Journal of Biopesticides and Environment
ISSN: 2449-1284 (Online); 2449-1292 (Print)
http://www.biopjournal.com

IMPACT OF SAW-MILL WOOD WASTES AND AGRO-CHEMICALS ON THE POPULATION STRUCTURE OF BENTHIC MACRO-INVERTEBRATES OF AFI RIVER, SOUTHERN NIGERIA

[1]Andem, A. B.,* [1]Okorafor, K. A and [2]Ekpenyong, E. M.
1. Department of Zoology and Environmental Biology, University of Calabar
PMB 1115, Cross River State, Nigeria. Tel: +2348060168081
2. Department of Botany, University of Calabar, PMB 1115, Cross River State, Nigeria.
*Corresponding Author's E-mail: andem1120unical@yahoo.com, Tel: +2348060168081.

ABSTRACT

Studies on the impact of saw-mill wood wastes and agro-chemicals on the distribution and population dynamics of benthic macro-invertebrates in Afi River were conducted between December and February, 2015. Monthly sample collection was carried out using the sweeping net, hand trowel and hand picking methods. Thirteen (13) genera of benthic macro-invertebrates were identified belonging to two Phyla and three classes from the total of 82 individuals collected across all the stations. Arthropoda was represented by Insecta and Arachnida accounted for 71.93% while Mollusca were represented by Gastropods which accounted for 28.06%. In the class Insecta, Order Lepidoptera, *Acraea* sp. was the most abundant species representing for 19.5% and the least abundant, were of the class Insecta, order Coleoptera, Plecoptera and Zygoptera i.e. *Dincutus* species, *Sialis* species and *Enallagma* species accounting for 2.44% each. There was significant difference (P<0.05) between the abundance of benthic macro-invertebrates across all stations. Margalef's index and Shannon wieners were not significantly difference (P>0.05) across all stations while Equitability index recorded significant differences (P<0.05) across all stations. Some of the organisms were tolerant to pollution while others were sensitive. The observed differences in the distribution of benthic macro-invertebrates may reflect the presence of pollution tolerant/sensitive species across all the stations. In this study, some organisms such as *Bolinus globosus and Pachymelania aurita* were to be identified opportunistic and were tolerant to organic pollutant such as saw-mill wood wastes and agro-chemicals.

Keywords: Saw-mill wastes, agro-chemical, population, macro-invertebrate, Afi River spoilage.

