column to direct solar radiation.

Water pH increased downstream from SL-1 to SL-4 and ranged from 6.6 to 9.6. The pH values of SL-1 to SL-3 were within the prescribed standard limits and at the optimum pH range for physiological activities in organisms. However, a pH of 9.6 recorded at SL-4 is beyond the upper prescribed standard limit. This exceedance of the FMEnv regulatory cap can be attributed to human-driven impacts (Agunbiade & Joshua, 2010; Edokpayi et al., 2016).

Salinity levels varied between the sample locations (SL-1, SL-2, SL-3, and SL-4). Salinity declined downstream, i.e., from SL-1 to SL-3. SL-1 recorded the highest salinity value (12.2 %), while the lowest value (2.0 %) was recorded at SL-3. The high salinity at SL-1, SL-2, and SL-4 could be attributed to the influence of intrusion of saltwater from the Bonny Estuary, to which Amadi-Ama Creek is connected. This high salinity corresponds with Davies *et al*. (2008), who reported similar results from Woji Creek. However, the lowest salinity recorded at SL-3 could be the result of heavy inflow of stormwater runoff from the surrounding land area.

Sample locations' dissolved oxygen (DO) concentrations were generally higher than the prescribed statutory minimum limit of 6 mg/L (FMEnv, 2001). DO content declined downstream from 10.6 mg/L at SL-1 to 8.1 mg/L at SL-3 and increased to 10.6 mg/L at SL-4. There was no statistically significant difference between SL-1 and SL-4; however, a significant difference was observed between the two sample locations at SL-3, at $p < 0.05$. Dissolved oxygen levels in surface water is an indication of the degree of aeration of a water body, which is influenced by temperature, photosynthetic activity by autotrophic organisms, organic carbon content decomposition, and salinity (DataStream Initiative, 2021).

Biochemical Oxygen Demand (BOD) at all four sample locations exceeded the FMEnv (2001) maximum standard limit of <4.0 mg/L. The highest BOD value (21.0 mg/L) was observed at SL-1, while the lowest (8.4 mg/L) was recorded downstream at SL-2. Generally, the high BOD results observed at the sample locations were notable, as they suggest organic pollution, which could have resulted from anthropogenic impacts, such as organic matter inputs (e.g., defecation) and waste disposal into the water, as observed on the creek shorelines. A similar high BOD result was reported by Orime (2014) from a study of Rumuolumeni Rivers.

Nitrate contents of the sample locations were below 9.1 mg/L, the FMEnv standard. Nitrate contents of SL-1 and SL-2 were higher than and different from those of SL-3 and SL-4. Although all sample locations satisfied the regulatory safety thresholds, statistical analysis of sample location results indicated spatial differences across the sites. The analysis demonstrated that nitrate levels at SL-1, SL-2, SL-3, and SL-4 were all significantly different from one another. The low nitrate content of this study corresponds with the findings of Gyawali *et al*. (2012) from an assessment of the effects of industrial waste disposal on surface water. A similar nitrate content result was also reported from a similar tropical lake by Pole *et al*. (2016). According to the New York Natural Heritage Program (2017), low nitrate concentration in water is natural and clearly shows no significant external input of the nutrient into the water body.

Total Hardness (TH) values ranged between 2496.0 mg/L and 3840.0 mg/L. The highest TH was recorded at SL-4 and the lowest at SL-2. Total hardness reduced from SL-1 to SL-2, and increased further downstream at SL-3 and SL-4. The TH results recorded in this study align with the findings of Duru *et al*. (2018). Statistically, there was no significant difference in TH between SL-1 and SL-2; however, there was a statistical difference between SL-1/SL-2 and the other sample locations at $p < 0.05$. The observed high TH result is natural due to the fact that brackish water is characteristically higher in total hardness. This is further justified by the fact that Amadi-Ama Creek receives saltwater input from the Atlantic Ocean through the Bonny Estuary during high tide.

