

## The Sediment Characteristics of Okpoka Creek, Niger Delta, Nigeria

<sup>1</sup>A.D.I. George, <sup>2</sup>J.F.N. Abowei and <sup>3</sup>M.E Allison

<sup>1</sup>Department of Fisheries and Aquatic Environment, Faculty of Agriculture, Rivers State University of science and Technology, Port Harcourt, Rivers State, Nigeria

<sup>2</sup>Department of Biological Sciences, Faculty of Science, Niger Delta University, Wilberforce Island, Amassoma, Bayelsa State, Nigeria

<sup>3</sup>Department of Fisheries and Lwestoac, Faculty of Agriculture, Niger Delta University, Wilberforce Island, Amassoma, Bayelsa State, Nigeria

**Abstract:** The sediment characteristic of Okpoka creek was studied for a period of two years. Sediment samples were collected using an Eckman grab of 10 cm diameter and 12 cm long. Water absorbency of the sediments was determined after samples had been oven-dried and crushed in a mortar using pestle. Water absorbency of the dry soils in the Okpoka creek ranged between 20.73±1.43% (station 3) and 46.7±4.29% (station 2) with a mean value of (27.55±2.31%). Particle density values varied from 1.27 g cm<sup>-3</sup> to 2.64 g cm<sup>-3</sup> across the stations with a mean value of 2.16 g cm<sup>-3</sup>. The highest value (2.64 g cm<sup>-3</sup>) was recorded in station 3, where as the least value (1.27 g cm<sup>-3</sup>) was observed in station 2. Similarly, bulk density had a low value of 0.76 g cm<sup>-3</sup> in station 2 and the highest value (1.45gcm<sup>-3</sup>) was obtained in station 1, with a density value of 1.28gcm<sup>-3</sup>. Porosity or percent (%) pore space of the sediments ranged between 29.89% in station 6 and 56.47% (station 2) with a mean value of 39.12%. The sand contents of the sediment were high across the stations. The percentage sand content ranged between 60.12% and 90.68% with a mean value of 73.97%. Station 3 had the highest value of 90.68% and the lowest value of 60.12% was obtained in station 2. The percentage silt content ranged between 13.46 and 38.35% with a mean value of 27.14%. The highest percentage silt content of 38.35% was recorded for station 2, while the lowest value of 13.46% was obtained for station 4. The mean value of clay content was 22%. Clay content was highest in station 2 with a value of 30.98%, while the lowest value (18.67%) was obtained in station 4. Generally, the result obtained showed that sand dominated across the stations, except station 2, which revealed loamy sand textural. The sandy sediment type observed in Okpoka Creek was an indication of the abundance of benthic macro invertebrates. Particularly swimming crabs whose daily lifecycle involve burrowing in the substratum are abundant in sandy sediment.

**Key words:** Niger Delta, Nigeria, Okpoba Creek and Sediment characteristics

### INTRODUCTION

Sediment is the loose sand, clay, silt and other soil particles that settle at the bottom of a body of water (United State Environmental Protection (USEPA, 2002). It can come from soil erosion or from the decomposition of plants and animals. Wind, water and ice help carry these particles to rivers, lakes and streams. Sediment texture refers to the proportions of sand, silt and clay below 2000micrometers in diameter in a mass of sediment (Table 1). Sand is generally coarse and gritty, silt is smooth like flour and clay is sticky and plastic when wet. Sediment that exhibits a combination of the, three properties is said to have a loam texture (Davies and Abowei, 2009). Sediments are the solid particles deposited at the bottom of water bodies. Mineral soils are often composed of inorganic particles of varying sizes called soil separates.

The relative proportions of the various separate or size groups of individual soil grains in a mass of soil are referred to soil texture. The soil texture specifically refers

to the proportions of sand, silt and clay in a mass of soil (Esu, 1999). The texture class determines the microbiological population of a soil and hence the biological and biochemical reactions taking place in such a soil, (Esu, 1999).

The role of organic matter has been highlighted by Brady (1974). These include its ability to influence the physical and chemical characteristics of soils. It is also known as a supplier of energy and bodybuilding constituents to soil micro flora.

