Available online at www.aexpbio.com

ISSN : 2348-1935

RESEARCH ARTICLE

Annals of Experimental Biology
2014, 2 (1):45-52

Effects of Flooding on Amassoma Flood Plain benthic macro-invertebrates Niger Delta, Nigeria

Akankali, J.A.[1], Abowei J.F.N[2] and CHARLES, E[2]

[1]Department of Animal Science and Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba, Port Harcourt, Nigeria
[2]Department of Biological Sciences, Faculty of Science, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

ABSTRACT

The Effects of Flooding on Amassoma Flood Plain benthic macro-invertebrates in the Niger Delta area of Nigeria was studied for a period of six months (November – December, 2012 and January, 2013 for the dry season and April, May and June; 2013 for the Wet season) and compared with results obtained from similar studies. A total of Twenty-seven (27 benthic macro-invertebrate species belonging to fourteen (14) families were present in both before and after flooding. These include: NAIDIDAE: Ophisdonias serpentine, Dera sp, Paranais sp, Uncinais uncinata and Styleria lacustris; LUMBRICIDAE: Eiseniella tetrahida and Lumbricus variegates; NEREIDAE: Nereis virens, Nereis diversicolor and Nereis pelagic; CAPITELLIDAE: Nephthys hombergi; CAPITELLIDAE: Capitella capitta, Notomastus tenuis and Notomastus latericeus; EUNICIDAE: Marphysa sp; GLYCERIDAE: Glycera capitata and Glycera convolute; ARENICOLIDAE: Arenicola marina and Polydora capensis; SYLLIDAE: Syllis profera; GAMMARIDAE: Gammarus lacustra; PANAIDAE: Paneus notialis; CHIRONOMIDAE: Chironomous sp; POTAMIDAE: Tympanotosonus fuscatus and Pachmelania fusca and TELLIDAE: Tellina nymphalis, Loripes sp and Tegalus andersoni. Benthic macro-invertebrate population also increased significantly after the flooding though there was no significant variation between sampling stations.

Key words: Flooding effects, benthic macro-invertebrates, Flood plain, Niger Delta, Nigeria

INTRODUCTION

Floodplain or flood plain is an area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge. It includes the floodway, which consists of the stream channel and adjacent areas that actively carry flood flows downstream, and the flood fringe, which are areas inundated by the flood, but which do not experience a strong current. In other words, a floodplain is an area near a river or a stream which floods when the water level reaches flood stage. Flood plains are made by a meander eroding sideways as they travel downstream. When a river breaks its banks and floods, it leaves behind layers of alluvium (silt). These gradually build up to create the floor of the flood plain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream. These are accumulations of sand, gravel, loam, silt, and/or clay, and are often important aquifers, the water drawn from them being pre-filtered compared to the water in the river [1].

Geologically ancient floodplains are often represented in the landscape by fluvial terraces (Fig. 1). These are old floodplains that remain relatively high above the present floodplain and indicate former courses of a stream. Sections of the Missouri River floodplain taken by the United States Geological Survey show a great variety of material of varying coarseness, the stream bed having been scoured at one place and filled at another by currents and floods of varying swiftness, so that sometimes the deposits are of coarse gravel, sometimes of fine sand or of fine silt. It is probable that any section of such an alluvial plain would show deposits of a similar character.

The floodplain during its formation is marked by meandering or anastigmatic streams, ox-bow lakes and bayous, marshes or stagnant pools, and is occasionally completely covered with water. When the drainage system has ceased to act or is entirely diverted for any reason, the floodplain may become a level area of great fertility, similar in appearance to the floor of an old lake. The floodplain differs, however, because it is not altogether flat. It has a gentle slope down-stream, and often, for a distance, from the side towards the centre. Floodplains can support particularly rich ecosystems, both in quantity and diversity. Amassoma forests form an ecosystem associated with floodplains [1]. They are a category of riparian zones or systems. A floodplain can contain 100 or even 1,000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly; however the surge of new growth endures for some time. This makes floodplains particularly valuable for agriculture.

