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Organic Carbon (OC) and Organic Matter (OM) in Sediments Collected from Two Wetlands in Central Bida Basin, Nigeria

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Abstract

An improvised auger sediment sampler was used to collect sediments at shallow depths from two wetlands in the Northern Bida Basin for laboratory studies in order to ascertain the impact on the chemical quality of groundwater within these two studied locations. The dissolved organic carbon content of water is an important component of the geochemical cycling of elements capable of affecting groundwater quality. The sediments which serve as a conduit and pathways for the elements' transport depending on the characteristics of the particle sizes are to be considered in the evaluation of contaminant mobility within the pathways. Representative cored sediment samples were collected and their particle size characterization and chemical analysis for Organic Matter (OM), Organic Carbon (OC) and Moisture Content (MC) were carried out. The hydrometer results show that the sediment particle sizes are in the order of sand > clay > silt in both locations with few exceptions. This represents the geology of the area (sandstone). The Mean values of 1.14% and 1.98% of OC and OM respectively were recorded in the sediment samples collected in parts of Ebgako. In contrast, 1.72% and 2.97% mean values were recorded in sediments collected in part of Bida for OC and OM respectively. The values of the OC and OM in the sediments from the two wetlands are low and may have been dissolved along the groundwater pathways to the aquifer. Other physicochemical parameters analysed in the sediments showed poor correlation. OM and OC were strongly positively correlated and showed an R^2 value of 1 and 0.9 respectively for parts of the Bida and Egbako sheets. There is low acidity of the sediments from the two study locations with a mean pH value of 5.64 and 5.13 respectively for Egbako and Bida. The low acidic nature of the sediments and the OM and OC composition have the po-

tential to influence biogeochemical processes in the sediments and can affect the chemical quality of the groundwater in these two study locations.

Keywords

Organic Matter, Organic Carbon, Biogeochemical Processes, Bida Basin, Nigeria

1. Introduction

According to the study conducted by Harjung et al. (2023), dissolved organic matter in terrestrial groundwater is generally low in concentration compared to inland surface waters. Groundwater also acts as an immense source and sinks for organic and inorganic matter with major implications for global biogeochemical cycles (Harjung et al., 2023). The concentration of organic matter in sediments remains largely undocumented. Slightly acidic groundwater in the shallow aquifers within the alluvial floodplains of river Gbako in Bida Basin was reported (Sidi et al., 2016). The source of the acid in the groundwater was attributed to dissolved carbon dioxides and organic acid from decay and leaching of plants materials (Langmuir, 1997). In areas with large scale crop production there may be possible concentration of organic matter in the sediments due to decay of plants which may get to the groundwater and concentrate in the aquifers. In the inland wetlands of river Kaduna at Wuya village and river Chanchaga at Kakakpagi village in central Bida basin Nigeria large scale cultivation of rice and sugarcane is carried out resulting in the possible accumulation of organic matter (OM) and organic carbon (OC) in the sediments. River as one natural wetland can deposit plant decays and denature pollutants (Cao et al., 2017). Wetland ecosystems can deposit a large amount of photosynthesized carbon (C) into sediments (Chen et al., 2017) and research on OC and OM contents of sediments is needed to established their influence on the biogeochemical activities within the sediments and the relationship to water pollution. The Food and Agricultural Organization (FAO, 2017) reported that OM from animal excreta, uneaten animal feed, animal-processing industries and mismanaged crop residues are all significant water pollutants. Because OM consumes dissolved oxygen in water as it degrades, it contributes strongly to hypoxia in water bodies (FAO, 2017).

The OM content of lake sediments provides a variety of indicators or proxies that can be used to reconstruct paleoenvironments of lakes and their watersheds (Dianto et al., 2019). The abundance of OM in sediments is described from the Total Organic Carbon (TOC) because it's a primary parameter (Dianto et al., 2019). The OM content of lake sediments provides information that is important to the interpretations of both natural and human induced changes in local and regional ecosystems (Meyers & Ishiwatari, 1995; Last & Smol, 2001). Uncontrolled agricultural activities in Nigeria especially within the wetland areas can contaminate sediments and water with trace elements. Sidi et al. (2019) reported OM and OC in the wetlands of river Gbako at Baddegi. The values reported are 0.44% and

0.95% for OC and OM respectively which is considered as very low base on Reynolds classification (Yoswaty et al., 2021). Farming system and sediments source can result in elevated levels of the OC and OM in sediments (Yu et al., 2022). Particles of clay and silt in sediment can adsorb many types of chemicals including nutrients, heavy metals and persistent organic pollutants (FAO, 2017). The river Niger wetland at Jebba town have most of the major oxides in the sediments depleted due to intensive weathering and increasing the elemental compositions of the water (Omotoso et al., 2017). OM and OC are very useful for determining organic sources in sediments (Dianto et al., 2019) and are important parameters that can be used to evaluate biogeochemical activities in these wetlands.

