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Physicochemical Characteristics and Levels of Cu, Fe, Pb, Mn and Zn in Sediments of Agbarho River, Delta State, Nigeria

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ABSTRACT: Sediment qualities assessment to ascertain the impact of anthropogenic activities such as dredging, waste disposal, and abattoir effluent on the sediments of a river is very vital. Hence, the objective of this paper was to evaluate the physicochemical Characteristics and Levels of Cu, Fe, Pb, Mn, and Zn in the Sediments of Agbarho River, Delta State, Nigeria using appropriate standard methods. The ranges of results obtained were; pH = 4.0 – 5.3, EC = 10.00 – 246.00μS/cm, OC = 0.36 – 62.72 LOI, N = 0.006 – 0.590 %, Clay = 6 – 14 %, Sand = 76 – 92 %, Silt = 2 – 11 %, Cu = 2.33 – 5.19 mg/kg, Zn = 4.71 – 81.78 mg/kg, Fe = 57.18 – 385.45 mg/kg, Mn = 1.60 – 42.43 mg/kg, Pb = 0.19 – 0.63 mg/kg. Assessment of heavy metals pollution, using pollution indices revealed that the contamination factor was low compared to NUPRC and other standard guidelines/values. These results obtained showed that there was no contamination in the study area.

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Surface water ordinarily has sediment and they assume essential parts for the oceanic biological system (Seiyaboh *et al.*, 2017). Sediment comprises a framework of garbage, inorganic, and natural particles. They act as a definitive sink for some impurities and thus, they represent the most elevated danger to marine life. They are generally heterogeneous regarding their physical, substance, and natural qualities, and contain a changed scope of molecule sizes, including rock, sand, sediment, and dirt (Fergusson, 1990; Sarkar *et al.*, 2004). Subsequently, sediment parts are very much perceived as a fundamental repository for the majority of persevering natural and inorganic synthetic compounds brought into the oceanic climate by environmental testimony, disintegration of the geochemical substrate, and anthropogenic sources (Sarkar *et al.*, 2004). Commonly, benthic life forms live in the residue, particularly in the saline and marine environments. Some fish species likewise blossom with the sediment, particularly shelled fish. Water sediment exists in two structures including suspended and saved silt (Seiyaboh *et al.*, 2017). Regardless of the kind of sediment, they are impacted by the water quality. For example, changes in water quality emerging from anthropogenic exercises in the water like water transportation, digging, squander statement, and normal impacts coming about because of overflow following precipitation can likewise influence the dregs quality. Besides, sediment additionally comes about because of enduring cycles of

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substances/materials that are moved by a few activities including wind and water. As such sediment is inclined toward contamination similar to water (Seiyaboh *et al.*, 2017). Sediments go about as natural files that show the timetable of a sea-going ecological defilement (Swarnalatha *et al.*, 2013). It is, by and large, realized that marine biological systems are imperiled by different impurities, for the most part, untreated sewage, squandered oils, plastics, and modern effluents that eventually influence the manageability of living assets and posture worldwide natural as well as general wellbeing risk (Naylor *et al.*, 2000; *Muduli et al.*, 2012). There is a supposition that the marine climate has a limitless ability to assimilate these impurities without being exposed to unjustifiable mischief (Clark, 2001). Be that as it may, the proceeded presentation of squanders into the marine climate might bring about a quantifiable ascent in the nearby degree of defilement. Unexpectedly the sediment is home to different species alluded to as benthic fauna which live either on a superficial level or tunnel underneath the surface and some which every so often visit to take care of before swimming once again into water. Their actual design influences species variety (Navel *et al.*, 2010), all the more so their substance structure (Richard *et al.*, 2008; Navel *et al.*, 2010). Given their fairly steady nature being at the lower part of the water, contaminations will generally settle, bringing about a scope of intense and persistent poisonousness consequences for the occupying fauna (Lobby and Frid, 1995). Considering that heavy metals that are intentionally or incidentally delivered into residue frequently incorporate exceptionally poisonous structures, the danger to manageable help of biotic life is a key concern that should be addressed to assess sediment quality and this is particularly significant in water bodies, for example, Agbarho River which is exposed to a scope of anthropogenic strain consistently. Hence, the objective of this paper was to evaluate the physicochemical characteristics and levels of Cu, Fe, Pb, Mn, and Zn in the Sediments of Agbarho River, Delta State, Nigeria.