Similarly, organic matter is known to influence the properties of sediments including water absorbency, particle density and bulk density. Brady (1974) defined particle density as “the mass per unit volume of the soil particles expressed as grams per cubic centimeter”, and bulk density as “the mass of dry soil per unit volume including the air spaces.”

Miller *et al.* (1990) reported that bulk density enumerates total water storage capacity of a given soil volume and determines the level of compaction of sediments to allow for adequate aeration.

Table 1: Size limits of sediment particle size in the United State Department of Agriculture (USDA) and International Soil Science Society (ISSS)

USDA SCHEME		ISSS SCHEME	
Name of particle size	Diameter range ( $\mu\text{m}$ )	Name of particle size	Diameter range( $\mu\text{m}$ )
Very coarse sand	2000-1000	Coarse sand	2000-200
Coarse sand	1000-500		
Medium sand	500-250	Fine sand	200-20
Fine sand	250-100		
Very fine sand	100-50	Silt	20-2
Silt	50-2		
Clay	<2	Clay	<2
COARSE FRAGMENT			
Gravels		2000-75000( $\mu\text{m}$ ) (2-75mm)	
Cobbles		75000-25400( $\mu\text{m}$ ) (75-254mm)	
Stones		>254000( $\mu\text{m}$ ) (>254mm)	

Source: Ivara, 1999 in Davies and Abowei 2009

Sandy soils whose particles lie in close contact with each other have high bulk densities. The bulk density or weight per unit volume of loose and porous soils is low while more compact soils have high bulk densities. On the contrary, soils with finer texture whose particles are not so compacted usually have high organic matter content and are well granulated. This encourages a porous condition and corresponding low bulk density values (Miller *et al.*, 1990).

The soil's pore space is that part of the soil that is occupied by air and water. This is mainly determined by the arrangement of the mineral solids. Compact soils have low porosity; while in loose soils with high organic matter the pore space per unit volume (porosity) is high (Miller *et al.*, 1990). Sandy soils have bulk density close to 1.4 or 1.5gcm<sup>-3</sup> and pore space percentage close to 45 – 50%; while particles densities of mineral soils are usually between 2.60 and 2.75 gcm<sup>-3</sup> (Miller *et al.*, 1990).

The structure of the sediments in the intertidal zone plays a major role in the distribution of the organisms that live in or on them, (Barnes and Hughes, 1988; Ajao and Fagade, 1991; Khan *et al.*, 2001; Adakole and Anunne, 2003; Egborge *et al.*, 2003; Atobatele *et al.*, 2005; Ikomi *et al.*, 2005)

Sankare *et al.* (1997) in their studies in Lagune Tendo, Cote d'Ivoire reported that benthic organisms show habitat preference for specific types of sediment. Apart from sediment structure, the physical and chemical parameters of the sediments such as salinity, dissolved oxygen, pH, and organic carbon could also influence the occurrence and abundance of species distributed in them (McLusky and Elliot, 1981)

An estuarine intertidal zone could be described as a narrow fringe between the ocean and land (Ssentongo *et al.*, 1986). The intertidal zone can be categorized into three habitat types, namely, mudflats, sandy beaches and rocky shores. The zone is characterized by several fluctuating environmental variables, which influence the distribution, abundance and composition of the ecosystem.

Ajao and Fagade (1990) studied the ecology of *Neritina* in the Lagos Lagoon and observed that their distribution and abundance were dependent on the silt

content, total organic matter and contamination of sediment. Rhoads (1974) observed that soft silt sediments are often unfriendly environment to which few invertebrate species have managed to adapt.

Darlington (1976) also recorded that the texture and stability of the substrate of Lake George in Uganda was primarily responsible for variation in horizontal distribution of benthos. Ombu (1987) reported that *Uca tangeri* densities were high in the dry season, declines during the rains and were generally influenced by substrate texture.