1. INTRODUCTION

Pollution of water ways by organic discharges in Nigeria is perhaps the most serious threat posed to the Nigerian inland waters. Sources of pollution of the inland waters of Nigeria are well known. The most notable point source arises from the dumping of untreated or partially treated sewage into the River (Adakole and Anunne, 2003), discharge of bio-degradable wood wastes from sawmills located along the lagoon (Nwankwo, 2008). Manufacturing operations that produces raw wood, such as sawmill, paper mills and furniture manufacturers are the major sources of pollution in the Nigeria water ways. Others include Agricultural and domestic wastes which find their ways into the river bodies (Vega *et al.*, 2006). Studies on activities of the sawmilling industry on the environment – reveals that, it is obvious that as long as man continues to use resources, wastes are inevitable. The most critical environmental impacts of the activities of wood based industries are pollution to marine life and aquatic environment (Green, 2006). Benthic organisms are found in almost all water bodies living on or inside deposits of the bottom substrate and are sedentary with reduced or no mobility (Odum, 1971). Benthic macro-invertebrates population cannot be exempted from the effects of human activities, including the use of agrochemical. Hence, environmental manipulations and other human activities are the major causes of stress on natural ecosystems exerting impact on the population dynamics of benthic macro-invertebrates (George *et al.*, 2009). Thus, many sources of surface water pollutants, agricultural activities have been identified as major contributors to environmental stress, which affects all ecosystem components, justifying the above, water bodies which are reservoirs of marine organisms, of which Afi River is one of them possess the qualification of faecal indicator organisms with various zoonotic pathogens contributing to wastes and other sources of pollution. Agro chemicals may influence the survival of these benthic macro-invertebrates in water bodies impacted by human activities by enhancing or reducing their survival. The problem of human activities involving saw mill wood wastes and Agro chemicals usage to some extent are believed to degrade the marine environment**.** The case is not different in Afi river, where the impact of sawmill wood wastes and agro-chemicals on the population structures of benthic macro-invertebrates is of great concern. Inspite of the day to day human activities in Afi River due to global economic trend, there is dearth of information involving the biological, chemical and physical features of Afi River (limnology). Therefore, we hypothesize that sawmill wood waste and agro-chemical discharged into Afi river, will affect the biotic (benthic macro-invertebrates) distribution and abundance. This study was aimed at evaluating the impact of sawmill wood wastes and agro chemicals on the population structure of benthic macro-invertebrates in Afi River, Southern, Nigeria.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Afi River lies within the forest bolt of central Cross River State of Nigeria. It is located in Boki Local Government Area which on latitude 6^0 25N and longitude $8^0 45^0$ and 8^0 55E (Figure 1). The Afi river runs through different ecological zones, thus through agricultural farm lands, industrial, commercial and socio-cultural areas such as Bakum, in Eastern Boki, Katabang, Oriem ekpang inland, Bendeghe Afi, Opu/balep, Ngbaka Mkpiri (Nde Afi) areas of Ikom to where it finally confluences at the Cross River. The Afi River drains part of the Afi Mountains in Boki Local government Area of Cross River State. The region has a clear distinction between wet and dry season. Heavy rains are usually experienced from early April to the end of September, during which temperature range is 24^0C. In the August-month of the season temperature rises to about 28^0C – 30^0C throughout the year, the relative humidity is high in the early mornings. Drainage is poor, so the area is subject to flooding, gully erosion and minimal landslides.

2.1.1 Sampling stations

Three sampling stations were chosen along the course of the river. The co-ordinates of the sampling stations were taken using geographical positioning system (GPS) and approximate distances of the stations were calculated.

Station 1 (S_1): Station one was located at Bakun community Boki and is the upstream station or control point, it was assumed to be unpolluted since the activities around that area is minimal. It is a small stream very clear and shallow. One could see the gravels underneath. Except that human activities such as laundry and bathing is done here, there are no fishing activities or sawmill located in this area. The stream rushes fast and constantly without stagnation. There are green vegetation's around and a small bridge leading end to end, sideways. It is between latitude 06^0 24'54.4' N and longitude 09^{0}' 06' 9.5 E.

Station 2 (S_2): This station was located at Katabang community in Boki Local Government and is the first discharge point. This area is almost totally surrounded by cocoa plantation in which agro chemicals are frequently used. A bridge also crosses over it sideways and tall trees abound. The water is coloured almost leaf green as a result of the presence of algae and agro chemicals draining into it. This station flows slowly and is between 06^0, 15' 53.7" N and longitude 09^0, 00' 22.7'E.

Station 3 (S_3): Station three was in Orimekpang community. This was the second discharge point. It is large area with sawmill located just around it. Fishing activities at this point was to some extent low. A longer and metallic bridge crosses over sideways. Sand excavation and sales take place here. Green vegetation and prominent trees abound. It lies between

Latitude 06^0 05^1 35.7'N and longitude 08^0'52 45.5"E.

2.3 Collection of benthic macro-invertebrates

Sediment samples were collected for benthic macroinvertebrate from three sampling stations of the study area (Bakum, Katabang and Oriemekpang) using hand trowel and sweeping net. For each sampling station, hand trowel were used to scoop the sediment. About twenty to twenty five sweeps were made across the vegetation with the bag carefully examined following each sweep. The sediments collected were poured into white a plastic can, about 10cm in size, labeled and brought to the laboratory for analysis. The sediments were passed through three sieves with mesh size of 2mm, 1mm and 0.5mm to collect the benthos. The benthos was poured into a white enamel tray, stained with dye solution (Rose-Benger) and sorted using forceps. Sample were stored in a para-labelled container and preserved in 10% formalin for further analysis. Later, they were then identified under a stereoscope microscope using identification guides of Pennak (1978); Edmunds (1978) and EPA (1998).

