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# ANALYSIS OF ORGANIC MATTER AND CARBONATE MINERAL DISTRIBUTION IN SHALLOW WATER SURFACE SEDIMENTS

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## Abstract

Some rivers deliver sediments that are rich in organic materials into estuaries and the open ocean, providing a food source for bacteria and zooplankton. Carbonate mineral (CM) distribution is helpful in comparing biogenic, (shell material) authigenic, (commonly aragonite) and carbonate abundance patterns in sediments. Organic matter in sediment consists of carbon and nutrients in the form of carbohydrates, proteins, fats and nucleic acids. Three samples at a distance of 100meters apart were collected from two rivers (Ome and Ona) draining Ago-Iwoye and its environs. The samples were analysed and the results were interpreted empirically. For both rivers, a strong relationship exists between %(OC) and %(OM) (where r =0.98 and 0.97 respectively). The test for significance of r, ($p < 0.05$) reveals a significant association between %OC and %OM across the two rivers. The high value of r clearly shows that input contributing to organic matter is constant and high and this include waste especially sewage effluents, plant and animal detritus flowing into the river from the catchments. This study reveals that environmental assessment of rivers becomes important to ensure healthy aquatic ecosystem for marine organisms and for proper functioning of river systems. It becomes therefore imperative to discourage anthropogenic activities that are inimical to river systems.

**Keywords:** Carbonate Mineral; Organic Content; River Systems; Environmental Assessment

## Introduction

Rivers carry sediments due to surface erosion from watersheds and bank erosion along the river. Yet, sediments can be geophysically significant for several different reasons. One reason is that sediment particles can be composed of materials that are highly reactive in the river systems. Some rivers deliver sediments that are rich in organic materials into estuaries and the open ocean, providing a food source for bacteria and zooplankton. Carbonate mineral (CM) distribution is helpful in comparing biogenic, (shell material) authigenic, (commonly aragonite) carbonate abundance patterns in sediments (Sussko et al., 1992). Organic matter in sediment consists of carbon and nutrients in the form of carbohydrates, proteins, fats and nucleic acids. Bacteria quickly eat the less resistant molecules, such as nucleic acids and many of the proteins. Organic Matter (OM) abundance can be used as a measure of benthic secondary productivity, terrestrial/aquatic productivity and organic matter flux in river systems (Palacios-Fest et al., 2005). Patterns of OM distribution in sediments can be compared across similarly sized watersheds with different land use histories to understand disturbance impact on river productivity and health. Sediment organic matter (SOM) can be a source of 'recycled nutrient' for water column productivity (including algal blooms) when it degrades. Dissolved oxygen concentration is usually lowered when organic matter is degraded by aerobic bacteria, and anoxic and hypoxic conditions may develop under stratified conditions (Palacios-Fest et al., 2005).

Organic matter is also source of food and energy and its nutritional balance (TOC: TN: TP ratio) plays an important role in material flow through ecosystems. Decomposition rates of organic matter increase as nitrogen and phosphorus content increase and as TOC/TN and TOC/TP ratios decrease. Organic matter with very high TOC: TN ratios consumes more dissolved oxygen, supports less denitrification and releases fewer nutrients to the water column when it breaks down than organic matter with low TOC: TN ratios (Sussko et al., 1992; Palacios-Fest et al., 2005). The decomposition of organic matter with very high TOC: TN ratio can be nutrient-controlled meaning that it can cause the uptake of dissolved inorganic nitrogen (DIN) from the water column. Sediments with high TOC: TN ratios (and lower N contents) tend to support a lower biomass of benthic invertebrates.

Organic Matter, measured as biochemical oxygen demand and ammonium are key indicators of oxygen content of water bodies. Concentrations of these determinants are naturally raised as a result of organic polluting, caused by discharges form waste water treatment plants, industrial effluents and agricultural run-off. Organic carbon compounds in river waters occur in both particulate and dissolved forms. More than 90% of the TOC occurs in the dissolved form. The bulk density of dissolved organic carbon compounds consists of biopolymers (e.g. polypeptides, polysaccharides) and geopolymers (humix substances). This study seeks to understand the pattern of organic matter and carbonate mineral distribution into shallow surface water within a semi-urban area in South-western Nigeria.

## Study Area

The area of study is Ago-Iwoye, Ogun State. This falls within the equatorial belt of Nigeria at longitude 3o 551 east of the Greenwich meridian and 60 561 north of the equator (Figure 1).