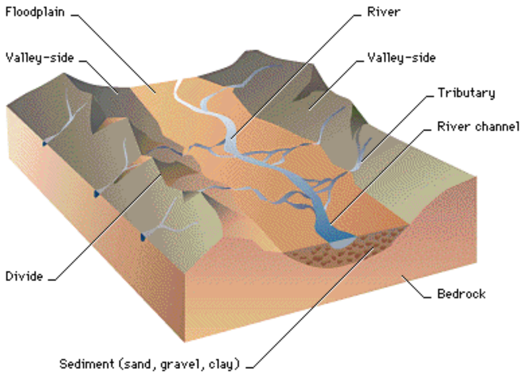

Fig 1 Anatomy of a Floodplain

The word "flood" comes from the Old English </wiki/Old_English_language> /flod/, a word common to Germanic languages (compare German /Flut/, Dutch /vloed/ from the same root as is seen in /flow, float/; also compare with Latin /fluctus/, /flumen/). Deluge myths are mythical stories of a great flood sent by a deity or deities to destroy civilization as an act of divine retribution, and are featured in the mythology of many cultures. Floods can also occur in rivers, when flow exceeds the capacity of the river channel, particularly at bends or meanders. Floods often cause damage to homes and businesses if they are placed in natural flood plains of rivers. While flood damage can be virtually eliminated by moving away from rivers and other bodies of water, since time out of mind, people have lived and worked by the water to seek sustenance and capitalize on the gains of cheap and easy travel and commerce by being near water. That humans continue to inhabit areas threatened by flood damage is evidence that the perceived value of living near the water exceeds the cost of repeated periodic flooding [2].

Floods (Plate 1) are also known to renew wetland areas which in turn host a wide range of flora and fauna. Preventing flood waters from entering such wetland areas will create imbalance to the natural state of things resulting in destruction of natural habitats and even extinction of various species of animals and plants. Floods play an important part in various ecosystems. Humans, therefore, should be careful when they try to prevent or control floods. Oftentimes, human intervention causes more harm than good [3]. Flooding of the rivers in the country is not uncommon; the September 2012 devastating flood which was clearly a natural disaster was a pointer to prior preparations being a proactive effort at mitigation of impacts of such disasters, but little information exits on how these flood events affect water and overbank sediment quality within the affected areas.

512 x 343.27KB jpeg
Source:Nayanet.com/news/source/1092p.html

768 x 510.95KB jpeg
Source:Nayanet.com/news/source/1092p.html

333 x 248.20KB.jpg
Source:www.nairalard.com/992375/niger-delta university

Plate1. Cases of flooding in Amassoma flood plain

Floods are caused by many factors: heavy rainfall, highly accelerated snowmelt, severe winds over water, unusual high tides, tsunamis, or failure of dams, levees, retention ponds, or other structures that retain water. Flooding can be exacerbated by increased amounts of impervious surface or by other natural hazards such as wildfires, which reduce the supply of vegetation that can absorb rainfall. Periodic floods occur on many rivers, forming a surrounding region known as the flood plain. During times of rain, some of the water is retained in ponds or soil, some is absorbed by grass and vegetation, some evaporates, and the rest travels over the land as surface runoff. Floods occur when ponds, lakes, riverbeds, soil, and vegetation cannot absorb all the water. Water then runs off the land in quantities that cannot be carried within stream channels or retained in natural ponds, lakes, and man-made reservoirs. About 30 percent of all precipitation becomes runoff and that amount might be increased by water from other flood causing factors [4].

River flooding is often caused by heavy rain, sometimes increased by melting snow. A flood that rises rapidly, with little or no advance warning, is called a flash flood. Flash floods usually result from intense rainfall over a relatively small area, or if the area was already saturated from previous precipitation. Even when rainfall is relatively light, the shorelines of lakes and bays can be flooded by severe winds that blow water into the shore areas. Coastal areas are also sometimes flooded by unusually high tides, such as spring tides, especially when compounded by high winds and storm surges. Tsunamis which are high, large waves, typically caused by undersea earthquakes, volcanic eruptions or massive explosions also cause flood.

There are many disruptive effects of flooding on human settlements and economic activities. However, floods (in particular the more frequent/smaller floods) can also bring many benefits, such as recharging ground water, making soil more fertile and providing nutrients in which it is deficient. Flood waters provide much needed water resources in particular in arid and semi-arid regions where precipitation events can be very unevenly distributed throughout the year. Freshwater floods, particularly, play an important role in maintaining ecosystems in river corridors and are a key factor in maintaining floodplain biodiversity. Flooding adds a lot of nutrients to lakes and rivers which leads to improved fisheries for a few years; also because of the suitability of a floodplain for spawning (little predation and a lot of nutrients). Fish like the weather fish make use of floods to reach new habitats. Together with fish birds also profit from the boost in production caused by flooding. Periodic flooding was essential to the well-being of ancient communities along the Tigris-Euphrates Rivers, the Nile River, the Indus River, the Ganges and the Yellow River, among others. The viability for hydrological based renewable sources of energy is higher in flood prone regions [1].

