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SEASONAL ASSEMBLAGE OF MACROBENTHIC INVERTEBRATES OF A SHALLOW TROPICAL EUTROPHIC AFRICAN RESERVOIR

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Abstract

A Seasonal assemblage of macrobenhic invertebrates of a tropical reservoir was carried out for 12 weeks. Three replicates of samples were collected from 3 sites using the kick net sampling technique. The collected macrobenthos were sorted into different taxonomic groups and identified to genus level. Three phyla namely Annelida with 1 class and 2 species, Arthropoda with 1 class and 6 species and Mollusca with 2 classes and 4 species were identified. All the 12 taxa were recorded in station 1 which is a riverine, unpolluted and devoid of human activities, while 9 and 10 taxa were recorded in stations 2 and 3 respectively. A total of 718 individuals comprising 32 gastropods, 423 bivalves, 39 oligochaetes, and 224 insects and larvae were sampled. The phylum mollusca with 455 individuals constituted 61.97%, arthropoda with 224 individuals 31.19% and annelid with 39 individuals 5.43%. The class bivalvia was dominant with 423 individuals constituting 58.9%, while class oligochaete was least with 39 individuals. There was significant difference ($P<0.05$) in the abundance of the macrobenthos among the stations and the weeks. The abundance of species in the stations is Station 1 > 2 > 3. The macrobenthic assemblage was linked to the organic loadings coming from the allochtonous inputs, low water level and high transparency at the period of sampling. Macrobenthic species of interest in the reservoir include *Aspatharia* which is a source of food (protein) to the people, *Bulinus* and *Biomphalaria* which are intermediate host of schistosomiasis, *Chironmous* larvae which are indicator of pollution. Based on the macrobenthic assemblages of the reservoir, the ecological status of the reservoir could be classified as excellent and its productivity high. The incidence of pollution as observed by the macrobenthic species in station 1 could be addressed by adopting best management practices (BMP) for the reservoir.

Keywords: Macrobenthic, assemblages, bivalvia, taxa, oligochaete, annelid, insecta.

1. INTRODUCTION

Oyun reservoir is located in the tropics and has been shown to be shallow, eutrophic, and undergoing cultural eutrophication as a result of seasonal anthropogenic activities on its watershed (Mustapha 2008; 2009). Macrobenthic invertebrates in lakes and reservoirs are important constituents of aquatic food webs and could be used for assessing ecological integrity of aquatic ecosystems.

The assessment of the reservoir macrobenthic invertebrate assemblages could serve as a bio monitor species in the determination and management of the reservoir's ecological status, water quality, and eutrophication challenges. The sedentary nature and ability to bio accumulate deleterious limnological conditions in reservoirs over time by macrobenthic invertebrates (even better than most other aquatic fauna) could be a useful index in assessing many important ecological problems facing reservoirs. Therefore, assessment of macrobenthic assemblages will help in studying short and long-term changes in reservoirs representing potential discriminators between natural and man-induced disturbances (Schirosi et al. 2010). Macrobenthic diversity, richness and abundance could be used in determining the productivity, ecological status of a reservoir as well as medical and health implications of using such reservoir.

Studies using macrobenthic invertebrate as bio-indicator of anthropogenic impact on aquatic ecosystem have shown general decrease in macrobenthic invertebrate assemblages and reduction in species diversity and richness (Ogbeibu & Victor 1989**)** with a higher ability to tolerate pollution-induced environmental stress than plankton (Rosenberg & Resh 1993).

The macrobenthic invertebrates described in this work are those animals visible to the naked eyes, lager than one millimeter and which lives at the bottom of the reservoir whose maximum depth is less than 10m.

Various aspects of the limnology of the reservoir have been undertaken which include water quality, influence of watershed activities on the water quality and fish assemblages, phytoplankton, zooplankton, fisheries potentials, problems, challenges, and management, conservation of fish species, use of biomanipulation to control eutrophication, seasonal influence of limnological variables on plankton dynamics, threatened fishes, fish fauna and heavy metals concentrations by Mustapha (2008; 2009a; 2009b; 2009c; 2009d; 2009e; 2009f; 2010a; 2010b; 2010c; 2010d; 2011, 2015).