## MATERIALS AND METHODS

**Study Area:** The study was carried out in Okpoka Creek, which is one of the several adjoining creeks off the Upper Bonny River estuary in the Niger Delta (Fig. 1). The Bonny River Estuary lies on the southeastern edge of the Niger Delta, between longitudes 6°58' and 7°14' East, and latitudes 4°19' and 4°34' North. It has an estimated area of 206Km<sup>2</sup> and extends 7Km offshore to a depth of about 7.5 meters (Irving, 1962; Scott, 1966; Alalibo, 1988). The Bonny River is a major shipping route for crude oil and other cargoes, and leads to the Port Harcourt quays, Federal Ocean Terminal, Onne, and Port Harcourt Refinery company terminal jetty, Okirika. Specifically, the Okpoka creek lies between Longitudes 7°03' and 7°05' East and Latitudes 4°06' and 4°24' and it is about 6 kilometers long.

Characteristically, the area is a typical estuarine tidal water zone with little fresh water input but with extensive mangrove swamps, inter-tidal mud flats, and influenced by semi-diurnal tidal regime. In the Bonny River estuary, the salinity fluctuates with the season and tide regime is influenced by the Atlantic ocean (Dangana, 1985). Tidal range in the area is about 0.8m at neap tides and 2.20m during spring tides (NEDECO, 1961).

It is strategically located southwestern flanks of Port Harcourt and Okirika of Rivers State. The creek is bounded by thick mangrove forest dominated by *Rhizophora* species interspersed by white mangrove (*Avecinia* sp.) and *Nypa* palm. Along the shores of the creek are located the Port Harcourt Trans - Amadi