MATERIALS AND METHODS

The Study Area: The Agbarho River is utilized as a case study for the dumpsite, dredging, and abattoir wastewater. Agbarho, which is among the most significant and populated communities in Delta state, South Nigeria, is thought to have 145,000 residents. According to Chudi (1994), the village is situated between latitudes N05o 35' 01.5" and E05o 52' 02.0" and is 8 meters above sea level. In Delta State, the Agbarho River plays a vital economic role by facilitating a range of socio-economic activities like automobile washers and fisheries. As it can support various dredging activities at various locations, the river also offers sand resources. The river is used by locals for swimming and water gathering. The river originates in Warri's Orho hinterland and travels westward to the state's Uvwie Local Government Area, where it joins with nearby creeks to empty into the Atlantic Ocean. The garbage from nearby abattoirs and municipal dumps is dumped into the river. Fig. 1 shows the map of the study area showing the sampling points along Agbarho River.

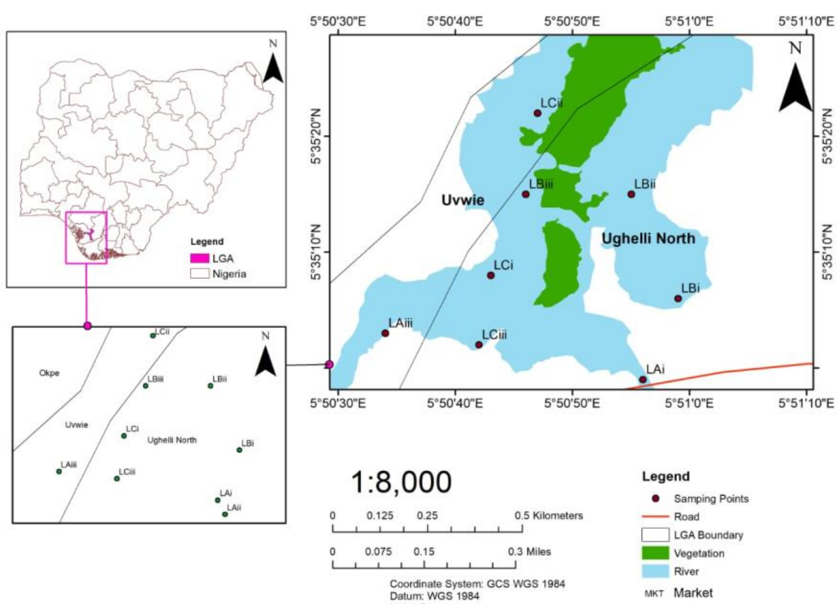

Fig. 1: Map of the Study Area.

Sediment Sampling: With the help of an Eckman Grab sampler, nine sediment samples were taken during the rainy season from three different sample locations (LA: dumpsite leachate point, LB: abattoir effluent, LC: dredging site) and nine (9) sampling points divided into the source point, upstream and downstream sections of the Agbarho River. The samples were transported to the laboratory for analysis after being sealed in polythene bags and kept in an ice chest. As advised by Spencer and Macleod (2002), the obtained sediment samples were stored and preserved using ice packs at the moment of collection. Before being transported to the lab, the collected sediment samples were held at a temperature of -4 °C in cool boxes with ice packs covered in polythene bags to preserve their condition and prevent any analytes from volatilizing. To prevent exposure to ambient temperature and modifications to the stored temperature, the cool boxes were covered and sealed. The International Institute of Tropical Agriculture (IITA) obtained samples for analysis. A reputable courier service brought the polytetrafluoroethylene (PTFE) bottles to the lab for storage after properly packaging and sealing them in plastic clear bags. To keep the storage conditions the same, samples were placed in cold boxes with ice packs. 3.5 Sample Pre-treatment Sediment samples had extraneous elements taken out of them. In contrast to samples for other tests, which were air dried, all samples for heavy metal and organic carbon studies were dried in an oven at 110^0C. A plastic mortar and pestle that had been acid-washed was used to pulverize the dry sediment samples from each treatment into a fine powder. Each treatment's samples were split into two and put through two distinct sieves, measuring 2 mm and 0.2 mm in size. Before being analyzed, they were then kept at room temperature in dry, acid-washed polyethylene bottles with screw tops. In contrast to the 0.2 mm samples, which were utilized for organic carbon, organic matter, and metal analyses, the 2 mm samples were used to determine pH, total nitrogen, particle size, and exchangeable bases.