This present study aims to assess the spatial-temporal distribution, composition and abundance of the macrobenthic invertebrates in the

reservoir. The study will provide more ecological information on this important drinking water reservoir in Nigeria from macrobenthic invertebrate assemblages' point of view.

2. METHODS

2.1 Study site description

The reservoir used for this study is Oyun reservoir, located in Offa, Nigeria, (8°30'05" N and 8°15'55" E) (Fig. 1a). The reservoir was created purposely to provide portable drinking water for domestic and industrial uses to an estimated population of about 300,000 people.

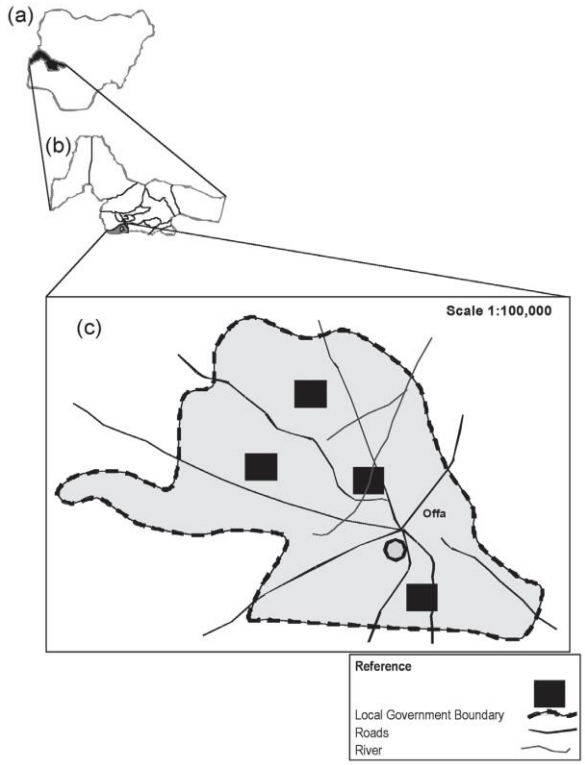

Fig. 1(a). Reservoir location in Offa (c), Kwara State (b), Nigeria (a).

It is a dam reservoir on Oyun River, created in 1964 (expanded in 1983 and 1995 with further expansions proposed) by damming the Oyun River. The reservoir is eutrophic (Mustapha, 2008) with diverse species of littoral plant occupying the shoreline length. Subsistence and commercial fishing activities is also carried out on the reservoir. The reservoir has a maximum length of 128m, maximum width of 50m and maximum depth of

8.0m, mean depth of 2.6m. The surface area is $6.9x10^5m^2$ while the water volume is $3.50x10^6$ m^3. The net storage capacity is $2.9x10^6m^3$. The reservoir is subjected to temporal fluctuations in water volume with high water volume in the rainy season and less water in the dry season due to high evaporation. The water retention time is between 4-5 months in the rainy season (May-October), with an average precipitation between 1 000mm and 1 200m, while the water residence time in the dry season (December-April) is between 1-2 months with average rainfall of about 100mm and 200mm. The morphometric characteristics of the reservoir are listed in Table 1.

Table 1. Morphometric characteristics of Oyun Reservoir, Offa, Nigeria

Elevation (m)	15
Surface area (m^2)	13.4×10^5
Volume (m^3)	3.50×10^6
Mean depth (m)	2.6
Maximum depth (m)	8.0
Mean depth to maximum depth ratio	0.325
Hydraulic residence time (days)	12
Length of Shoreline (km)	10
Shoreline Development	2.43

2.2 Samplings

Weekly samplings of the macrobenthos were done for 12 weeks between January and April 2014 corresponding to the dry season. The samples were collected from 3 sites on the reservoir (Fig. 1b) using the kick net sampling technique (Ausden, 1997, Freshwater Biological Association 2011). The dimensions of net are 1 meter (m) x 1 m attached to 2 poles with the net made of nytex screen of 500 μ mesh size. The samples were collected from an area of nearly 100 m^2 in order to include all possible microhabitats in each sampling site. Three replicates of the samples were taken at each site from the downstream to the upstream (dam site). Site A was at the upstream, B at the middle of the reservoir while C was at the dam site where a lot of human activities such as washing, fish landing etc take place.