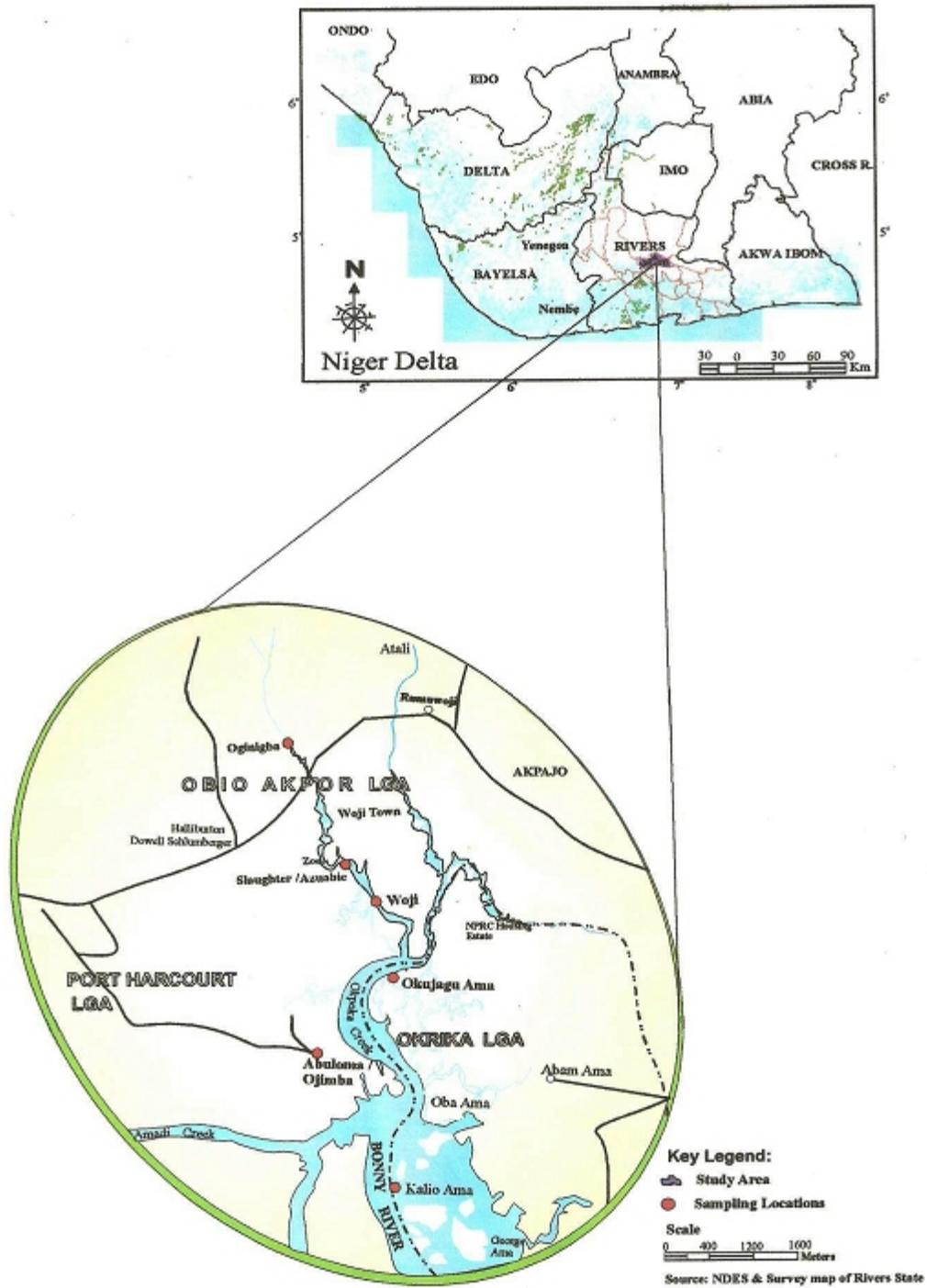


Fig 1: Map of Niger Delta showing Rivers State and the Study Area

Industrial layout, several establishments, markets, the main Port Harcourt Zoological garden and several communities. The communities are Oginigba, Woji New layout, Azuabie, Okujagu- Ama, Ojimba- Ama, Abuloma, Okuru- Ama, Oba- Ama and Kalio - Ama.

Artisanal fishers mainly exploit the fisheries. The fishers use wooden/dug-out canoes ranging in size from

3 to 8m long. The canoes are either paddled or powered by small outboard engines, and manned by an average of two men. From these boats, the fishers operate their cast nets, hook and lines, gillnets, crab pots, etc.

**Sampling stations:** Six sampling stations were established along a spatial grid of the Okpokoka Creek

covering a distance of about six kilometers. The sampling stations were established based on ecological settings, vegetation and human activities in the area. The sampling station is about one kilometer apart from each other.

**Station 1:** Located upstream of the Port Harcourt main abattoir at Oginigba waterfront with living houses on the left flank of the shoreline. Vegetation is sparse with mainly red mangrove (*Rhizophora sp*) white mangrove, *Avicenia sp* and Nypa palm (*Nypa fructicans*).

**Station 2:** Situated at Azuabie / Port Harcourt main abattoir waterfront. It is located downstream of Station 1. The bank fringing the Azuabie/abattoir is bare with no visible plants except toilet houses, residential houses, animal pens, boats and badges, while at the opposite side there are few mangrove and Nypa palm. Human activities here include slaughtering of animals, marketing, fishing and boat building. It is located downstream of station 1 and it is a major collection point of abattoir wastes and other human and market wastes.

**Station 3:** It is downstream from the Port Harcourt abattoir at the Woji sand Crete. It is about one kilometer away from Station 2. The major activities here included sand mining and loading.

**Station 4:** This station is located at Okujagu-Ama area. There are no industrial activities here. Mainly fishers occupy the area. Nypa palm dominates the marginal vegetation while the opposite side is thickly populated with *Rhizophora racemosa* and *Rhizophora mangle*. The main activity is fishing, boat ferrying and occasional sand moving.

**Station 5:** Is situated at Ojimba cum Abuloma waterfronts. There are no commercial activities apart from ferryboats operations. The shoreline fringes have mainly Nypa palm. The area is shallow and at low tide, the greater part of the bottom mud flat is exposed.

**Station 6:** Is located in front of Kalio-ama directly between Okpoka and Amadi creeks. The human activities here include jetty operations, oil and non-oil industrial activities, boat traffic and fishing. Vegetation is few dominated by red mangrove interspersed with white mangrove *Avicenia africana*.

**Sediment sampling:** Sediments were collected using an Eckman grab of 10cm diameter and 12cm long mostly during the low tides. At each sampling station, sending the grab down into the bottom and using the messenger to close and grab, some quantity of sediment made 3 hauls. The grab was then removed under suction pressure. Sediments collected at each sampling station were stored in a labeled polythene bags, and kept in an ice-chest box before transferring to the laboratory. The collected sediments were air dried at room temperature in the

laboratory. The dried samples were further crushed to fine texture in a ceramic mortar, sieved using 2.0 mm mesh sized sieve for particle size (sand, silt and clay). Composite samples was composed from each station and put into labeled polythene bags for subsequent determination of the sediment particle sizes.