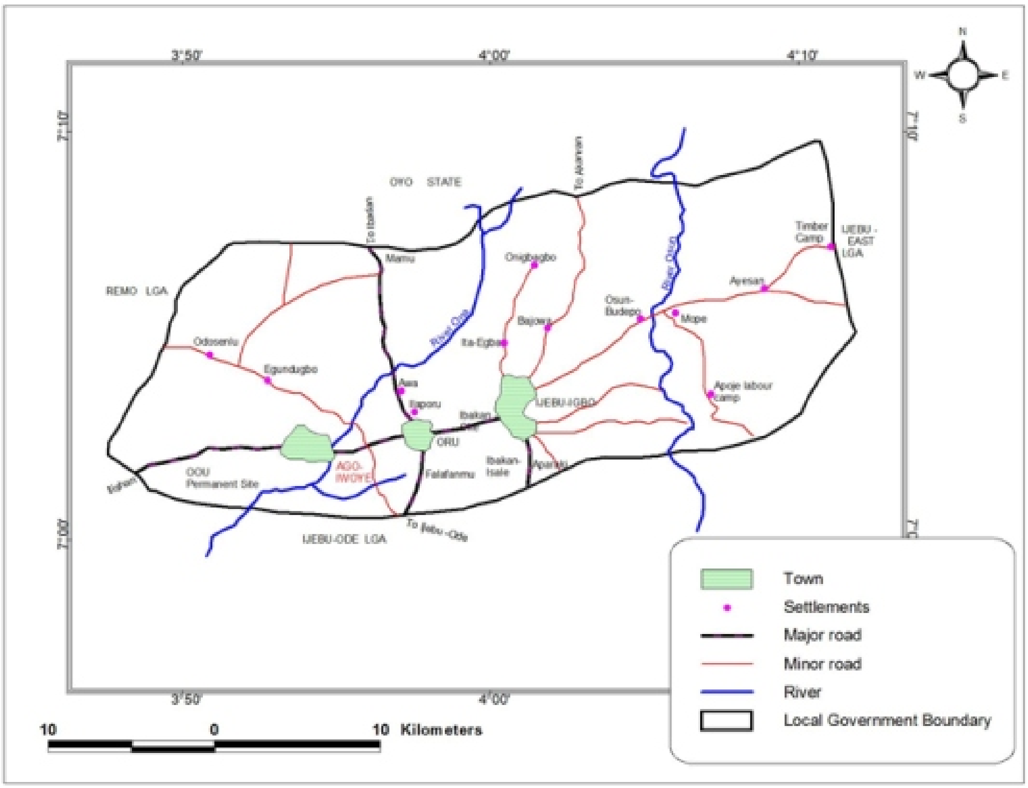


**Figure 1:** Map of Ago-Iwoye
*(Source: Onakomaya, 1992)*

Ago-Iwoye falls within the rainforest region of the Nigeria with two main alternating air masses; the tropical continental air mass and the tropical maritime air mass. The tropical continental air mass is the north easterly wind which is dry and dusty which brings in the harmattan season while the tropical maritime is the cool south westerly which sets in the rainy season. The dry season is from early November to mid-march while the wet season is from March to early November with a period of dry season in august termed "august break". The mean annual rainfall is around 1350mm with about 80% of it being concentrated within the months of April and October. Ago-Iwoye has a high records of humidity ranging from 80% to 87% for the afternoon and 100% during and after rainfalls. The wind speed in Ago Iwoye locality normally ranges between 1.5 meters and 1.8 meters per seconds. The temperature of the area ranges from 270C to 250C and this low range accounts for its constantly high temperature. Ago-Iwoye is generally undulating with a few gentle to steep slopes. A range of relatively steep sided hills running north south is situated towards the western part of Ago-Iwoye. The highest range is about 110 meters (the Oloro hill). Ago-Iwoye is drained mainly by Ona River (Figure 1) with a major tributary (Ome River). The vegetation of Ago-Iwoye (study area) is characterised by evergreen forest of tall trees with under growth of linas and other climbing plants. But, because of human interference in satisfying their needs, the evergreen forest is now giving way to secondary forest. The soil is also a significant factor in the distribution of vegetation types in Ogun State because it has been observed that the distribution of the major vegetation types coincides with the distribution of the major soil types.