2. The Study Areas

The two wetlands are located on the floodplains of River Kaduna around Wuya village and River Chanchaga along Minna-Bida road near Kakakpagi village. Their coordinates are latitude 9˚4"N to 9˚14"N and longitude 5˚46"E to 5˚54"E in Egbako sheet and latitude 9˚10"N to 9˚20"N and longitude 6˚6"E to 6˚14"E in Bida sheet. The aerial extent of each of the wetlands is 27 km^2 and are low lying plains with lowest elevation of 70 m and 80 m at Wuya and Kakakpagi villages respectively. Geologically, they are on the Campanian Bida sandstone formation (Kakakpangi) and the Maastrichtian Batati formation at Wuya. According to the National Cereal Research Institute Badeggi (NCRIB) Agro-metrological department, the mean annual average temperature of the area ranges between 33˚C to 34˚C and average annual rainfall ranges between 900.6 to 1340.4 mm.

3. Research Methodologies

Sixty-four (64) sediments including cored and surficial sediments samples were collected. The Cored sediment samples were collected with an improvised metal pipe (core sampler) having a diameter of 0.5 m and a length of one (1) meter. 0.2 m opening was created in the pipe and sediments visual studies were carried out. Sediments samples were collected at intervals of 0.2 m from the top to the bottom (Kalaivanan et al., 2017) and on the observed physical changes in the sediments profile. Within the gridded cells, representative surface sediments samples were also collected within the wetlands. The surface sediments samples were collected at 0.1 m depth using a shovel. Composite of the sediment samples were formed at each sampling location by collecting sediments at 100 m by 100 m distances to form the composites. The samples were packed in sealed polypropylene bags after the visual identification. The coordinates of each location of sampling were recorded with a hand-held Global Positioning System (GPS). Particle size analysis of the sediment samples was carried out using hydrometer (Gavlack et al., 2005). Sediments organic matter was measured by Fe_2SO_4 titration of an acid-dichromate digestion (Walkley & Black, 1934) and soil organic carbon was calculated empirically using equation one (1). All the sediments samples were air-dried, gently ground and sieved through a 2-mm sieve before the

OM was determined.

$$SOC = 0.58 \times SOM \quad (1)$$

SOC is sediment organic Carbon and SOM is Sediment Organic Matter.

4. Results

4.1. Sediment Particle Size Characteristics and Physico-Chemical Parameters

The result of sediments particle size characteristics of sixty-four (64) sediments from the two wetlands are presented in Figure 1 and Figure 2 respectively. Their respective basic chemical parameters and descriptive statistics are presented in Table 1 and Table 2. The percentage composition of the sediment's particle sizes are in the order of sand > clay > silt. High sand composition in the sediments represents the major lithology in the two locations which is sandstone. All the sediments samples analysed are slightly acidic with mean values of 5.64 and 5.13 for Egbako and Bida sheets respectively. The pH values of the sediments are controlled by the carbon dioxide/bicarbonate equilibrium and usually ranges from 4.0 to 9.0 (Geetha et al., 2010). The recorded sediment mean EC value for Egbako sheet is 44.77 μs/cm while for the Bida sheet is 36.00 μs/cm. There is