2.4 Statistical Analysis

Data obtained from this study was subjected to analysis of variance (ANOVA) to compare the differences in species composition and abundance in the three stations. Effects with a probability of ($P<0.05$) were considered significant.Microsoft Excel 2013 (Microsoft Corporation 1985-2013) were used for graphical illustrations (Ogbeibu, 2005).

2.4.1 Determination of Biological Parameters

The occurrence and relative numerical abundance of benthic macro-invertebrates was calculated using diversity indices such as Species richness (d), species abundance (H) and Species equitability or evenness (E). These parameters were determined as follows:

Margalef's index (d): is a measure of species richness (Margalef's, 1949) and was determined using the equation below:

$$d = \frac{S-1}{\text{In}\,(N)}$$

Where;

S = the number of species in samples.
N = the total number of individuals in the sample and '*In*' is the natural logarithm

Shannon and Weiner's index (H): is a measure of species abundance (Shannon and Weiner, 1949) and was determined using the equation below:

$$H \quad = \quad H = \sum \frac{Ni}{N} \;\; \log_2 \;\; \frac{Ni}{N}$$

Where;

N = the total number of individual in the sample
Ni = the total number of individuals of species *ith* in the sample

Species equitability or evenness (E) (Pielou, 1966) was determined by using the equation below:

$$E = \frac{H}{\text{In}\ S}$$

Where;
H = the Shannon and Wiener's index.
S = the Number of species in samples.

3. RESULTS

4.1 Benthic macro-invertebrates

Summary of the relative abundance of the various benthic macro-invertebrates taxa encountered at the different sampling stations is presented in Table 1 while the illustration in Figure 2 shows the percentage composition of benthic macro-invertebrate phyla in Afi River. Thirteen (13) genera were identified belonging to two Phyla and three classes from the total of 213 taxa comprising 82 individuals collected across all the stations. Arthropoda was represented by Insecta and Arachnida, accounted for 71.93% and while Mollusca were represented by

Gastropods which accounted for 28.06%. The class Insecta, Order Lepidoptera, *Acraea* sp. was the most abundant species representing 19.5% and the least abundant, belonging to the class Insecta, order Coleoptera, Plecoptera and Zygoptera i.e. *Dincutus* species, Sialis species and *Enallagma* species which accounting to 2.44% each. *Gerris* species were abundant in S_1 while *Pachymelania aurita* was abundant in S2 and S_3. Arthropods had the highest percentage composition of 72.0% while Mollusca had the least with 28.0%. Percentage abundance of arthropods per order was high ranging from 2.44-19.51%. Arthropods had the highest number of taxa (11), namely; *Dincutus* species, *Hydrophilus* species, *Stenelnus* species, *Gerris* species, *Hydrometra* species, *Acraea* species, *Centroptilum* species, *Macromia* species, *Sialis* species, *Enallagma* species. and *Araneae* species. There was significant differences ($P<0.05$) in the abundance of benthic macro-invertebrates across the three stations examined.

4.2. Diversity Indices of benthic macro-invertebrates from Afi River

Summary of the diversity indices calculated for the three stations (Table 2) shows that taxa richness was the least in S_1 (2.058) which is the upstream station while S_2 accounted for the highest diversity (2.462) which was the first downstream station. Shannon diversity index (H), revealed that S_2 had the highest diversity (0.837) while S_3 recorded for the lowest diversity (0.7807). Equitability was least in S2 (0.3089) and highest in S1 (0.377). From the values reported above, there were no significant differences ($P>0.05$) in the taxa richness among the three stations sampled. However, species equitability recorded significant differences ($P<0.05$) across the stations evaluated.

