

## Effects of Water Pollution on Benthic Macro Fauna Species Composition in Koluama Area, Niger Delta Area, Nigeria

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**Abstract:** The effects of water pollution on benthic macrofauna species composition in Koluama Area of Niger Delta in Nigeria was studied to create awareness of the consequences of water pollution. A total of seven sampling stations were established: Foroupa (N4 36.004 E5 39.128); Ekeni (N4 41.659 E5 34.451); Ezetu 2(N4 43.333 E5 34.640); Kuluama 1(N4 28 433 E5 46.248); Kuluama 2 (N4 25.805 E5 49.582); Fish Town (N4 24.642 E5 51.128) and Ikebiri fishing port (N4 30.374 E5 50.298). Replicate samples were collected and the mean used for further analysis. The benthic samples for the analysis of benthic organism were collected using an Eckman grab of 10 cm diameter and 12 cm long. 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 from each station. The remaining benthic samples were washed through 1 × 1 mm mesh size to collect the benthic organisms. The washed sediment with macro-invertebrates were poured into a wide mouth labeled 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. The preserved samples were taken to the laboratory for further analysis. A total of 383 species belonging to four major taxonomic groupings were recorded. These groupings and their percentage contribution to the total macro-benthic collection are Crustaceans (48%), Polychaetes (35%) and Gastropod Molluscs (12%) Bivalve Molluscs (5%). Density of benthos fluctuated between 36 (SW/SD 5) and 118 (SW/SD C2) while species count per station was 9 in SW/SD 5 and 21 in SW/SD C2. Twenty-eight species belonging to 14 families, 6 classes and 3 phyla of macro-invertebrates were recorded in the study area. The faunal composition was dominated by polychaetes with 13 species from 7 families (46.4%) in terms of the species richness. Oligochaeta had 2 families and 7 species (25%), Bivalvia had 1 family and 3 species (10.7%). Crustacea was represented by 2 families and 2 species, Gastropoda had one family 2 species and insecta had 1 family and one species constituting 7.2, 7.2 and 3.6% of the species richness respectively. The diversity of benthic macro-invertebrates in the study area in the stations was generally low. Polychaete was dominant in the brackish water station (Degema). This 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 the mud flat of station the study area is grossly polluted.

**Keywords:** Benthic macro fauna species composition, effects, Koluama area, Niger delta, Nigeria, water pollution

### INTRODUCTION

Benthic macro fauna are those organisms that live on or inside the deposit at the bottom of a water body (Barnes and Hughes, 1988; Idowu and Ugwumba, 2005). Several species of organisms which cut across different phyla of annelids, coelenterates, mollusks, arthropods and chordates are found in the brackish water ecosystem, where they play a vital role in the circulation and distribution of nutrients in aquatic ecosystems. They form the link between the unavailable

nutrients in detritus and useful protein materials in fish and shell fish. Most benthic organisms feed on detritus that settle on the bottom of the water and in turn serve as food for a wide range of fishes (Imevbore and Bakare, 1970; Adebisi, 1989; Ajao, 1990; Oke, 1990; Idowu and Ugwumba, 2005). They accelerate the breakdown of decaying organic matter into simpler organic forms such as phosphates and nitrates (Gallep *et al.*, 1978). All forms of aquatic plants, which are the first link of several food chains existing in aquatic environments, can utilize the nutrients. These

organisms therefore form a major link in the food chain as most estuarine and marine fishes, birds and mammals depend directly or indirectly on the benthos for their food supply (Barnes and Hughes, 1988).

Macro-benthic invertebrates are useful bio-indicators providing a more accurate understanding of changing aquatic conditions than chemical and microbiological data, which at least give short-term fluctuations (Ravera, 1998, 2000; Ikomi *et al.*, 2005). The most popular biological method in assessment of freshwater bodies receiving domestic and industrial wastewaters is the use of benthic macro-invertebrates (Odiete, 1999). The composition, abundance and distribution of benthic macro-invertebrates can be influenced by water quality (Imevbore, 1967; Haslam, 1990; APHA/WWA/WEF, 1998; Odiete, 1999). They all reported that variations in the distribution of macro-benthic organisms could be as a result of differences in the local environmental conditions.