The macrobenthos collected from each site were then sorted into different taxonomic groups after which they were placed in a specimen bottle containing 4% formalin. Identification of the macrobenthos to genus level was done with the aid of a compound microscope using identification guides of Pennak (1978), Needham & Needham (1962), Victor & Ogbeibu

(1985). Each identified taxon was counted and the number of individuals recorded per unit station.

2.3 Statistical analysis

The abundances of groups were analyzed using Duncan multiple range test (DMRT) procedure with the mean difference of the macrobenthos compared using two-way analysis of variance (ANOVA) at $P<0.05$ to see the variations due to stations and weeks.

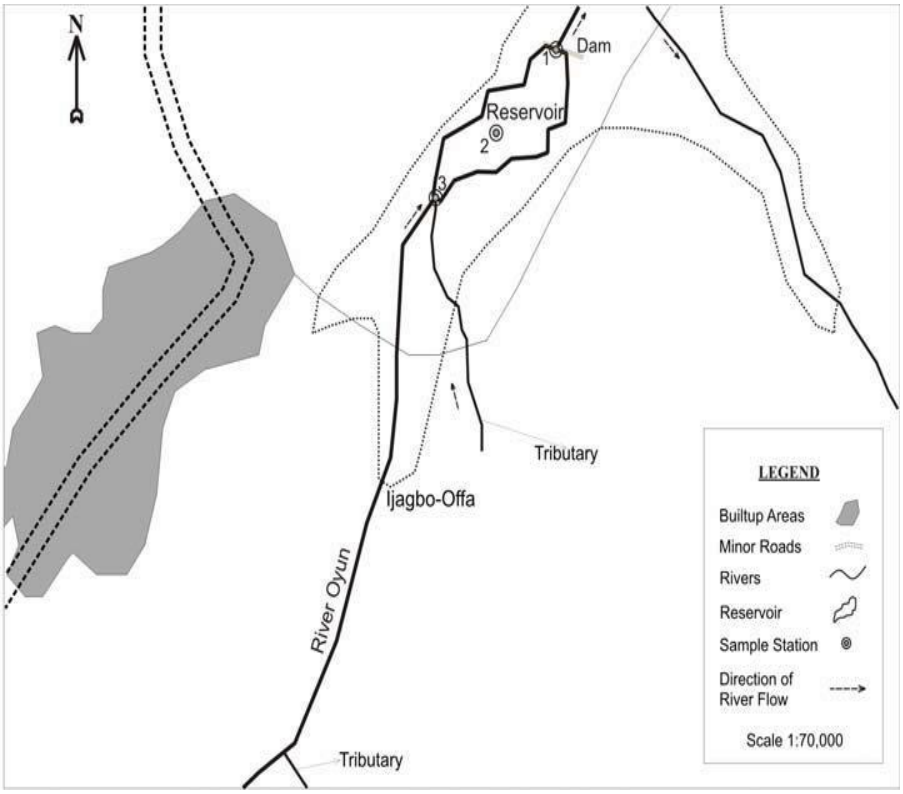

Fig. 1(b). Map of Oyun Reservoir Showing the Sampling Stations.

3. RESULTS AND DISCUSSION

The results of the spatial-temporal distribution and assemblages of the macrobenthic invertebrates of Oyun reservoir Offa, Nigeria is presented in Table 2. Three phyla namely Annelida with 1 class and 2 species, Arthropoda with 1 class and 6 species and Mollusca with 2 classes and 4 species were identified from the reservoir. All the 12 taxa were recorded in

station 1 which is a riverine, unpolluted and devoid of human activities section of the reservoir, while 9 and 10 taxa were recorded in stations 2 (middle) and 3 (dam site) of the reservoir respectively.