4. DISCUSSION

The findings of the present investigation revealed that the prominent features of the saw mill wood wastes and agro-chemicals have negative effect on benthic macro-invertebrates distribution and their communities. The 213 taxa comprising of 82 individuals recorded was low when compared with other taxa reported for tropical streams (Edokpayi *et. al.*, 2000; Ogbeibu, 2001; Adakole and Annune, 2003). The low species diversity could be due to some physico-chemical conditions like fast flow, high pH, low dissolved oxygen and low conductivity of the water. Odum (1971) had reported that diversity tends to be low in physically controlled systems. These factors probably caused disruption of life cycle, reproductive cycle, food chain and migrations or imposed physiological stress on even the tolerant macro-invertebrates (Adakole and Annune, 2003). The taxonomic breakdown of the benthic macro-invertebrate's indicated the dominance of arthropods in species richness followed by mollusc. *Pachymelania aurita* was the dominant mollusc. Among the arthropods aquatic butterfly (Lepidoptera), and Ephemeroptera, which include the *Acraea* species and *Centroptilum* species, occurred in all stations. Gaufin (1973) reported that most aquatic beetles can renew their oxygen supply directly from the atmosphere, they are thus unaffected by oxygen depleting wastes while others possess special adaptations for obtaining oxygen (Marques *et al.*, 2003). All the benthic macro-invertebrates reported in this study belong to the tolerant classes in water bodies, which indicate organic pollution. However, these groups did not show the expected pattern of opportunistic population, that is, few species and large number of individuals (Ogbeibu, 2001; Marques, 2003). This suggests that there may be other factors, which caused oxygen depletion such as oxidation of iron, accumulation of sediment or inorganic fertilizer from irrigation run-offs. Few species of Odonata, Plecoptera and Zygoptera which are fauna associated with clean water quality were recovered only after rainfall in the last month (March) of this research. This could be due to dilution during the rains, which caused some improvement in the water quality. Stonefly, though low in number, was the only sensitive class present during the dry season. Since most species of stoneflies are clean water species (Gaufin, 1973), it is possible that this species occupied in a niche where the oxygen concentration was higher than values recorded for the stream. The absence of Plecoptera especially at Station 1 and 2 can be traced to increase in farming activities around that region. The use of fertilizers increases the amount of nutrients entering the water and this may lead to a corresponding increase in ammonia, nitrate-nitrogen levels and a reduction in dissolved oxygen (Yakub, 1998). The presence of gastropods can be traced to their tolerance to some levels of pollution. This explains why only *Bulinus globosus* was found in Station 2 and 3 respectively. Victor and Onomivbori (1996) documented some species as opportunistic fauna with high reproductive rates, short life span, high dispensability and reduced long-term competitive abilities occupying disturbed habitats. This was especially true for *Gerris* species which was only found in Station 1 and 3. Oben, (2000) and Tyokumbur *et al*, (2002) did not record this organisms. It is possible that *Gerris* species was transported by water current from their original source and being tolerant to the alkaline and anoxic condition of the sample site may proliferate at the expense of resident taxa. According to Chaphekar (1991), each organism within an ecosystem has the ability to report on the health of its environment. Bioindicators are used to detect changes in the natural environment, monitor for the presence of pollution and its effect on the ecosystem in which the organism lives, monitor the progress of environmental cleanup and test substances like drinking water, for the presence of contaminants The most important reasons for using bioindicators are the direct determination of biological effects, the determination of synergetic and antagonistic effects of multiple pollutants on an organism, the early recognition of pollutant damage to the organisms as well as toxic dangers to humans and relatively low cost compared to technical measuring methods (Adams *et al*, 2005). The relatively lower taxa observed in station 1 and 2 could be attributed to the resultant effect of continuous dredging activities at this station and lack of vegetation cover which is the primary source of allochthonous material that may be used as food by the benthos. Hence, anthropogenic activities such as dredging results in substratum instability and increased siltation. Suspended silt has the ability of reducing light penetration and primary productivity and can clog the gills of aquatic fauna thereby smothering them (Edokpayi and Nkwoji, 2007). The class Gastropoda recorded the largest number of individuals for the period of study. *Pachymelania aurita* was the species that has the highest number. It was however not found in the polluted sites. All the *P. aurita* collected were concentrated at the relatively unimpacted station 3. Brown and Oyenekan (1998) had identified *Pachymelania aurita* and *Bolinus globosus* as pollution sensitive species. Results are consistent with the importance of the physical and chemical characteristics for community composition.