Sediment Sample Digestion and Analysis: According to Radulescu *et al.* (2014), samples were initially air-dried before being ground into tiny particles, going through a 2 mm sieve, and being homogenized. A 100 ml glass beaker containing 5 g of the homogenized sample was weighed, and 2 mL of HNO_3, 6 mL of HCl, and 20 mL of distilled water were then added to it. A temperature-adjustable block digester's heating mantle was used to heat the mixture, which was then allowed to digest to a volume of roughly 5 mL. The digested material was filtered into a 50 mL volumetric flask using Whatman No. 42 filter paper after being allowed to cool. Using distilled water, the filtrate was diluted to 50 mL.

According to ASTM D1971/4691 (2016), the levels of heavy metals in the samples were measured using a Flame Atomic Absorption Spectrophotometer (Buck 211).

Statistical Analysis: This study result was subjected to descriptive statistical analysis to compute the mean and standard deviation of the obtained data. One-way ANOVA was used to determine the significant difference between the source point, upstream and downstream.

RESULTS AND DISCUSSIONS

pH: One of the reliable methods for determining the acidity or alkalinity of water is pH. The majority of chemical reactions in an aquatic environment are regulated by pH, which is a straightforward yet crucial parameter. The pH of the sediment samples ranged from 4.0 – 5.3 for samples taken at the source point, 4.4 – 4.5 across all the sampling locations taken upstream while the downstream samples had pH values that ranged from 4.3 – 4.4. According to Anon (1986), soil with a pH range of 4.5-.5.0 is classified as very strongly acidic, pH 5.1 - 5.9 as strongly acidic while those within the range of pH 5.6 - 6.5 as slightly acidic. Considering this classification, sediment within the area can be categorized as very strongly acidic.

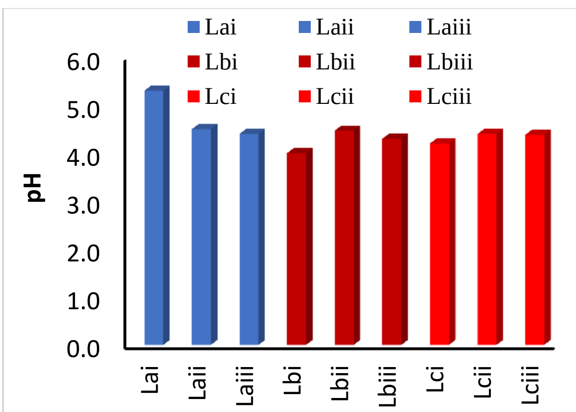

Fig. 2: variations of pH for sediment sample obtained from source points, upstream and downstream sampling locations

Electrical conductivity (EC): Electrical conductivity is a widely recognized indicator of dissolved solids. The measurement of conductivity is used to assess the mineralization of water. The physiological consequences that certain plants and animals undergo are frequently impacted by the ion count that is accessible in the water. The sediments had a range of

10.00 to 246.00 µS/cm, with LAii (upstream dumpsite) having the highest value. The high electrical conductivity recorded in the sediments could be due to the presence of a high concentration of charged ions (both cations and anions) in the area (Chukwuemeka *et al.,* 2017). The sediment can be described as saline since the electrical conductivity levels were above 120µS/cm as prescribed by DPR (2018).