The water absorbency of the sediments was determined after samples had been oven-dried and crushed in a mortar using pestle. There after, 2-3g of sub-sample were weighed, soaked in water for 24 h, excess water drained and the sample reweighed (Head, 1992; Smith, 1996).

The particle density and bulk density of sediments were determined according to Ansa (2005) using a mass balance and cylinder. Labeled cylinders of predetermined volumes and weights were used to collect sediments from sampling stations. The soil in the cylinder was then oven dried till constant weight was achieved. The volume and weight of the oven-dried soil were then determined. The values obtained were then used as inputs for the equations below:

Particle density =

$$\frac{\text{Weight of solids}}{\text{Volume of Solids after oven drying}} \quad (\text{Brady, 1974}) \quad (1)$$

$$\text{Bulk density} = \frac{\text{Weight of solids}}{\text{Volume of Solids after oven drying}} \quad (2)$$

N/B: volume of soil before oven drying is equal to the volume of the cylinder.

Porosity or percentage pore space was determined using the ratio of bulk density to particle density (Brady, 1974) as follows:

$$(\%) \text{ Pore space} = \frac{100 - \text{bulk density}}{\text{Particle density}} \times \frac{100}{1} \quad (3)$$

Soils texture or sediment particle size was analyzed by the Bouyoucous hydrometer method modified by Day (1967). The soil was dispersed with a solution of sodium hexamta phosphate (Calgon 44 g/L) and sodium carbonate (8 g/L). The pH of the solution was maintained at about 8.3. The textural class was determined using the triangular diagram.

**Data Analysis:** Analysis of variance (ANOVA), Duncan multiple range (DMR), and Pearson correlation coefficient were used to analyse data using SAS (2003) and Microsoft Excel (2003) packages.

## RESULTS

**Water absorbency:** Water absorbency of the dry soils in the Okpoka creek ranged between 20.73±1.43% (station 3) and 46.7±4.29% (station 2) with a mean value of (27.55±2.31%) (Table 2).

Table 2: Characteristics of Sediment in the Okpoka Creek off Upper Bonny River, Niger Delta, Nigeria

Parameters	Stations						Mean value
	1	2	3	4	5	6	
Water Absorbency (%)	26.74±2.41	46.73±4.29	20.73±1.43	2247±1.36	25.41±1.96	23.18±2.42	27.55±2.31
Particle Density (gcm <sup>-3</sup> )	1.99	1.27	2.64	2.25	2.08	2.15	2.16
Bulk Density (gcm <sup>-3</sup> )	1.45	0.76	1.39	1.28	1.41	1.37	1.28
Porosity (%)	39.19	56.47	35.0	36.94	37.23	29.89	39.12
Sand (%)	67.47	60.12	90.68	69.84	79.72	75.82	73.97
Silt (%)	27.24	38.35	29.48	13.46	30.45	23.86	27.14
Clay (%)	20.23	30.98	19.64	18.67	21.86	20.62	22.0
Textural class	Sand	LoamSand	Sand	Sand	Sand	Sand	Sand

**Particle density, bulk density and porosity:** The results of the particle density, bulk density and porosity of the sediments observations are shown in Table 2. Particle density values varied from 1.27gcm<sup>-3</sup> to 2.64 g cm<sup>-3</sup> across the stations with a mean of 2.16 g cm<sup>-3</sup>. The highest value (2.64 g cm<sup>-3</sup>) was recorded in station 3, where as the least value (1.27 g cm<sup>-3</sup>) was observed in station 2. Similarly, bulk density had a low value of 0.76 g cm<sup>-3</sup> in station 2 and the highest value, (1.45 g cm<sup>-3</sup>) was obtained in station 1, with a density value of 1.28gcm<sup>-3</sup>. Porosity or percent (%) pore space of the sediments ranged between 29.89% in (station 6) and 56.47% (station 2) with a mean value of 39.12%.

**Sediment particle size:** Table 2 also shows the results of the percentage composition of sand, silt and clay of the sediments in the study area. The sand contents of the sediment were high across the stations. The percentage sand content ranged between 60.12% and 90.68% with a mean of 73.97%. Station 3 had the highest valued of 90.68% and the lowest value of 60.12% was obtained in station 2.