CONCLUSION

The health of the water environment could easily be assessed by the abundance, distribution and diversity of the benthic macroinvertebrates. When a water body is negatively impacted, environmental degradation and biodiversity loss also occur. Some organisms are indicators of pollution and hence, the health of the environment. Such organisms are called bioindicators. Some of them are tolerant to pollution while others are sensitive to it. The presence or absence of such organisms is a measure of the health of that environment. This is the crux of this study. In this study, some organisms which are termed opportunistic and are tolerant to organic pollutant such as sawmill wastes and agrochemicals, have been identified. These organisms were found to be relatively abundant in the polluted sites which are stations 1, 2 and 3. They include the Lepidoptera, *Acraea* species, Arachnida, *Araneae* species and the gastropod, *Pachymelania aurita*.

REFERENCES

Adams, S. M., Giessy, J. P., Tremblay, L. A And Eson, C.T. (2005). The use of Biomarkers in ecological risk assessment: Recommendation from Christchurch conference on biomarkers in ecotoxicology. *Biomarkers*, 6, 1-6.

Adekole, A. O And Annune, E. B. (2003). Benthic Macro-invertebrates as Indicators of Environmental Quality of an Urban

Stream, Zaria, Northern Nigeria. *Journal of Aquatic Sciences*, 18 (2), 85-92.

Brown, C. A And Oyenekan, J. A. (1998). Temporal variability in the structure of benthic macro-fauna communities of the Lagos Lagoon and harbour, Nigeria. *Pol. Arch. Hydrobiology*, 45(1), 45-54.

Chaphekar, S. B. (1991). An overview on bio-indicators. *Journal Environmental Biology*, 12,163-168.

Edmunds, J. (1978). *Sea shells and Other Molluscs Found on West African Coast and Estuaries*. Ghana University Press, Accra. Pp.146.

Edokpayi C.A., Okenyi, J.C., Ogbeibu, A. E. And Osimen, E.C. (2000). The effect of Human activities on the macrobenthic Invertebrates of Ibiekuma stream, Ekpoma, Nigeria. *Bioscience Resources and Communication*, 12(1), 79-87.

Edokpayi, C.A. And J.A. Nkwoji, (2007). Annual changes in the physico-chemical and macrobenthic invertebrate characteristics of the Lagos lagoon sewage dump site at Iddo, Southern Nigeria. *Journal of Ecology, Environment and Conservation*, 13, 13-18.

Environmental Protection Agency (EPA) (1998). *Lake and Reservoir Bioassessment and Biocriteria*. *Technical Guidance Document*, 841(B), 98-007.

Gaufin, A. R. (1973). Use of Aquatic Invertebrates in the Assessment of Water Quality. Biological methods for the Assessment of water Quality. *American Society for Testing Materials*, 528, 96-116.

George, A. D. I., Abowei, J. F. N And Daka, E. R. (2009). Benthic Macro-invertebrate Fauna and Physico-chemical Parameters in Okpoka Sediments, Niger Delta, Nigeria. *International Journal of Animal and Veterinary Advance*, 1, 59-65.

Green, H. (2005). W*ood*: Craft and Culture. History Penguin Books, New York, Pp. 403.