Phosphate contents were below 3.5 mg/L (i.e., FMEnv standard; Table 2), as they ranged from 0.013 mg/L to 0.016 mg/L. The lowest phosphate level was recorded at SL-4, while the highest was recorded at SL-3. There were significant statistical differences between sample locations (Table 2) at the $p = 0.05$ level of significance. The finding that all sampled sites maintain phosphate levels of magnitude below the FMEnv (3.5 mg/L) standard cap demonstrates that the water is currently safe from phosphorus-induced environmental degradation (Onwuka *et al*., 2024; Onwordi *et al*., 2010). Phosphorus typically serves as the primary limiting nutrient in many aquatic and soil environments (Minnesota Pollution Control Agency, 2008; Anyanwu, 2022). Maintaining such low baseline conditions ensures that the ecosystem is free from ecological disruptions. Therefore, the observed low phosphate content is good for the ecosystem and simply suggests the creek is oligotrophic in phosphate content.

Calcium ion (Ca^{2+}) concentration results did not show any definite trend. The highest Ca^{2+} content (652.8 mg/L) was recorded at SL-1, while the lowest (155.2 mg/L) was recorded at SL-4. In relation to the FMEnv (2001) standard, Ca^{2+} contents are above the permissible limit at SL-1 to SL-3. Calcium, as a natural component of water, and its concentration in water is affected by different factors, some of which are natural and others are due to human activities. The high Ca^{2+} concentration recorded at SL-1 to SL-3 agrees with the findings of Reid & Mosley (2015), who stated that the observation may be the result of low uptake of the ion by plants and low precipitation in water to buffer and maintain optimum pH for life support. This explanation sufficed to account for the Ca^{2+} result obtained at the creek, as there was low vegetation growth density.

Analysis of Mg^{2+} levels across the sample locations showed spatial variations. Sample location three (SL-3) exhibited significantly higher Mg^{2+} levels (21.6 mg/L) than the other sample locations, followed by SL-2 (15.0 mg/L) and SL-1 (13.1 mg/L). Conversely, SL-4 (0.9 mg/L) recorded the lowest concentration of the mineral, indicating a distinct environmental profile or a diminished influence of magnesium-yielding sources. Generally, the mean Mg^{2+} concentration results of the sample locations agree with the findings of Musa *et al*. (2024) from a hydrogeochemical characteristics investigation of surface water in Pago, North Central Nigeria.

Magnesium is a critical alkaline earth metal essential for various biological functions. The high concentrations of Mg^{2+} recorded in SL-1 to SL-3 are in contrast with those reported by Seiyaboh *et al*. (2017). The elevated concentration in aquatic systems often indicates specific geological weathering or anthropogenic inputs. The significantly higher concentration of Mg^{2+} at SL-3 could be attributed to localized factors such as intense weathering of magnesium-rich minerals (like dolomite or magnesite) or direct anthropogenic discharges. Such discharges often include human waste materials, agricultural runoff containing magnesium-based fertilizers, or industrial effluents.

Table 2: Water Physico-chemical Properties

Parameter	**Sampled Location**				**FMEnv Limits**
	SL-1	**SL-2**	**SL-3**	**SL-4**	
Temperature (^{0}C)	30.0±1.5^{ab}	30.5±0.5^{ab}	29.1±1.2^{b}	32.4±0.7^{a}	< 40.0
pH	6.6±1.8^{b}	6.8±1.0^{b}	6.9±0.8^{b}	9.6±0.7^{a}	6.5–8.5
Salinity %	12.2±0.9^{a}	9.0±1.5^{b}	2.0±0.7^{d}	6.1±2.1^{c}	NS
DO (mg/L)	10.6±2.2^{a}	9.7±1.5^{ab}	8.1±2.1^{b}	10.6±1.9^{a}	> 6.0
BOD (mg/L)	21.0±0.5^{a}	8.40±1.9^{d}	14.0±0.9^{c}	17.5±1.1^{b}	< 4.0
NO_3^- (mg/L)	0.88±0.2^{a}	0.84±0.2^{b}	0.51±0.09^{d}	0.58±0.05^{c}	9.1
Total Hardness (mg/L)	2976.0±40.9^{bc}	2496.0±38.9^{c}	3456.0±25.9^{b}	3840.0±35.6^{a}	NS
PO_4^- (mg/L)	0.015±0.001^{ab}	0.014±0.009^{bc}	0.016±0.001^{a}	0.013±0.004^{c}	3.5
Ca^{2+} (mg/L)	652.8±42.4^{a}	384.0±27.6^{c}	499.2±31.9^{b}	155.2±19.1^{d}	180.0
Mg^{2+} (mg/L)	13.1±2.0^{c}	15.0±1.7^{b}	21.6±2.1^{a}	0.9±0.09^{d}	40.0