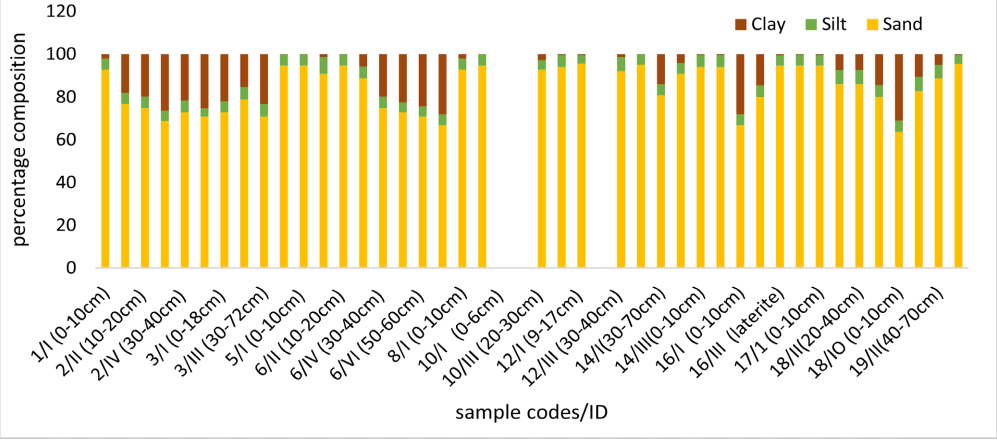

Figure 1. Sediment particle size characteristics of Egbako Sheet.

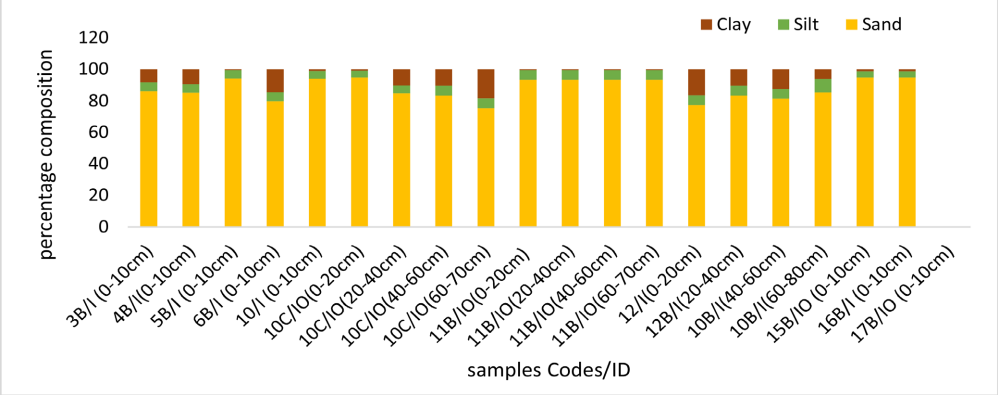

Figure 2. Sediment particle size characteristics of Bida sheet.

Table 1. Physico-chemical parameters of sediments in Egbako sheet.

	pH	EC	MC	OC	OM
Mean	5.64	44.77	13.81	1.14	1.98
Median	5.68	30.00	12.47	0.86	1.49
Mode	5.48	20.00	13.23	0.79	0.68
Standard Deviation	0.55	32.59	11.89	0.78	1.34
Range	2.73	160.00	56.35	3.45	5.95
Minimum	4.03	10.00	0.25	0.04	0.06
Maximum	6.76	170.00	56.6	3.49	6.01
Count	44	44	44	44	44

Table 2. Physico-chemical parameters of sediments in Bida sheet.

	pH	EC	MC	OC	OM
Mean	5.13	36.00	17.17	1.72	2.97
Median	5.17	35.00	16.92	1.72	2.97
Mode	5.2	40.00	13.75	2.07	3.57
Standard Deviation	0.25	17.59	7.86	0.62	1.06
Range	1.12	70.00	32.97	2.46	4.23
Minimum	4.48	10.00	2.55	0.49	0.86
Maximum	5.60	80.00	35.52	2.95	5.09
Sum	102.64	720.00	343.58	34.44	59.5
Count	20	20.00	20	20	20

no direct correlation between EC and pH in the two locations studied (Geetha et al., 2010).

4.2. OC and OM in the Sediments

The mean values for the OC and OM recorded in the sediments of the two wetlands are 1.14% and 1.98% for Egbako sheets and 1.72% and 2.97% for Bida sheet respectively. The sediments OM for the two wetlands are low using Reynolds classification (Simanjuntak et al., 2020). Sediment OM content consists of 5 classes, namely: >35% is considered very high organic matter content; 17% - 35% is high organic matter content; 7% - 17% is medium organic matter content; 3.5% - 7% is low organic matter content (Yoswaty et al., 2021). A correlation of the Physico-chemical parameters of the sediments from the two wetlands showed poor correlation except for the OM and OC which are strongly positively correlated meaning that, OC or OM increases with increasing concentration of OM or OC **Figure 3** and **Figure 4**. Strong relationship between soil organic carbon and soil organic matter was reported by (Perie & Ouimet, 2007). It

has also been indicated that soil organic carbon/soil organic matter ratio depends on soil type (Jain et al., 1997) and soil depth (Westman et al., 2006). The r^2 value for all the parameters analysed is less than 1 except the OM and OC which is 1 and show the degree of their mutuality. Other parameters are not predictable on one another because there was no correlation.