Margalef, D. I. (1949). Diversidad De Species en Las Comunidales Naturals. *Publication institute biological application* (Barcelona). 9, 5-27.

Marques, M. J., Martinez –Conde, E. And Rovira, J.V. (2003). Effects of zinc and lead mining on the benthic macroinvertebrate fauna of a fluvial Ecosystem. *Water Air and soil pollution*, 148, 363-388.

Meier, E. (2010). *Wood Allergies and Toxicity*. The Wood Database. Carlos Publisher, New York, Pp. 403.

Oben, B.O. (2000). Limnological Assessment of the Impact of Agricultural and Domestic Effluents in Three Man-made Lakes in Ibadan, Nigeria. PhD Thesis, University of Ibadan, Ibadan, Pp. 176.

Odum, E. P. (1971). *Fundamentals of Ecology*. Third W.B. Saunders Company. Philadelphia, pp. 574.

Ogbeibu, A. E. (2001). Distribution, Density and Diversity of Dipterans in a Temporary pond in Okomu Forest Reservoir, Southern Nigeria. *Journal of Aquatic Science*, 16:43-52.

Ogbeibu, A. E. (2005). *Biostatistics: A Practical Approach to Research Data Handling*. Mindex Publishing Company Ltd. Nigeria, Pp. 153 -162.

Pennak, E. (1978). *A field Guide to African Fresh Water Snails*. West African Species, WHO Snail Identification Centre Danish Bilharziasis Laboratory, Pp. 5-15.

Pielou, E. C. (1966). The Measurement of Diversity in Different Type of Biological Collections. *Journal of Theoretical Biology*, 13,131-144.

Shannon, C. E. And Weiner, W. (1949). *The Mathematical Theory of Communication*. University of Illinois Press-Urbana, Pp. 125.

Tyokumbur, J., Okorie, T. G. And Ugwumba, O. A. (2002). In Limnological Assessment of the Effects of Effluents on Fauna in Awba Stream and Reservoir, Ibadan, Nigeria. *The Zoologist*, 1 (2), 59-69.

Vega, M. M., Fernadez C., Blazquez, T., Tarazona, J. V And Castano, A. (2006). Biological and Chemical Tools in the Toxicological Risk Assessment of Jarama

River Madrid, Spain. *Environmental Pollution*, 93(2), 135-139.

Victor, R And Onomivibori, O. (1996). The Effects of Urban Perturbation on the Benthic Macro-invertebrates of a Southern Nigerian Stream. In Schiemer, F and Boland, K. T. (Eds). *Perspectives in Tropical Limnology*. S.P.B Academic Publishes. Amsterdam, Netherlands, Pp. 223-238.

Yakub, A. S. (1998). Physico-chemical Parameters, Macro-invertebrates and Fish fauna of lower Ogun River at Ishasi-Olofin, Ogun State. Ph.D Thesis, Department of Zoology, University of Ibadan, Ibadan Pp. 162.