The structure of macro-invertebrate communities has been the subject of much research in river systems (Miserendiro, 2001). Potential benefits of research on macro-invertebrates include the quick assessment of biological resources for conservation purposes and the detection of pollution through differences between predicted and actual faunal assemblages (Ormerod and Edwards, 1987). The fauna of marine sediments is more difficult to describe in general terms because more phyla are well represented and there is more diversity within each phylum (Lopez, 1988). The polychaetes are very diverse and are often the single most important group in marine muds (Lopez, 1988). Decapod crustaceans are important arthropods in marine sediments. Insects are rare and restricted to the intertidal zone. Marine bivalves are also highly diverse and often dominant members of marine muds (Lopez, 1988). Salinity is the major environmental factor restricting the distribution of marine and lacustrine taxa resulting in the well known poverty of species in brackish and freshwater (Ramane and Schlieper, 1971).

Low biomass of macro-benthic fauna of some intertidal areas in Java, Indonesia was attributed to abiotic stress factors such as instability of the substratum, occurrence of toxic substances or drastic salinity fluctuations (Eretemeijer and Swennen, 1990). They reported that the mud flats in the Serewean Estuary and Porong Delta consisted of bare soft mud with a low biomass of benthic macro-fauna. In the Serewean Estuary the benthic macro-fauna consisted of only small polychaetes. Towns (1979) surveyed the macro-invertebrate fauna of Waitakere River and its tributaries, a Northern New Zealand Kauri forest stream and reported 144 taxa. He also stated that the small

number of species obtained else-where in New Zealand is probably partly due to imprecise identification and partly the result of poor taxonomic coverage of many groups. Downstream changes in species composition and parallel change in the number of insect families occurred. Towns (1979) reported that in most streams throughout the world the largest number of species in the invertebrate fauna is comprised of Diptera, dominated by Chironomidae.

Longitudinal changes in the available habitats in rivers have been seen as influences on species composition and community structure (Friberg *et al.* 1977; Minshall *et al.*, 1985; Stratzner and Higler, 1986). The management of water systems based on multiple needs has become an important focus of many Federal, State, local and private authorities (Nelson and Lieberman, 2002). These social needs include mandated water deliveries, by hydroelectric power production, recreation and requirements for fish and wildlife benefits. The task of balancing these compelling demands is sometime difficult for management agencies because they lack the information needed to make sound decisions, especially for fish and wildlife. Alterations in downstream lotic communities, such as aquatic invertebrates, may result from these operational changes (Vinson, 2001). Considerable evidence exists that hydraulic conditions are driving forces affecting distribution and abundance patterns of benthic invertebrates. There is theoretical and empirical support from stream ecology studies for a strong relationship between environmental variation (environmental gradients) and macro-invertebrate community composition (Faith and Norries, 1989).

This theme is most strongly developed in the work on the River Continuum Concept (RCC) (Vannote *et al.*, 1980; Minshall *et al.*, 1985; Statzner and Higler, 1985), in which streams are conceptualized as continua with predict Table responses of communities to environmental gradients corresponding to stream order. In addition, biological monitoring studies using macro-invertebrates (Moses, 1987) have produced a range of predictive models successfully relating community composition to various Physico-chemical variables.

The daily life of the people of Koluama in Bayelsa State reflects the daily existence of most people along the creeks and rivers in the Niger Delta. It is a life of extreme struggle, with both the vagaries of nature and man-made obstacles. Most times, communities are far removed from another, connected only by the waters that flow along the extensive creeks into the Atlantic Ocean. Since there are no roads, those who live there and want to reach out to their neighbors, go to market or go fishing, must necessarily move on water, by

means of slow-moving dug-out canoes, while some of the more illustrious citizens are able to make use of posh speed-boats for their daily endeavours. Koluama 1 and 2 are part of the eight communities in the State affected by the blowout of gas facility owned by Chevron in January, this year, the others being Ezetu I, Ezetu II, Furoupa, Fish Town, Sangana and Ekeni, with a combined population of about 30,000 people. Access to the communities from Yenagoa, the state capital, takes two and half hours ride by speedboat through the creeks. For other boats, the time can be much longer. The journey can be particularly frightening, especially for non-natives not used to water. For the indigenes, there is nothing to worry about as far as riding the waves is concerned. Life in the waters is normal for them. It is a way of life that they were born into.