5. Conclusion

Wetlands are places that are constantly or frequently flooded or saturated long enough to produce oxygen-deficient conditions in the soil. The two wetlands studied are cultivated largely with sugar cane and rice throughout the seasons a vegetation uniquely suited to wetland conditions. The OM and OC content in the sediments of these wetlands are very low on the classification type. The actual

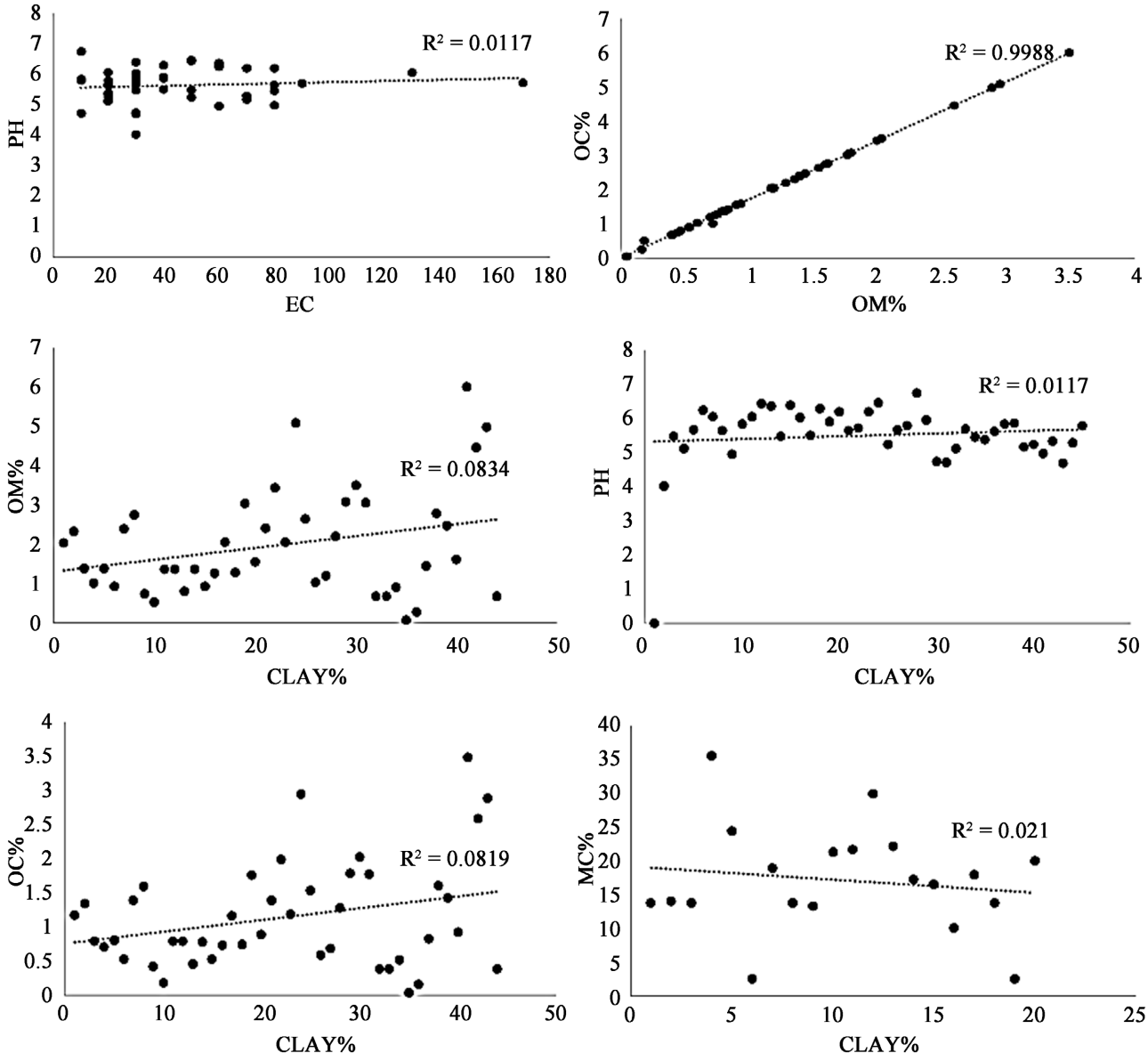

Figure 3. Correlation among the physico-chemical parameters in the sediments of Egbako sheet.