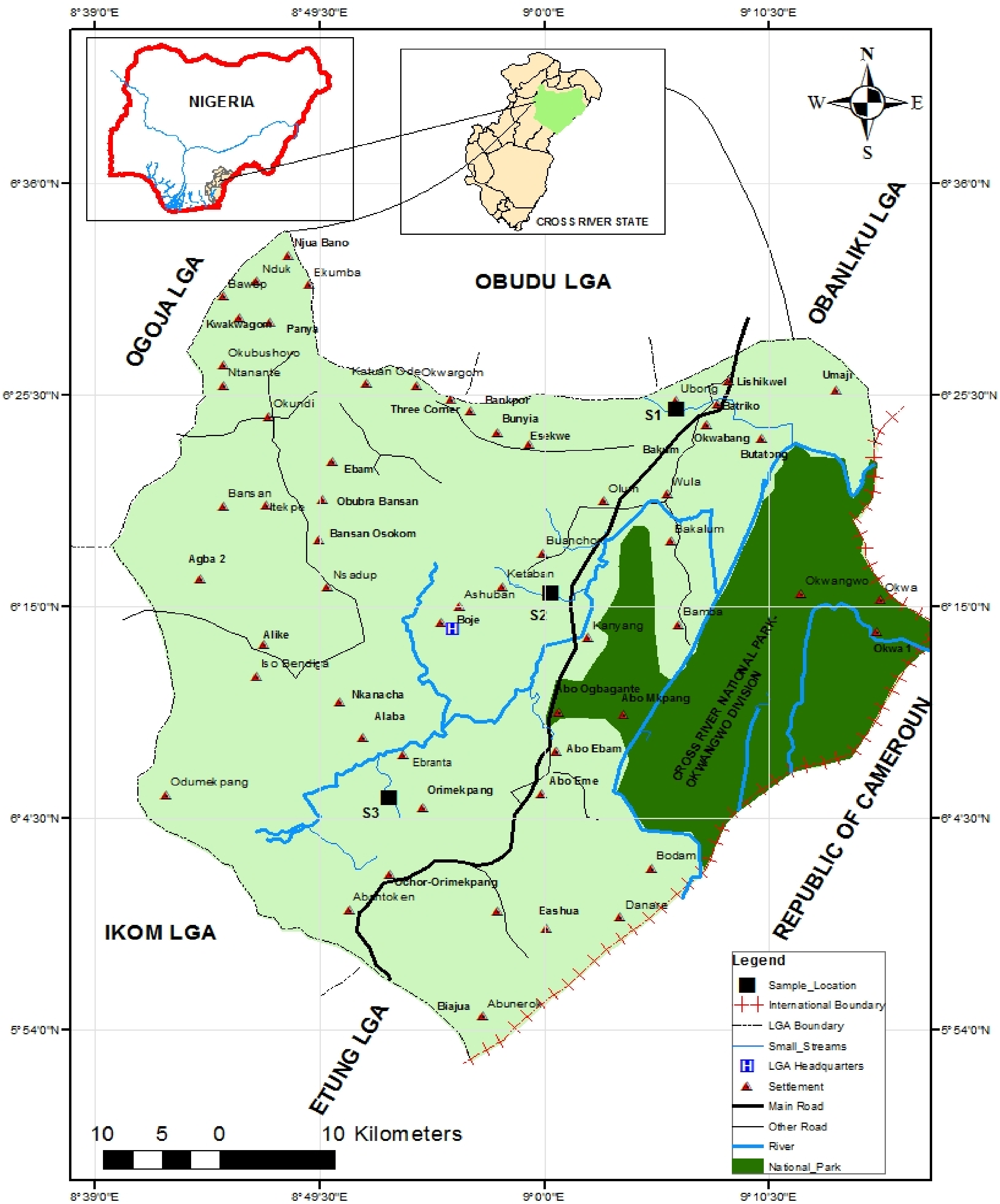

Figure 1: Map of Study Area Showing Sampling Stations (1-3)

Table 1: Composition and Abundance of Benthic macro-invertebrates of Afi River, Southern, Nigeria