The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers. Organisms living in this zone are called benthos, e.g. the benthic invertebrate community, including crustaceans and polychaetes[5]. The organisms generally live in close relationship with the substrate bottom and many are permanently attached to the bottom. The superficial layer of the soil lining the given body of water, the benthic boundary layer, is an integral part of the benthic zone, as it greatly influences the biological activity which takes place there. Examples of contact soil layers include sand bottoms, rocky outcrops, coral, and bay mud. The benthic region of the ocean begins at the shore line (intertidal or eulittoral zone) and extends downward along the surface of the continental shelf out to sea. The continental shelf is a gently sloping benthic region that extends away from the land mass. At the continental shelf edge, usually about 200 meters deep, the gradient greatly increases and is known as the continental slope. The continental slope drops down to the deep sea floor. The deep-sea floor is called the abyssal plain and is usually about 4,000 meters deep. The ocean floor is not all flat but has submarine ridges and deep ocean trenches known as the hadal zone [4].

For comparison, the pelagic zone is the descriptive term for the ecological region above the benthos, including the water-column up to the surface. Depending on the water-body, the benthic zone may include areas which are only a few inches below water, such as a stream or shallow pond; at the other end of the spectrum, benthos of the deep ocean includes the bottom levels of the oceanic abyssal zone. For information on animals that live in the deeper areas of the oceans see aphotic zone. Generally, these include life forms that tolerate cool temperatures and low oxygen levels, but this depends on the depth of the water.

Benthoses are the organisms which live in the benthic zone, and are different from that elsewhere in the water column. Many are adapted to live on the substrate (bottom). In their habitats they can be considered as dominant creatures, but they are often a source of prey for Carcharhinidae such as the lemon shark. Many organisms adapted to deep-water pressure cannot survive in the upper parts of the water column. The pressure difference can be very significant (approximately one atmosphere for each 10 meters of water depth). Because light does not penetrate very deep into ocean-water, the energy source for the benthic ecosystem is often organic matter from higher up in the water column which drifts down to the depths. This dead and decaying matter sustains the benthic food chain; most organisms in the benthic zone are scavengers or detritivores. Some microorganisms use chemosynthesis to produce biomass.

Benthic organisms (Plate 2) can be divided into two categories based on whether they make their home on the ocean floor or an inch or two into the ocean floor. Those living on the surface of the ocean floor are known as epifauna. Those who live burrowed into the ocean floor are known as in-fauna. Sources of food for benthic communities can derive from the water column above these habitats in the form of aggregations of detritus, inorganic matter, and living organisms [6]. These aggregations are commonly referred to as marine snow, and are important for the deposition of organic matter, and bacterial communities. The amount of material sinking to the ocean floor can average 307,000 aggregates per m^2 per day. This amount will vary on the depth of the benthos, and the degree of benthic-pelagic coupling. The benthos in a shallow region will have more available food than the benthos in the deep sea [7].

Plate 2 Typical benthic animals, including amphipods, a polychaete worm, a snail, and achironomous midge larvae
Source: http://en.wikipedia.org/wiki/file:Benthic GLERL. 1_.jpg

The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers. Organisms living in this zone are called benthos, e.g. the benthic invertebrate community, including crustaceans and polychaetes [8]. The organisms generally live in close relationship with the substrate bottom and many. In oceanic environments, benthic habitats can be further zoned by depth. From the shallowest to the deepest are: the epipelagic (less than 200 meters), the mesopelagic (200–1,000 metres), the bathyal (1,000–4,000 meters), the abyssal (4,000–6,000 meters) and the deepest, the hadal (below 6,000 meters) [4]. The lower zones are in deep, pressurized areas of the ocean. Because of the high pressures and seclusion neither tidal changes nor human impacts have had much of an effect on these areas, and the habitats have not changed much over the years. Many benthic organisms have retained their historic evolutionary characteristics. Some organisms are significantly larger than their relatives living in shallower zones, largely because of higher oxygen concentration in deep water. It is not easy to map or observe these organisms and their habitats, and most observation has been done through remote controlled submarines.