The percentage silt content ranged between 13.46% and 38.35% with a mean value of 27.14%. The highest percentage silt content of 38.35% was recorded for station 2, while the lowest value of 13.46% was obtained for station 4. The mean value of clay content was 22%. Clay content was highest in station 2 with a value of 30.98%, while the lowest value (18.67%) was obtained in station 4. Generally, the result obtained showed that sand dominants across the stations, except station 2, which revealed loamy sand textural class (Table 2).

## DISCUSSION

The results observed for both particle density and bulk density of the sediments in Okpoka creek revealed that both have similar profiles. Particles density of the sediments of the study area was observed to increase with an increase in bulk density. While porosity of the sediments increased with a decrease in bulk density. Station two had the lowest bulk density (0.76 g cm<sup>-3</sup>) with very high porosity (56.47%). The high porosity is an indication of availability of more pore spaces for air and water as opposed to the other sediments in stations one, three to six. The low particle density in station two could be attributed to the high organic matter content of the soil which weighs less than an equal volume of soil, Brady (1974) and Ansa (2005).

The particle size of sediments in Okpoka creek indicated that the soils are sandy mud in five stations (stations one, two, four, five and six) and station three was classified as sand (90.68%). This is at variance with the observation by Ombu (1987) who reported that silt and clay contributed to the total weight of sediments in the central Bonny estuary. In comparison, sediments in station two had the highest percentage of silt (38.35%).

Lowest percentage of silt (13.46%) was observed in station four. The high silt contents of the sediments in station two may be due to high organic matter discharge from the abattoir. Allan (1995) reported that sediments depend on the parent material available and deposits of materials. The highest percentage of clay (30.98%) was also observed in station two, which also had the highest percentage of slit content (38.35%).

The overall results of the particle size of the sediments of the study area indicated that the creek had sandy mud (73.97%) sediment. This may have accounted for regular sand mining going on in the creek (personal observation). The sandy sediment type observed in the creek was an indication of the abundance of crabs. Swimming crabs whose daily lifecycle involve burrowing in the substratum are abundant in sandy sediment (Warner, 1977; Fischer, 1978).

## REFERENCES

- Adakole, J.A. and P.A. Anunne, 2003. Benthic macroinvertebrates as indicators of environmental quality of an urban stream, Zaria Northern Nigeria. *J. Aqua. Sci.*, 18(2): 85-92.
- Ajao, E.A. and S.O. Fagade, 1990. A study of sediment communities in Lagos Lagoon, Nigeria. *J. Oil Chem. Pollut.*, 7: 85-105.
- Alalibo, O., 1988. The fisheries resource exploitation of the Bonny/New Calabar Estuarine fishing ground in the Niger Delta. M.Phil. Thesis, Rivers State University of Science and Technology, Port Harcourt, pp: 111.
- Allan, J.D., 1995. *Stream Ecology-Structure and Function of Running Waters*. 1st Edn., Chapman and Hall, New York, pp: 388.
- Ansa, E.J., 2005. Studies of the benthic macrofauna of the Andoni flats in the Niger Delta Area of Nigeria. Ph.D Thesis University of Port Harcourt, Port Harcourt, Nigeria, pp: 242.