Taxanomic	**STATIONS**							
	S1	%	**S2**	%	**S3**	%	**Total**	%
Arthropoda								
Insecta								
Coleoptera								
Dincutus sp.	2.0	6.67	-	-	-	-	2.0	2.44
Hydrophilus sp.	5.0	16.7	1.0	3.85	-	-	6.0	7.32
Stenelnus sp.	1.0	3.33	3.0	11.54	-	-	4.0	4.88
Hemiptera								
Gerris sp.	10.0	33.3	-	-	1.0	3.85	11.0	13.41
Hydrometra sp.	2.0	6.67	1.0	3.85	-	-	3.0	3.66
Lepidoptera								
Acraea sp.	6.0	20.0	4.0	15.4	6.0	23.1	16.0	19.51
Ephemeroptera								
Centroptilum sp.	1.0	3.33	1.0	3.85	2.0	7.69	4.0	4.87
Odonata								
Macromia sp.	3.0	10.0	1.0	3.85	-	-	4.0	4.87
Plecoptera								
Sialis sp.	-	-			2.0	7.69	2.0	2.44
Zygoptera								
Enallagma sp.	-	-			2.0	7.69	2.0	2.44
Arachnida								
Araneae sp.	-	-	2.0	7.69	3.0	11.54	5.0	6.09
Mollusca								
Gastropods								
Bolinus globosus	-	-	7	26.9	1.0	3.85	8.0	9.76
Pachymelania aurita	-	-	6	23.1	9.0	34.6	15.0	18.3
Number of species	8.0	100	9.0	100	8.0	100	13.0	100
Total Number of Individual	30	36.6	26.0	31.7	26.0	31.7	82	100
ANOVA		**F**	**FCrit**	**P-value**	**Inference**			
		90.35	7.71	0.007	P<0.05 (S)			

S1 = Bakun, S2 = Katabang, S3 = Orimekpang

Table 2: Diversity indices of benthic macro-invertebrates in different sampling stations of the Afi River, Nigeria.

	Stations					
Biotic Indices	**S1**	**S2**	**S3**	**F-Values**	***P*-Probability**	**Total**
Margalef's Index (d)	2.058	2.462	2.154	0.145	P>0.05(NS)	2.723
Shannon wieners (H)	0.784	0.837	0.7807	4.312	P>0.05(NS)	0.789
Equitability(E)	0.3770	0.3089	0.355	8.188*	P<0.05(S)	0.308

* Indicates significant difference at a probability level of 5%, S = significant, NS = Not significant
S1 = Bakun, S2 = Katabang, S3 = Orimekpang

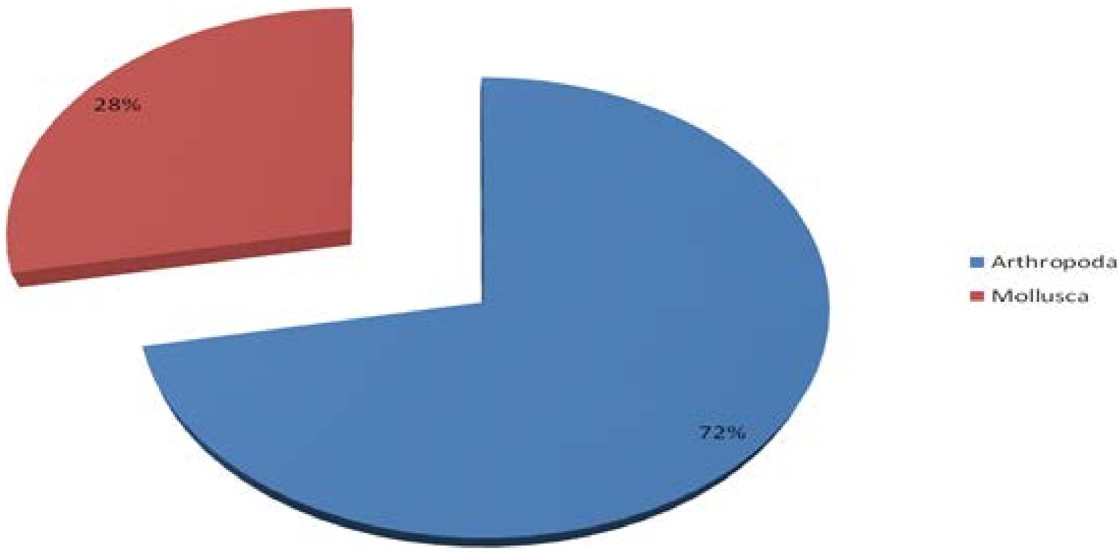

Figure 2: Percentage Composition of benthic macro-invertebrate phyla in Afi River during the Study Period.

****