The benthic (bottom-dwelling) macro-invertebrates supported by a stream are a great indicator of overall stream health due to their variable tolerance of pollution. Generally speaking, mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), and riffle beetle larvae (Coleoptera) require a relatively pristine environment [9]. Macroin-vertebrates highly tolerant of pollution include midge larvae (Diptera), snails (Gastropoda), leeches (Hirundinea), and aquatic worms (Oligochaeta). Organisms such as scuds (Amphipoda), clams (Bivalvia), crayfish (Decapoda), cranefly larvae (Diptera), and aquatic sowbugs (Isopoda), are somewhat tolerant, and are found in a wide variety of water conditions [1]. Because macro-invertebrates are relatively immobile as compared to other aquatic organisms, they provide a quick snapshot of the condition of their surrounding habitat and the state of the stream’s food web. Macro-invertebrate samples are best taken from within a riffle because the increased level of dissolved oxygen available generally provides the most diverse population of the stream organisms. High diversity and numbers of macro-invertebrates indicate good water quality conditions, whereas presence of only pollution tolerant species or absence of macro-invertebrates suggests a degraded environment. Because naturally occurring coldwater and warm water streams support different species of macro-invertebrates, researchers should not attempt to compare data from these two types of streams to each other in determining stream health.

MATERIALS AND METHODS

Study Area

The Niger Delta (Fig. 1) covers 20,000 km² within wetlands of 70,000 km² formed primarily by sediment deposition. Home to 20 million people and 40 different ethnic groups, this floodplain makes up 7.5% of Nigeria's total land mass. It is the largest wetland and maintains the third-largest drainage basin in Africa. The Delta's environment can be broken down into four ecological zones: coastal barrier islands, mangrove swamp forests, freshwater swamps, and lowland rainforests [10]. This incredibly well-endowed ecosystem contains one of the highest concentrations of biodiversity on the planet, in addition to supporting abundant flora and fauna, arable terrain that can sustain a wide variety of crops, lumber or agricultural trees and more species of freshwater fish than any ecosystem in West Africa [11].

Fig.1 Location of the Niger Delta

The region could experience a loss of 40% of its inhabitable terrain in the next thirty years as a result of extensive dam construction in the region. The carelessness of the oil industry has also precipitated this situation, which can perhaps be best encapsulated by a 1983 report issued by the NNPC, long before popular unrest surfaced. There has been the slow poisoning of the waters of this country and the destruction of vegetation and agricultural land by oil spills which occur during petroleum operations. But since the inception of the oil industry in Nigeria, more than twenty-five years ago, there has been no concerned and effective effort on the part of the government, let alone the oil operators, to control environmental problems associated with the industry [12]. It is estimated that:

- 1.5% of the country is at risk from direct flooding from the sea

- About 7% of the country is likely to flood at least once every 100 years from rivers
- 1.7m homes and 130,000 commercial properties, worth more than £200 billion, are at risk from river or coastal flooding in England
- Many more properties are also at risk from flash floods.

Sample collection

The study was carried out in Amassoma flood plain, in the Niger Delta of Nigeria for a period of six months (November – December, 2012 and January, 2013 for the dry season and April, May and June; 2013 for the Wet season) and compared with results obtained by Ezekiel, 2001[13] and Abowei, 2010[26]. Four sampling stations were established along the length of the Amassoma River whenever, it was accessible by road. Sediments were collected using an Eckman grab of 10cm diameter and 12cm long mostly during the low tides. Three hauls were made at each sampling station by sending the grab down into the bottom and using the messenger to close and grab some quantity of sediment. The benthic samples were collected monthly from each station. Composite samples were composed from each station and put into labeled polythene bags for the determination of the sediment particle sizes. The remaining benthic samples were washed through 1 mm × 1 mm mesh size to collect the benthic organisms. The washed sediment with macro-invertebrates were poured into a wide mouth labelled plastic container and preserved with 10% formalin solution to which Rose Bengal (dye) had been added. The Rose Bengal dye strength was 0.1% selectivity colored all the living organisms in the sample [14] [15][16]. The preserved samples were taken to the laboratory for further analysis.