- Atobatele, O.E., O.A. Morenikeji and O.A. Ugwumba, 2005. Spatial variation in physical and chemical parameters and benthic invertebrate fauna of River Ogunpa, Ibadan. *The Zoologist*, 3: 58-67.
- Barnes, R.D. and S. Hughes, 1988. *An Introduction to Marine Ecology*. 2nd Edn. Blackwell Scientific Publications, UK., pp: 351.
- Brady, N.C., 1974. *The Nature and Properties of Soils*. 8th Edn. MacMillan Publishing Co. Inc., New York, pp: 639.
- Dangana, L.B., 1985. Hydrogeomorphological controls of the mangrove environment in parts of the River State. In: *Proceedings of the mangrove ecosystem of the Niger Delta Workshop*. Wilcox, B.H.R. and C.B. Powel, (Eds.), pp: 6-23. <http://iodeweb1.vliz.be/odin/bitstream/1834/2441/1/NIOMR%20TP-75-.pdf>
- Darlington, J.P.E.C., 1976. Temporal and spatial variation in the benthic invertebrate fauna of Lake George Uganda. *J. Zool.*, 180: 95-112.
- Davies, O.A. and J.F.N. Abowei, 2009. Sediment quality of the lower reaches of Okpoka Creek, Niger Delta, Nigeria. *Eur. J. Sci. Res.*, 26(3): 437-442.
- Egborge, A.B.M., L.I. Ezemonye and G.E. Awoze, 2003. Macroinvertebrate fauna of Udu Ughievwen wetlands, Southern Nigeria. *J. Aqua. Sci.*, 18(1): 1-8.
- Esu, I.E., 1999. *Fundamentals of Pedology*. Stirling-Horden Publishers (Nig.) Ltd. University of Ibadan, Nigeria, pp: 54.
- Fischer, W. (Ed.), 1978. *FAO species identification sheets for fisheries purposes Western Central Atlantic (Fishing area 31)*, (6): 278.
- Head, K.H., 1992. *Manual of Soil Laboratory Testing. Soil Classification and Compactment Tests*. Pentech Press, London, 1(2): 208.
- Ikomi, R.B., F.O. Arimoro and Odihirin, O.K., 2005. Composition, distribution and abundance of macroinvertebrates of the Upper Reaches of River Ethiope Delta State, Nigeria. *The Zoologist*, 3: 68-81.
- Irving, E.G., 1962. *Bonny River entrance (Admiralty Chart, 3287)*, The Admiralty, London, pp: 249.
- Khan, R.N., N. Aravindan and C. Kalvati, 2001. Distribution of two postlarval species of commercial prawns (*Fenneropenaeus indicus* and *Penaeus monodon*) in a coastal 55.
- McLusky, D.S. and Elliot, M., 1981. The Feeding and Survival Strategies on Estuarine Mollusks. In: *Feeding and Survival Strategies of Estuarine Organisms*. N.V. Jones and W.F. Wolff, (Eds). Marine Science. Plenum Press. New York and London. 15: 109-121.
- Miller, R.W., R.L. Donahue and J.U. Miller, 1990. *Soils: An Introduction to Soils and Plant Growth*. 6th Edn., Prentice-Hall International, pp: 768.
- NEDECO., 1961. *The waters of the Niger Delta Report of an investigation by NEDECO (Netherlands Engineering consultants)*. The Hague, pp: 210-228.
- Ombu, E., 1987. *Impacts of Okrika Oil Terminal on Bonny river estuary*. M.Phil. Thesis, Rivers State University of Science and Technology, Port Harcourt, pp: 93. *workshop on microbial degradation, Pensacola Beach Florida*, pp: 423-431.
- Rhoads, D.C., 1974. Organism-Sediment relations on the muddy sea floor. *Oceanogr. Mar. Ann. Rev.*, 12: 263-300.
- Sankare, Y., E. Kodjo and N.G. Kouassi, 1997. *L aquaculture en habitat artificiel (acadja-enclos): modifications transformations du milieu lagunaire (lagune Tendo, Cote d Ivoire)*. *Vie Milieu*, 47(1): 25-32.
- Scott, J.S., 1966. *Report on the Fisheries of the Niger Delta Special Area*. NDDB Port Harcourt, Nigeria. pp: 160.
- Smith, S.G., 1997. *Models of crustacean growth*. Ph.D. Thesis, University of Maryland, pp: 295.
- Ssentongo, G.W., E.J. Ukpe and T.O. Ajayi, 1986. *Marine Fishery Resources of Nigeria: A review of exploited fish stocks*, Rome FAO CECAF/ECAF SERIES 86/40 (En). pp: 62.
- United States Environmental Protection Agency (USEPA), 2002. *Water Quality Monitoring for Coffee Creek (Porter County, Indiana)*. Retrieved Sept. 29, 2006, from: <http://www.USEPA/Research/Research.htm.modecode=62-28-00-00>.
- Warner, G.F., 1977. *The Biology of Crabs*. Paul Elek Scientific Books Ltd., London, pp: 202.