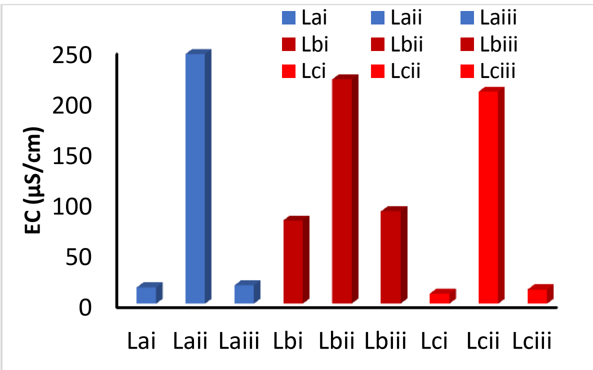

Fig. 3: Variations of EC for sediment sample from source point, upstream and downstream sampling locations

Organic carbon (OC) and total nitrogen (N): OC concentrations ranged between 0.36 – 62.72 LOI in the order of LCi < LCiii < LAi < LAiii < LCii < LBiii < LAii < LBii, < LBi. High OC in LBi could be a result of the effluent discharge of abattoir waste and increased rates of biodegradation.

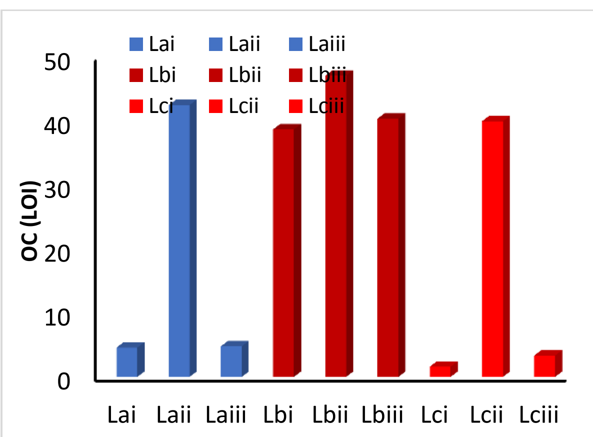

Fig. 4: Variations of OC for sediment sample obtained from source points, upstream and downstream sampling locations

N concentrations ranged from 0.006 to 0.590%, with the abattoir source location (LBi) recording the highest value. Dredging may have contributed to the low values of OC and N. Both too little and too much OC can endanger the ecosystem, causing pollution or the extinction of wildlife. It is typical to conclude that using organic materials to increase sediment organic carbon is a good idea. However, it is important to exercise caution when adding excessive inputs because doing so can result in sediment nutritional imbalances of nitrogen or phosphorus and river pollution.

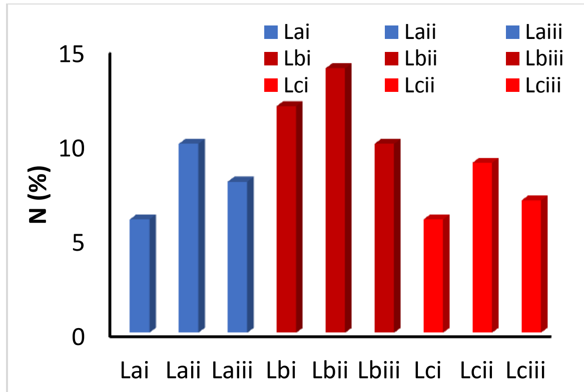

Fig. 4: Variations of N for sediment sample obtained from source points, upstream and downstream sampling locations

Particle size: According to Zauca *et al.* (2013), particle size is crucial to several sediment processes, including aggregate stability. Sand, clay, silt, and fine silt were the different particle sizes that were measured. Given that routine dredging is taking place, it is obvious that over time, the bigger parent surface soil/ sediment materials would have been removed, leaving only the finer forms, which are normally at lower strata. This has repercussions for the microbenthic fauna since such severe harm would lead the sediment to drastically change and lose the organic elements that make up their natural habitat.

Copper (Cu) Levels in Sediments of the Agbarho River: Copper concentrations in sediments ranged from 2.33 mg/kg at LCi (dredging site source point) to 5.19 mg/kg at LAi (dumpsite source point). The concentrations were within the NUPRC, NOAA standards (Table 1). In addition to contributions from natural sources, farming activities may also result in copper inputs to bottom sediments because its compounds can be added to fertilizers and animal feeds to act as nutrients to encourage plant and animal growth (Jumbe and Nandini, 2009).