Figures with the same superscript alphabet are not significantly different.
NS = Not Specified

Table 3 displays the values of sediment physico-chemical properties at the assessed sample locations. Sediment pH ranged from 6.3 to 7.5. A peak pH of 7.5 was observed at SL-3, and the lowest pH (6.3) was recorded at SL-1. The pH of SL-1 indicates slightly acidic conditions; a deviation that suggests localized environmental stress, potential acidic effluent discharge, or specific geological influences unique to that sampling point. The pH results are within the prescribed standard range and therefore ecologically suitable for supporting the survival of aquatic life except for SL-1.

The spatial distribution of Organic Carbon across the four sampled locations against an unspecified standard for the parameter by the Federal Ministry of Environment is displayed in Table 3. The organic carbon content results reveal significant spatial heterogeneity. The highest organic carbon level is recorded at SL-4 (2.01%), closely followed by SL-1 (1.76%) and SL-3 (1.56%). These high organic carbon content results correspond with the findings at Nwaja Creek by Adesuyi *et al*. (2015), Sombriero River by Ezekiel *et al*. (2011), and Azuabie Creek as reported by Daka and Moslen (2013). These elevated organic carbon contents at SL-4, SL-1, and SL-3 indicate high accumulation of decomposing organic matter or direct organic waste input from anthropogenic pollution.

The concentration of phosphate (PO_4^{3-}) in Amadi-Ama Creek across the four sample locations against 3.5 mg/kg, the permissible limit set by the Federal Ministry of Environment (FMEnv), showed that only SL-2 (2.70 mg/kg) remains within the regulatory limit, while the other sample locations exceeded the statutory limit. Sample location four (SL-4) had the highest concentration level (8.73 mg/kg), followed by SL-1 (6.91 mg/kg) and SL-3 (5.66 mg/kg). The above-limit phosphate concentrations at SL-4, SL-1, and SL-3 suggest heavy inputs from localized emission sources. Conversely, the lower concentration at SL-2 indicates the absence of or minimal discharge of phosphate containing substance into water.

The Nitrate-nitrogen (NO_3^--N) content ranges of the sample stations range from 4.72 mg/kg (SL-2) to 9.20 mg/kg (SL-4). Nitrate-Nitrogen levels of SL-1, SL-2, and SL-3 comply with the FMEnv regulatory threshold of 9.1 mg/kg. However, SL-4 was slightly below the prescribed maximum standard limit. The observed marginal excess over the standard limit at SL-4 indicates nitrification, which may have been induced by long-term input of nitrogenous organic matter or chemical fertilizers (Brady & Weil, 2017); concentrations at these levels indicate eutrophication (Sparks, 2003).

Nitrite-nitrogen observations reveal non-compliance across all four sample locations. The concentrations scale from 2.40 mg/kg (SL-2) up to a peak of 4.00 mg/kg (SL-4). In an unpolluted environmental matrix, NO_2^--N is an unstable intermediate product that rapidly oxidizes into nitrate via microbial action. The observed high accumulation of nitrite across all stations indicates a perturbation in the ecosystem nitrogen cycle. Wetzel (2001) explained that a lag in the conversion of nitrite to nitrate is usually associated with hypoxic (low oxygen) conditions or the presence of specific contaminants that inhibit nitrite-oxidizing microorganisms.