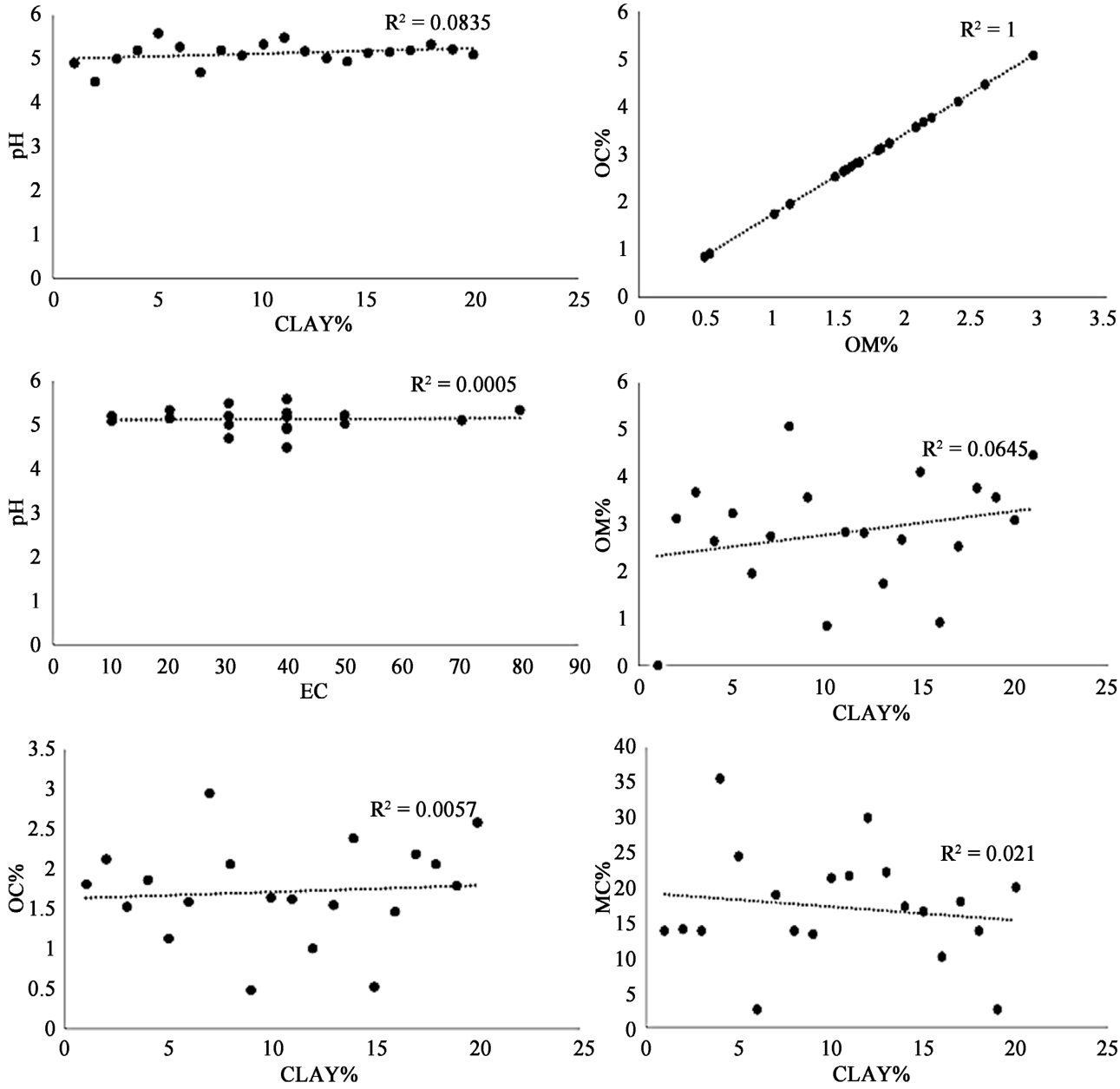

Figure 4. Correlation among the physico-chemical parameters in the sediments of Bida sheet.

OM and OC of the sediments may have been depleted and responsible for the slight acidity of the sediments. Lack of correlation among the physico-chemical parameters in the sediments of these two wetlands means they are not the controlling factors on the possible biogeochemical processes in the areas. Studying the relationship between sediments OM, OC and groundwater quality of these areas can give an understanding into the geochemical processes operating at the water/sediments interface.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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