In the beginning, in spite of the distances they had to cover in the waters, there was peace, harmony and understanding with nature. But things have been drastically altered, especially with the activities of the oil prospecting companies and their manner of operation in the area. They make good money but are hardly interested in giving back to the communities. It is now common to find oil floating on the creeks, not necessarily from the activities of the oil majors but from the enterprise of Niger Delta indigenes who have established local petroleum refineries along the banks of the rivers and creeks. The base of the mangrove forest bordering the creeks is colored by moulds of oil which will require an unprecedented effort to restore to their natural state. The people burst oil pipelines buried by the oil majors and cause spills in an attempt to siphon the crude for illegal bunkering activities and refine some to dispose of at the readily available markets. The business is risky but who cares? How can oil pipelines pass through their houses and they do not benefit from their content? That is what they seem to think.

Many people do not see how the risky bunkering and illegal petroleum refining and, consequently, the degradation on the creeks, can be stopped in the Niger Delta because of the number of people involved on the one hand and the perceived complicity of the Joint Task Force (JTF) stationed in the area on the other. Apart from the inadequate knowledge of the creeks where the business thrives, the JTF operatives are said to be more interested in extorting money from those in the bunkering and illegal petroleum refining than checking their economic sabotage. Therefore, all along the route to Koluama, thick smoke rises at various positions on the river banks, indicative of the existence of local refineries where business is booming.

Koluama community gained added prominence on the January 16 this year when the Chevron gas facility



Plate 1: Chevron gas rig explosion in Koluama communities in the early hours of Monday January 16, 2012, (Daily Time Nigeria, 2012)

at its Atlantic Ocean backward exploded, shaking the very foundation of the structures in the community (Plate 1). The blowout released harmful gas into the atmosphere and caused a huge conflagration that burnt in the sea, with concomitant disaster to the aquatic life. The cries of the people for remedy to their plight attracted President Goodluck Ebele Jonathan who, last Monday, personally undertook an aerial inspection of the affected gas platform in the sea and later met with members of the communities.

A spokesman of the eight communities affected, Hon. Nimibofa Ayawei, painted a gloomy picture of the disaster to the president, narrating how the incident occurred and how the inhabitants of the area had been neglected by Chevron, the owner of the facility and government. According to him, in the early hours of Monday January 16, 2012, the residents heard a loud explosion from the K.S. Endeavour (Panama) Rig where Fode Drilling Limited, a company contracted by Chevron Nigeria Limited was drilling gas at the North Apoi Field, west of Funiwa Field, Koluama Clan about 5 nautical miles from the Koluama communities in Southern Ijaw Local Government Area of Bayelsa State. The explosion resulted into a huge gas fire and a massive spill.

The huge flame in the sea which was visible could be sighted from the Koluama River burning uncontrollably and emitting dangerous gases and other toxic chemicals into the environment. The Koluama River directly empties into the Atlantic Ocean and as such, the polluted water is carried into the Koluama Rivers and Creeks and other neighbouring communities in the coast line. Ayawei told the President that the massive explosions shook the foundations of houses in Koluama 1, Koluama 2, Kalaweiama, Opuama, Tamazo, Kiriseighegbene, Abiakwei and Lobia, among other communities in the Koluama Clan, saying that “we are worried about this development because it was explosions in the course of seismic activities by

Shell D'Archy while exploring for oil and gas in the same area that led to the wiping away of ancient Koluama in 1953.”

He emphasized that with this incident, the air space and the ocean had been seriously polluted and the current was carrying the dangerous gases and chemicals into the rivers and creeks of the communities within the coastal areas where the incident occurred. The aquatic or marine life has been adversely affected and dead fishes could be seen floating on the water in the ocean, shore, creeks and rivers of the coastal communities in the area. Dark colored pollutants have been seen spreading on the surface of the ocean from the first day and have been impacting seriously on the people and the coastal shoreline. The health implications of this are no doubt overwhelming, he remarked, as the gases released into the environment such as carbon monoxide, sulphur dioxide, etc., most of which are acidic gases, have wide-ranging implications on the populace. The former lawmaker spoke of incidents of various forms of ailments including vomiting, stomach pains, difficulty in breathing, acute asthma, etc., resulting in a couple of deaths which had been reported, stating that people had been moving out of the communities for the fear of the unknown.