Table 1: *Target values/limits for heavy metals in soil/sediment.*

Parameter (mg/kg)	NUPRC	NOAA
Copper	36.00	18.70
Iron	38000.00	N/A
Lead	85.00	30.4
Manganese	850.00	N/A
Zinc	140.00	124

Lead (Pb) Levels in Sediments of the Agbarho River: The sediments had lead concentrations ranging from 0.21 to 0.63 mg/kg, with LAi (the dumpsite leachate source point), LAiii (the dumpsite downstream), LCi (the dredging source point), and LBii (the abattoir downstream/run-off) having the greatest lead concentrations and LCi (the dredging source point) having the lowest. Pb concentrations in bottom sediments were found to be lower than the limits of DPR (2018), NOAA (1999), when compared to standard values/limits. Through consumption and inhalation, lead enters the human body, accumulating in the brain to produce poisoning (also known as plumbism), which can also result in death (Wuana and Okieimen, 2011).

Iron (Fe) Levels in Sediments of the Agbarho River: The highest concentration of iron in sediments was 385.45mg/kg at LBi (abattoir source point) while the lowest was 57.18mg/kg at LCi (dredging source point), and the value was found to be lower than that of NUPRC standard.

Zinc (Zn) Levels in Sediments of the Agbarho River: Zinc concentrations ranged from 0.590 to 81.78 mg/kg and were all within the acceptable limits of the applicable standards. Wuana and Okieimen (2011) guarantee that water-dissolvable zinc in soils can pollute groundwater and that plants habitually take in a lot of Zn which is a lot for their bodies to the union because of soil gathering of Zn.

Manganese (Mn) Levels in Sediments of the Agbarho River: Concentrations of Mn ranged from 1.60- 42.96 mg/kg (LCi - LAii); and were found to be lower than that of NUPRC (Table 1). Mn happens normally in many sorts of rocks and soil (Izomoh and Akpambang, 2017). The degree of Mn found in sediments from this study could accordingly be credited to its normal event in the encompassing soils nearby.

Table 2: Levels [mg/kg; range: mean ± STD] of Heavy metals in sediments of Agbarho River, Delta State, Nigeria.

	LA			LB			LC		
Heavy Metals	Range (mg/kg)	Mean	STD	Range (mg/kg)	Mean	STD	Range (mg/kg)	Mean	STD
Copper	2.90–5.91	3.85	1.19	2.35–4.62	3.39	1.14	2.33–2.97	2.66	0.32
Iron	200.80–336.96	253. 02	73.40	245.62–385.45	326.16	72.29	57.18–173.38	104.58	60.98
Lead	0.24–0.63	0.50	0.22	0.19–0.24	0.21	0.025	0.28–0.63	0.50	0.19
Manganese	4.58–42.43	17.26	21.79	38.65–47.04	42. 0	4.44	1.60–39.92	14.95	21.63
Zinc	31.19–81.78	61.50	26.74	0.590–31.78	19. 06	16.37	4.71–6.50	5.50	0.91

Contamination factor: CF was used to express the extent of the sediments' metal contamination (Abdullah et al., 2015). According to Muzerengi (2017), it depicts each trace metal's unique effect on the soil. It was stated as:

$$CF = \frac{Ci}{Cn} \qquad (1)$$

Where Ci denotes the heavy metal concentration in the soil sample taken from the study region, and Cn (background) denotes the standard reference level for the metal (using the DPR standard value). According to Hassan *et al.* (2016), Bashir *et al.* (2014), Abdullah *et al.* (2011), the classification of contamination factor and degree is as follows: CF < 1 (low), CF < 3 (moderate), CF < 6 (significant), and CF ≥ 6 (extremely high).

Conclusion: The evaluation carried out showed that there was no contamination of sediment in Agbarho River, Delta State, Nigeria in terms of the selected heavy metals and the physicochemical characteristics. The physicochemical and the levels of heavy metals examined fell within NUPRC-permitted limits. Marine sediments should be sampled more frequently as a result of this. When compared to international norms, this technique will improve monitoring and give more precise information, notably for determining bioavailability data and the ecological risk of heavy metal concentrations in marine sediments.

Declaration of Conflict of Interest: The authors declare no conflict of interest.

Data Availability: Data are available upon request from the first author.

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