## Methodology

This study employs the use of primary source of data for this research. The main river draining Ago-Iwoye (Ona River) and its major tributary (Ome River) where studied downstream for the distribution of Organic matter and Carbonate minerals. Water samples were collected with a very clean bottle, stored in a refrigerator and then conveyed carefully to avoid contamination to the laboratory using standard practices (AOAC, 1990). Organic matter and carbonate abundance of collected grab samples were determined using loss-on-ignition methods. Ceramic crucibles was washed, dried and pre-combusted at 9000C in a furnace to clean them. Each grab sample was mixed to homogenise the sediment before sub-sampling. Approximately 5g of sediment was added to each pre-weighed crucible and then heated at 600C in a drying oven overnight to remove water. Once dry, samples were weighed, heated in a furnace to 5500C for 2 hours to remove organic matter and then reweighed. Samples were combusted once more at 9000C for two hours to remove inorganic carbonate mineral (shell materials or antigenic carbonate/aragonite crystals). The final weight of each sample was then measured. Total organic matter and carbonate mineral percentages were then calculated from sample post-combustion weight loss. Due to the coarse grain size of shallow water surface sediments of these rivers, the coarse fraction of sieved grab sample sediment will also be macroscopically observed to determine relative abundance of shell material (biogenic carbonate). Given the shallow depth of all grab samples need in this study, shell material is thought to be the major contribution of CM in collected sediments. Each grab sample was also sub-sampled to create smear slides. A small amount of sediment will then be used to separate out the fine-grain fraction for further analysis. Abundance estimates of organic matter constituents, when were made by establishing the absolute percentage of a field view covered by the variable to be measured (AOAC, 1990). At each point of study, three samples are taken at regular intervals and then mixed together for that particular point. In all, a total of six (6) samples of water were collected (three samples from each river) across the water (shallow) surface. Correlations Analysis was employed to show level of association and student t test was used to show the level of significance.

## Results and Discussion

For River Ome, a strong relationship exists between %Organic Content (OC) and %Organic Matter (OM) ($r^2$ = 0.98). The test for significance of r, ($p < 0.05$) reveals a significant association between %OC and %OM in river Ome. For River Ona, a strong relationship exists between %OC and %OM ($r^2$ = 0.97). The test for significance of r, ($p < 0.05$) reveals a significant association between %OC and %OM in river Ome. The high value of r clearly shows that input contributing to organic matter is constant and high and this include waste especially sewage effluents, plant and animal detritus flowing into the river from the catchments and also increased nitrogen and phosphorus (Chenhall, 1995; Cole et al., 1993) whose value are also considerably high for the two rivers (Table 1). Average value for % nitrogen in river Ome is 0.042 and 0.081 for river Ona likewise average value for phosphorus is 10.38 in river Ome and 10.02 for river Ona. The presence of these two elements (nitrogen and phosphorus) during mineralization contributes significantly to organic matter accumulation in the two rivers. The concentration of organic carbon has been a long standing concern where raw sewage are discharged directly into rivers; which is expected as various anthropogenic activities can be seen along the rivers, especially discharge of sewage (Chenhall et al., 2005; Hodgkin and Hesp, 1998; Neil, 1998).

**Table 1:** Laboratory Results of Samples

| Code | pH | Na | Ca | K | mg | Bi-carbonate | Total Hardness | Mn | Zn | Fe | %OC | %Om |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 6.5 | 0.5 | 0.7 | 0.47 | 0.12 | 180.5 | 0.82 | 1.1 | 0.07 | 1.1 | 1.7 | 2.93 |
| A2 | 6.4 | 0.6 | 0.6 | 0.42 | 0.2 | 180.5 | 0.8 | 1.2 | 0.08 | 1 | 1.83 | 3.15 |
| A3 | 6.3 | 0.55 | 0.55 | 0.38 | 0.25 | 144.4 | 0.8 | 0.8 | 0.1 | 1 | 1.7 | 2.93 |
| B1 | 6.5 | 0.7 | 0.4 | 0.27 | 0.17 | 288.8 | 0.57 | 0.75 | 0.11 | 1.1 | 1.84 | 3.17 |
| B2 | 6.2 | 0.68 | 0.53 | 0.4 | 0.2 | 216.6 | 0.73 | 0.85 | 0.12 | 1.1 | 1.86 | 3.21 |
| B3 | 6.3 | 0.7 | 0.47 | 0.38 | 0.18 | 216.6 | 0.65 | 0.9 | 0.1 | 1.1 | 1.75 | 3.02 |

*A rep River Ome; B rep River Ona*

In terms of % Nitrogen and % Organic Content, the two tributaries shows great associations $r_1 = 0.98$; $r_2 = 0.98$). The correlation coefficient shows that the association between these two parameters is high. Looking at the N:OC ratios in river I and II (1:41.5, 1:22.3) respectively. It clearly shows that with a unit input of nitrogen there is a high increase in the value of organic carbon accumulation and this increase the sedimentation rate (Sussko, 1992; Cohen et al., 2005) and enhanced sediment rates can lead to the smoothening of benthic communities which can affect how nutrients are recycled. Absolute values of %N also reveals high content in both rivers which shows that there is a likelihood of eutrophication occurrence in both rivers and this has adverse effect on the river ecosystem as it greatly effects the flora and fauna community (Cole et al., 1993; Hancock, et al. 1996).