The washed and preserved sediment with the benthic macro-invertebrates were poured into a white enamel tray and sorted in the laboratory. For effective sorting, moderate volume of water was added into the container to improve visibility. Forceps were used to pick large benthos while smaller ones were pipetted out. The benthos were sorted into their different groups and preserved in 5% formalin. The preserved benthos were later identified to their lowest taxonomic group under light and stereo dissecting microscope and counted. The identification was done using the keys by Day (1967), Pennak (1978) and Hart (1994) [17] [18] [19]. The monthly percentage occurrence and relative numerical abundance of macro-invertebrates were estimated. The densities of abundant species were analyzed for each of the sampling stations using the formula:

$$\text{Density} = \frac{\text{Total Number of Organisms}}{\textbf{\textit{Area of sampling}}}$$

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

RESULTS

Table 1 shows the benthic macro-invertebrate species present before and after flooding in the study area. A total of Twenty-seven (27 benthic macro-invertebrate species belonging to fourteen (14) families were present in both before and after flooding. These include: NAIDIDAE: *Ophisdonias serpentine, Dera sp, Paranais sp, Uncinais uncinata* and *Styleria lacustris;* LUMBRICIDAE: *Eiseniella tetrahida and Lumbricus variegates*; NEREIDAE: *Nereis virens, Nereis diversicolor and Nereis pelagic*; CAPITELLIDAE: *Nephthys hombergi;* CAPITELLIDAE: *Capitella capitta, Notomastus tenuis* and *Notomastus latericeus*; EUNICIDAE: *Marphysa sp;* GLYCERIDAE: *Glycera capitata* and *Glycera convolute*; ARENICOLIDAE: *Arenicola marina* and *Polydora capensis*; SYLLIDAE: *Syllis profera*; GAMMARIDAE: *Gammarus lacustra*; PANAIDAE: *Paneus notialis*; CHIRONOMIDAE: *Chironomous sp*; POTAMIDAE: *Tympanotosonus fuscatus* and *Pachmelania fusca* and TELLIDAE: *Tellina nymphalis, Loripes sp* and *Tegalus andersoni*. Benthic macro-invertebrate population also increased significantly after the flooding though there was no significant variation between sampling stations.

DISCUSSION

Benthic macro-invertebrate population also increased significantly after the flooding though there was no significant variation between sampling stations. This result compared favorably with the report of Bariweni, *et al*; 2012[20]. The benthic macro-invertebrate composition in this study was similar to other studies of benthic macro-invertebrates from other water bodies in Nigeria. Nkwoji et al (2010) have also reported low macro benthic abundance and composition from the Lagos Lagoon [21]. The differences in species composition and abundance may be attributed to the ecological differences of the different habitat locations and period of investigation water quality, immediate substrate for occupation and food availability may also affect the abundance and distribution of the macro-invertebrates communities.

Table 1. Benthic Macro-Invertebrate Species Present in the study area

Benthic macro-invertebrate species	Before flooding				After Flooding			
	SS 1	SS 2	SS 3	mean	SS1	SS2	SS3	mean
NAIDIDAE								
Ophisdonias serpentine	161	172	161	165	216	347	289	284
Dera sp	97	129	94	107	197	209	328	245
Paranais sp	98	69	75	81	173	198	92	154
Uncinais uncinata	114	113	116	115	288	416	297	218
Styleria lacustris	87	141	119	107	413	389	136	267
LUMBRICIDAE								
Eiseniella tetrahida	143	144	124	137	209	178	235	207
Lumbricus variegates	91	78	84	84	173	89	130	131
NEREIDAE								
Nereis virens	72	97	45	71	176	218	253	216
Nereis diversicolor	66	43	84	64	89	324	138	174
Nereis pelagic	73	94	121	96	141	163	192	132
NEPHTHYLDAE								
Nephthys hombergi	257	143	179	193	289	213	289	266
CAPITELLIDAE								
Capitella capitta	20	58	67	48	143	187	193	174
Notomastus tenuis	30	84	64	59	96	101	111	103
Notomastus latericeus	124	78	35	79	133	215	101	150
EUNICIDAE								
Marphysa sp	16	-	46	21	73	89	123	95
GLYCERIDAE								
Glycera capitata	20	73	47	47	112	153	128	121
Glycera convoluta	50	23	-	24	91	100	87	93
ARENICOLIDAE								
Arenicola marina	36	77	20	44	143	126	138	136
Polydora capensis	101	57	-	53	88	72	49	49
SYLLIDAE								
Syllis profera	103	65	97	83	149	128	115	131
GAMMARIDAE								
Gammarus lacustra	16	-	-	5	58	79	131	89
PANAIDAE								
Paneus notialis	33	84	43	53	218	269	201	229
CHIRONOMIDAE								
Chironomous sp	-	32	54	29	89	72	91	307
POTAMIDAE								
Tympanotosonus fuscatus	50	86	53	63	58	151	138	116
Pachmelania fusca	101	44	87	77	189	216	299	201
TELLIDAE								
Tellina nymphalis	11	76	42	43	143	136	159	146
Loripes sp	60	86	55	67	182	98	172	151
Tegalus andersoni	14	-	21	12	136	187	266	196