Table 2: Spatio-temporal variation in Macro benthic invertebrate's assemblages of Oyun reservoir, Offa, Nigeria for the 3 sites over 12 weeks

TAXA	SITES	1	2	3	4	5	6	7	8	9	10	11	12
Aspatharia	3	7	33	8	10	9	16	10	14	8	4	2	8
Class Bivalvia	2	4	18	5	7	5	11	9	7	4	5	2	1
	1	1	2	4	5	6	7	4	3	5	3	1	3
Unio	3	3	14	10	9	7	11	12	6	5	7	5	5
Class Bivalvia	2	1	4	6	5	4	8	7	4	2	4	2	3
	1	1	1	2	4	5	4	3	2	3	1	1	1
Bulinus	3	-	-	-	1	-	-	-	-	-	-	-	-
Class	2	-	-	1	-	-	-	1	-	-	-	-	-
Gastropoda	1	1	2	1	1	1	-	1	1	-	-	-	-
Biomphalaria	3	-	-	-	-	1	-	-	-	-	-	-	-
Class	2	1	1	-	1	1	-	1	-	-	-	-	-
Gastropoda	1	1	1	2	4	2	1	2	1	1	-	-	-
Tubifex	3	1	1	-	1	1	-	-	-	-	-	-	-
Class	2	1	1	-	1	1	-	-	-	-	-	-	-
Oligochaete	1	2	3	1	2	2	2	1	1	1	1	-	-
Nais	3	2	1	1	2	1	1	1	1	-	-	-	-
Class	2	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaete	1	1	1	-	1	-	1	-	1	-	-	-	-
Lethocerus	3	4	1	1	3	1	-	-	2	1	1	-	-
Class Insecta	2	3	1	1	1	-	1	-	1	-	-	-	-
	1	1	-	1	-	-	-	-		-	-	-	-
Nepa	3	1	-	-	1	1	2	-	-	-	-	-	-
Class Insecta	2	-	-	-	-	-	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-	-	-	-	-	-
Ranatra	3	1	1	-	-	-	-	1	-	-	-	-	-
Class Insecta	2	-	-	-	-	-	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-	-	-	-	-	-
Dysticus	3	2	3	1	1	1	2	-	1	1	1	-	-
larvae	2	1	1	-	1	-	1	1	1	-	-	-	-
Class Insecta	1	1	1	-	-	-	-	-	-	-	-	-	-
Aeshna larvae	3	5	6	8	7	3	3	2	1	2	1	1	2
Class Insecta	2	2	1	3	3	2	1	-	1	-	1	-	1
	1	2	1	1	2	1	-	-	-	-	-	-	-
Chironomous	3	2	3	3	2	1	1	1	1	1	1	-	-
larvae	2	3	5	4	3	2	2	2	1	1	1	-	-
Class Insecta	1	12	18	10	6	5	4	2	2	3	2	2	2

A total of 718 individuals of the macrobenthos comprising 32 gastropods, 423 bivalves, 39 oligochaetes, and 224 insects and their larvae were recorded in the reservoir for the 12 weeks sampling period.

The phylum mollusca with 455 individuals constituted 61.97%, arthropoda with 224 individuals 31.19% and annelid with 39 individuals 5.43% of the macrobenthic assemblages in the reservoir. The class bivalvia was the dominant class with 423 individuals constituting 58.9% of the benthic population, while class oligochaeta was the least with 39 individuals (Table 3).

Table 3: Abundance and percentage composition of macrobenthic taxa in Oyun reservoir,Offa, Nigeria in 3 sites over 12 weeks

Taxa	Phylum	Class	Station 1	Station 2	Station 3	Total	% composition
Aspatharia	Mollusca	Bivalvia	129	78	44	251	34.96
Unio	Mollusca	Bivalvia	94	50	28	172	23.96
Bulinus	Mollusca	Gastropoda	1	2	8	11	1.53
Biomphalaria	Mollusca	Gastropoda	1	5	15	21	2.92
Tubifex	Annelida	Oligochaeta	4	4	16	24	3.35
Nais	Annelida	Oligochaeta	10	-	5	15	2.08
Lethocerus	Arthropoda	Insecta	14	8	2	24	3.35
Nepa	Arthropoda	Insecta	5	-	-	5	0.69
Ranatra	Arthropoda	Insecta	3	-	-	3	0.42
Dysticus	Arthropoda	Insecta	13	6	2	21	2.93
Aeshna	Arthropoda	Insecta	41	15	7	63	8.77
Chironomous larvae	Arthropoda	Insecta	16	24	68	108	15.04
Total			331	192	195	718	100

There was significant difference ($P<0.05$) in the abundance of the macrobenthos among the stations and the weeks. The abundance of the species in the stations followed the trend, Station 1 > 2 > 3, while there were more species recorded during the first 10 weeks (dry season), and decline observed from 12 weeks corresponding to the beginning of the rains.