Ammonium-nitrogen levels indicate contamination concentrations in the study area. All sample locations exceeded this baseline, ranging from 1.66 mg/kg at SL-2 to 10.10 mg/kg at SL-4. High concentrations of NH_4^+-N serve as an indicator of recent raw anthropogenic organic chemical pollution, specifically of untreated domestic sewage, animal manure dumps, or the anaerobic decomposition of fresh organic waste by heterotrophic bacteria (ammonification) (Reddy & DeLaune, 2008). This is exhibited by the high concentrations of NH_4^+-N at SL-4 and SL-1, which reflect a high rate of accumulation of organic nitrogen over nitrification rates.

The distribution of Total Kjeldahl Nitrogen **(**TKN) follows the pattern of the other nitrogen fractions. It ranges from a low of 0.03% at SL-2 to 0.24% at SL-1 and a maximum of 0.26% at SL-4. The strong spatial correlation between high TKN and the high organic carbon percentages observed at SL-4 and SL-1 simply validates the proposition that the sample locations are used as sites for organic waste discharge. However, SL-2 was lowest TKN of all nitrogen variables assessed.

The concentrations of essential exchangeable cations: Ca^{2+}, Mg^{2+}, and K^+ obtained across the four sample locations are presented in Table 3. An analysis of the data reveals that all three cations in all four sample locations were generally below their respective permissible limits defined by the FMEnv. Calcium (Ca^{2+}) values ranged from 0.53 mg/kg at SL-2 to 1.67 mg/kg at SL-4, which are significantly lower than the regulatory maximum limit of 180 mg/kg. Similarly, Magnesium (Mg^{2+}) content ranged from 0.51 mg/kg at SL-2 to 3.22 mg/kg at SL-4; both were within the safe ecosystem threshold of 40 mg/kg. Potassium (K^+) followed an identical spatial pattern. The result shows a spatially consistent trend of the cations across the research area, as the magnitude of concentration was in the order: SL-4 > SL-1 > SL-3 > SL-2. These exchangeable base cations are important indicators of nutrient fertility and buffering capacity. That all values were below the FMEnv guidelines confirms that the study area has no evidence of salt contamination or alkaline chemical discharge.

Table 3: Sediment Chemical Properties

Parameter	**Sample Location**				**FMEnv Limits**
	SL-1	**SL-2**	**SL-3**	**SL-4**	
pH	6.2	6.6	7.5	7.4	6.5 – 8.5
Organic Carbon (%)	1.76	0.17	1.56	2.01	NS
PO_4^{3-} (mg/kg)	6.91	2.70	5.66	8.73	3.5
NO_3^--N (mg/kg)	7.30	4.72	6.04	9.20	9.1
NO_2^--N (mg/kg)	3.28	2.40	3.07	4.00	0.02
NH_4^+ -N (mg/kg)	8.20	1.66	4.70	10.1	0.05
Total kjeldahl N (%)	0.24	0.03	0.15	0.26	NS
Ca^{2+} (mg/kg)	1.20	0.53	0.95	1.67	180
Mg^{2+} (mg/kg)	2.41	0.51	1.00	3.22	40
K^+ (mg/kg)	1.50	0.28	1.03	2.80	50

CONCLUSION

Amadi-Ama Creek provides several resource benefits and services to Trans-Amadi communities. However, the sustenance of these functions will be affected by the deterioration of water quality and pollution. Therefore, water quality and pollution monitoring are the basis for the determination of the status of the aquatic system for ecological services and conservation management. Based on the physico-chemical properties of surface water and sediment samples results, Amadi-Ama Creek surface water is at the threshold of degradation and may lose the ability to serve as a habitat medium for diverse aquatic flora and fauna. Further examination of the creek for petroleum hydrocarbon pollution is recommended.

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