As regards % nitrogen and organic matter existing in both rivers, correlation analysis value for both rivers reveals a value of 0.98. The r value is high showing nearly a perfect association between the two parameters. This suggests that an increase in one of the parameter will cause an increase in the other one. Considering the ratio of N: OM in river I (1:72) and in river II (1:39). It shows that for an additional input of nitrogen in river I, it raises the level of organic matter by 72% and likewise an additional unit of nitrogen in river II, it raises the level of Organic matter by 39%. Both inputs are considerably high and increase in organic matter accumulation increases eutrophication which is an increase in the rate of organic matter production in an ecosystem. Increase in organic matter accumulation also increase sedimentation rates and this reduce the contact time between organic matter and dissolved oxygen in the water column, and therefore can contribute to higher concentrations of carbon and nutrients in sediment.

**Water Quality Indicator**

Advances in the treatment of municipal and industrial wastes and changes in manufacturing and processing techniques over the past two decades have led to improved water quality but the presence of toxic compounds; nutrient loadings adversely affect water quality and the health of ecological communities. Considering some important variables in the water sample taken from the rivers to show the degree of quality of the river water the following variables were considered (PO4, SO4, acidity, alkalinity, total hardness, zinc, nitrate) and the following results were realised (Table 2).

From Table 2, pH value clearly reveals that the river water is acidic. Looking at the phosphorus content, it reveals that there is high value of phosphorus in the river water and this account for domestic sewage draining into the river which is being observed along the river course and also toxigenous inputs from catchment areas or nearby agricultural lands. Phosphorus is also an indicator of eutrophication in both rivers. The acidity and alkalinity for both rivers is high and also total hardiness reveals that the water is hard which will make it difficult for domestic use especially for washing of clothes. The presence of zinc is a sign of toxicity but this has to be dependent on the ion form of zinc occurrence, calcium presence and magnesium, as well as pH of the water. Eutrophication affects oxygen and it brings about sever reductions in water quality and in fish and other animal populations (Chenhall, 1995).

**Table 2:** Indicators of Water Quality (average values)

| | pH | $PO_4$ | $SO_4$ | Acidity | Alkalinity | Total Hardness | Zinc | $\%NO_3$ |
|---|---|---|---|---|---|---|---|---|
| R I | 6.43 | 10.5 | 13.07 | 0.036 | 84.23 | 0.81 | 0.08 | 0.01 |
| R II | 6.33 | 10.02 | 12.3 | 0.027 | 120.33 | 0.65 | 0.17 | 0.01 |

## Conclusion

Water population and influx of nutrient into the river system have been a very serious problem that has been plaguing the Nigerian environment from many years. All over the country, there are series of various nutrients and effluents being released into the aquatic ecosystem and these adversely destroy or disturb the boundary of variations within the system. Hence apart from the fact that this study sheds more light on organic matter and carbonate mineral distribution in two rivers in Ago-Iwoye, it has also been able to establish the fact that toxigenous nutrients affect nutrients abundance in rivers in Ago-Iwoye area. Various anthropogenic activities of man affect the nutrient release within the river and also their abundance at different points. It has been shown that various anthropogenic activities along the river accounts for the abundance of some minerals recycling. This in itself increases euthrophication rate and mineralization which majorly occur in both rivers and poses adverse effect on the river ecosystem by increasing its toxicity and also making it difficult for use both domestically, agriculturally and industrially.

Refuse should be discouraged from being dumped into the rivers and also farmlands bordering the rivers should be carefully managed to curtail the flow of organic nutrients into the river system. Sewage effluents should not be channelled into river system. Sewage effluents should be channelled away from the river into proper septic tanks to prevent adverse condition experienced in the river ecosystem. A careful consideration of the distribution of organic matter and carbonate mineral, their impact loading and some other elements in the river system, it reveals that environmental assessment of rivers are necessary to improve their health for aquatic communities and for human use.

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