The observed dominance of Polychaeta in this study is in agreement with the report of Umeozor 1995; Hart and Zabbey, 2005; Eretemeijer and Swennen, 1990 and George et al 2010). [22] [23] [24] [25]. The dominance of Polychaetes in the brackish water station (Degema) may be attributed to their level of pollution tolerance. The numerical numbers of the individual species recorded in this study were high. This suggests that he mud flat of station one is grossly polluted presently. The diversity of benthic macro-invertebrates in the study area estimated by the Margalef, Shannon-Wienner, Pielou and Simpsin's Dominance indexes in the stations were generally low and compared favorably with Nkwoji *et al* (2010) who reported low values for Margalef's species richness and Shannon – Wienner diversity Index[21]. The low diversity of the benthic macro-invertebrates in this study is not unusual in the Niger Delta. Umeozor (1995) reported 23 species from New Calabar River [22]; Hart and Zabbey (2005) reported 30 species belonging to 20 families and 5 classes [23] and George *et al, 2010* reported 19 species from Okpoka creek sediments [25].

REFERENCES

[1] BB Ikomi, FO Arimoro, OK Odihirin. *The Zoologist*, **2005**; 3:68-81.
[2] RL David, LP David, WE Kenneth, *Hydrobiologia* 1981, 79: 187 – 194.
[3] IE Esu, Sterling – Hordon Publishers (Nig.) Ltd. University of Ibadan, Nigeria, **1999**. 54pp.
[4] OE Atabatele, OA Morenike, OA Ugwumba, *The Zoologist*, **2005**, 3:58-67.
[5] EA Ansa, University of Port Harcourt, Port Harcourt, Nigeria, **2005**, pp: 242.
[6] RN Khan, N Aravindan, C Kalvati, *Pakistan Vet. J*., **2001** 21 (1): 22-26
[7] ABM Egborge, LI Ezemonye and GE Awoze,. *J. Aqua. Sci*., **2003** 18(1): 1-8.
[8] JA Adakole and PA Anunne, *J. Aqua. Sci*., **2003** 18(2): 85-92,.
[9] AA Nweke, Rivers State University of Science and Technology, Port Harcourt, Nigeria. **2000**: Pp. 287.
[10] HE Welch, PEK Symons and DW Narver, Can. Technical Report **1977** No. 745. St. Andrew's New Brunswick.
[11] MT Thompson, Geological Survey Water-Supply Paper 1779-M. **1964**, Washington, D.C.: United States Government Printing Office.
[12] WG Powell, Applied Research Project. Texas State University **2009**, – San Marcos. <http://ecommons.txstate.edu/arp/296/>
[13] EN Ezekiel, University of Port Harcourt, Choba, **2001**. pp: 77.
[14] T Claudiu, HG Rogers and H Judith, *Hydrob.* **1979**: *64*: 59 – 95.
[15] N Zabbey, University of Port Harcourt, **2002**, pp: 102.
[16]EO Idowu and AAA Ugwumba, *The Zoologist*, **2005**. *3*:15-25pp.
[17] JA Day, British Museum of Natural History, London, **1967** 458 pp.
[18]RW Pennak and JohnWiley and Sons, New York. **1998,** 810pp.
[19] AI Hart, University of Port Harcourt, Rivers State, **1994**, 262pp.
[20] PA Bariweni, CC Tawari and JFN Abowei, *International Journal of Fishes and Aquatic Sciences,* **2012**, *1(1): 34-46.*
[21] JA Nkwoji, IC Onyema and JK Igbo, *Science World Journal* **2010**, Vol. 5 (5): 7-14.
[22] OC Umeozor, *Trop. Fresh. W. Biol*. **1995** *4*:41-51.
[23]AI Hart and N Zabbey, *Environ. Ecol*., **2005**, 23(2): 361-368.
[24] P Eretemeijer and C Swennen ., **1990**, Wallaceana 59 and 60.
[25] ADI George, JFN Abowei and ME Allison, *Asian Journal of Agricultural Sciences*, **2010** 2 (1): 9-14.
[26] JFN Abowei, *Adv. J. Food Science Technology* **2010** *2 (1)*: 16 – 21.