In spite of the dangers associated with the situation, no assistance has so far gone to the people. That is why, he said, they were very angry with Chevron which they believed had demonstrated stark insensitivity to their plight. “We therefore feel insulted by the claim of Chevron that the gases emitted from the blowout which burnt were not harmful to human and the environment. We really feel insulted by this claim because if these gases were not harmful, Chevron could not have immediately evacuated its personnel from its oil facilities around the scene of the accident. The above claim was not only inciting but was aimed at preventing the victims of this unfortunate incident from taking drastic actions against the company,” the community spokesman added.

They have now put up a list of demand before the President, including shore protection and embankment, reclamation and sand filling of land, canalization, provision of functional health facilities, implementation of the Bayelsa Central Senatorial road/coastal Ring road, provision of concrete walk ways, provision of potable water, quality education for their people and employment, especially with the multinational oil companies operating in their areas. The Managing Director of Chevron, Mr. Andrew Fawthrop, who was present at the occasion, appeared to be loss for words following the bashing he received from the community and managed to say that the blow-out was dying out down to about 3,000 ft and progressing to put the fire

out. While appreciating the community as well as staff of Chevron, he spoke of what seemed to the community like a token effort to provide medical assistance, saying that “there will be some community work going on with medical works starting from Wednesday to improve the quality of life.”

The Group Managing Director (GMD) of the Nigerian National Petroleum Corporation (NNPC), Mr. Austen Oniwon, remarked that the rig that exploded was one dedicated to gas, adding that though the incident happened, the Corporation would not be discouraged. “It was an accident. We believe that we have learnt a lot of lessons from it. Immediately it happened, we tried everything possible to control and contain it,” he said. Oniwon revealed that there were 154 people on the rig when the incident occurred out of which two, a Frenchman and an Indian lost their lives and their corpses never found. He explained that “because it is a blow-out, it is very difficult to quench the fire, but what we are doing now is to drill another well to try and reach the hole and then block it.” Oniwon acknowledged that the communities had been “very magnanimous and very patient with us”, saying, “in spite of all the devastation the oil spill would have caused them, they have not taken to the streets to demonstrate.”

In his remark, the governor of the state, Seriake Dickson, noted that while the people do not have any problem with the exploitation of oil to sustain the national economy, they however want the oil companies to respect the fragile environment of the area as he observed that what happened in these communities was a common occurrence which the people of the Niger Delta had been contending with. “Mr. President, as we all know, what has happened in Koluama is a very familiar event; it is the same story in the Niger Delta, the same story of sacrifice, the same story of inconveniences, the same story of living with risks day by day to be able to produce the mainstay of the economy of our great country.

What has happened in Koluama is the same story in all our communities, countless communities, villages and settlements in Bayelsa State, the Ijaw nation and across the Niger Delta. We have no problem producing what has become the mainstay of our economy but the least we can ask from Mr. President is respect for our environment, protection of our very fragile ecosystem,” he declared. Dickson was however furious with the people who burst oil pipelines for the sake of bunkering and illegal refining, stating that his government had set up a task force to try to fight the ugly situation. After listening to the people, President Jonathan promised the provision of relief materials and compensation to those affected, assuring the people of government's

commitment to tackling environmental management issues, not only in the Niger Delta but also in the extreme north of the country where he observed there was desert encroachment. Jonathan added that the federal government would collaborate with Bayelsa State government and Chevron to provide relief materials for the people and noted: "In terms of other demands that have been documented, I noticed that many issues have been raised and these are issues we are quite conversant with. I can assure you that we will look into it, the company, the state government and the federal government will continue to address them."