Species found in station 1 were those whose habitat is muddy and riverine, station 3 recorded species that live in low oxygen condition and organic rich environment, while station 2 species were cosmopolitan in nature.

The assemblages, of the macrobenthic invertebrates in the reservoir could be linked to the organic loadings coming from the allochtonous inputs into the reservoir. The organic content found in the reservoir offered an excellent ecological niche to the macrobenthos. Also the low water level and high transparency at the period of sampling corresponding to the dry season provided a good opportunity for foraging by the macrobenthos and hence

their assemblages. This could be seen in the high abundance, species diversity and richness of the macrobenthos in the first 10 weeks which corresponds to the peak of the dry season and subsequent decrease in the abundance, species diversity and richness of the macrobenthos at the beginning of the rainy season corresponding to the 11^{th} and 12^{th} weeks respectively. Rain-induced instability of the substratum could be responsible for the low abundance at the 11^{th} and 12^{th} weeks. This observation has been reported by Atobatele & Ugumba (2010).

High numbers of the macrobenthos were found to be from the upstream of the reservoir (station 1) to the downstream (station 3), with all the species represented in station 1. This scenario paints a picture of the effects of human activities and other anthropogenc inputs on the assemblages of the macrobenthos in the stations. This could be seen in the high numbers of *Chironomous* larvae and *Tubifex* (species tolerant to low oxygen) in station 3 and the decline in the numbers of taxa from station 1 to 3. This showed that most of the macrobenthic invertebrates are intolerant of anthropogenic loads. As reported by Ogbeibu & Victor (1989**),** using macrobenthic invertebrate as bio-indicator of anthropogenic impact on aquatic ecosystem have shown general decrease in their assemblages and reduction in species diversity and richness. The presence of heavy metals or toxic compounds could have also influenced the macrobenthic assemblages in the reservoir.

The high number of Bivalves especially *Aspatharia* is related to its preference to living buried in the mud which is the characteristics of station 1. The species is a rich source of protein to the people and thus its abundance is a blessing to the users of the reservoir. Another macrobenthos species of medical importance in the reservoir are *Bulinus* and *Biomphalaria*. The two species are known to be intermediate host of schistosomiasis. Their numbers in the reservoir could not be said to be high to the extent of posing health risk of schistosomiasis to the users of the reservoir, but, there is the need to monitor their abundance periodically to check their assemblages. Their abundance in station 3 showed their preference for slow running to stagnant water which is the characteristics of the station.

Majority of the insects and their larvae were found in station 1 which is a lotic environment. Akindele & Malaki (2001) have reported the preference of lotic environments by benthic macroinvertebrates. The high number of the class is related to the velocity and high amount of dissolved oxygen in the station. The absence of these insects in station 3 was linked to their sensitivity to polluted environment. Most of the species recorded in the

station and in the reservoir have also been observed by Andem et al. (2012), Akindele & Liadi (2014), Avoaja et al. (2007), in other Nigerian reservoirs.

The dominance of *Tubifex* among the oligochaeta and *Chironomous* larvae among the insecta was a result of the high organic detritus and hypoxic conditions in the reservoir. Similar findings have been reported by Callisto (2005) and Manoharan et al. (2006).

Based on the macrobenthic assemblages of the reservoir, the ecological status of the reservoir could be classified as excellent and its productivity high. The influence of watershed activities that is contributing to the high number and diversity of chironomid and oligochaete worms which are indicators of pollution in the reservoir could be addressed by adopting best management practices (BMP) for the reservoir.

4. CONCLUSIONS

This study showed that highest composition and abundance of macrobenthic in the reservoir is at the upstream and the lowest downstream where there is a lot organic loadings coming from influence of human activities. This is reflected in the type of macrobenthic found in these sites. The types of substrate in which the macrobenthos live also play a major role in their assemblages. There is the need for continuous seasonal survey and monitoring of the macrobenthic assemblages of the reservoir in order to provide more information over time on the ecological status, biotic integrity, as well as medical and health implications of the macrobenthic species inhabiting the reservoir.

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