The President told the people that "communities impacted must have some relief, some compensation. That is obvious but the quantum will depend on studies that have been carried out by the company and the federal government," adding that "on my own part, I will reassure you that the federal government is totally committed to the issues bordering on environmental management, from the Niger Delta to extreme north where we have desert encroachment." Besides what Chevron and other government agencies would do, he assured that the federal government through the National Emergency Management Agency (NEMA) would provide some of the relief materials sought by the communities. A study of the effects of water pollution on benthic macro fauna Species composition in Koluama area, Niger Delta Area, Nigeria is aimed at establishing the effect of water pollution on benthic macrofauna species composition.

#### MATERIALS AND METHODS

Sampling was carried out from April 15 to May 14 2012. A total of seven sampling stations were established: Foroupa (N4 36.004 E5 39.128); Ekeni (N4 41.659 E5 34.451); Ezetu 2 (N4 43.333 E5 34.640); Kuluama 1 (N4 28 433 E5 46.248); Kuluama 2 (N4 25.805 E5 49.582); Fish Town (N4 24.642 E5 51.128) and Ikebiri fishing port (N4 30.374 E5 50.298). Replicate samples were collected and the mean used for further analysis. The benthic samples for the analysis of benthic organism were collected using an Eckman grab of 10 cm diameter and 12 cm long. 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 from each station. The remaining benthic samples were washed through 1 × 1 mm mesh size to collect the benthic organisms. The washed sediment with macro-invertebrates were poured into a wide mouth labeled 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 (Claudiu *et al.*, 1979; Zabbey, 2002; Idowu and Ugwumba, 2005). 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). The monthly percentage occurrence and relative numerical abundance of macro-invertebrates were estimated.

#### RESULTS

The percentage compositions of each of the major benthic fauna are presented in Table 1. A total of 383 species belonging to four major taxonomic groupings were recorded. These groupings and their percentage contribution to the total macro-benthic collection are Crustaceans (48%), Polychaetes (35%) and Gastropod Molluscs (12%) Bivalve Molluscs (5%). Twenty-eight species belonging to 14 families, 6 classes and 3 phyla of macro-invertebrates were recorded in the study area. The faunal composition was dominated by polychaetes with 13 species from 7 families (46.4%) in terms of the species richness. Oligochaeta had 2 families and 7 species (25%), Bivalvia had 1 family and 3 species

Table 1: Relative abundance of major families of benthos in study area

Major families of benthos	Composition (%)
Crustaceans	48
Polychaetes	35
Gastropods molluscs	12
Bivalve molluscs	5

Table 2: Spatial variation in number of benthos species in the study area

Sampling stations	No. of species of phytoplankton	Total (No of Org/L) × 1000
SW/SD 1	45	11.7 × 10 <sup>3</sup>
SW/SD 2	41	11.1 × 10 <sup>3</sup>
SW/SD 3	49	11.9 × 10 <sup>3</sup>
SW/SD 4	48	11.8 × 10 <sup>3</sup>
SW/SD 5	36	10.9 × 10 <sup>3</sup>
SW/SD C1	45	11.7 × 10 <sup>3</sup>
SW/SD C 2	118	21.8 × 10 <sup>3</sup>

(10.7%). Crustacea was represented by 2 families and 2 species, Gastropoda had one family 2 species and insecta had 1 family and one species constituting 7.2, 7.2 and 3.6% of the species richness respectively.

The spatial variation in the total number of benthos in the study area is presented graphically in Table 2. Density of benthos fluctuated between 36 (SW/SD 5) and 118 (SW/SD C2) while species count per station was 9 in SW/SD 5 and 21 in SW/SD C2.

### DISCUSSION

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; Hart and Zabbey (2005) reported 30 species belonging to 20 families and 5 classes and George *et al.* (2010) reported 19 species from Okpoka creek sediments.

The results of the benthic macro-invertebrate composition in this study are also 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. 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.

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; George *et al.*, 2010). 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 the mud flat of station one is grossly polluted presently.

The diversity of benthic macro-invertebrates in the study area estimated by the Margalef, Shannon-Wiener, Pielou and Simpson'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-Wiener diversity Index.

### CONCLUSION

- The diversity of benthic macro-invertebrates in the study area in the stations were generally low.

- Polychaetes was dominant in the brackish water station (Degema).
- This 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 the mud flat of station one is grossly polluted presently.

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