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Composition and abundance of macro-benthic invertebrates in Owena reservoir, Ondo State, Nigeria

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Abstract: Owena reservoir was established for the supply of portable water, fisheries exploitation, irrigation of agricultural lands and hydro-electricity. These activities subject the reservoir to environmental degradation which will reflect on the quality of water, sediment and organisms. This necessitates the study since abundance, diversity, biomass and composition of the benthic invertebrates can be used as indicators of changing environmental conditions. Hence, on monthly basis (February–April, 2013), macro-benthic invertebrates were collected from Owena reservoir using Van veen grab. Also, some physico-chemical parameters were determined. Five species of macro-benthic invertebrates were recorded, which include *Chironomus* larva (24), *Melanoides tuberculata* (80), *Physa waterlotti* (6), *Bulinus globussus* (12) and *Lynmea natalensis* (6) belonging to two phyla; Arthropoda and Mollusca. The analysis of the physiochemical parameters showed that a negative relationship exists between temperature and dissolved oxygen (r^2=-0.911). Also, *Melanoides tuberculata* and *Lynmea natalensis* have negative correlation with DO (r^2=-0.836 and r^2=-0.592 respectively) and Nitrate (r^2=-0.896 and r^2=-0.490 respectively). The presence and absence of some macro-benthic invertebrates in the study area is an indication of the impact of human activities on the reservoir; thereby requires a good management program in order to keep the relevance of the reservoir in its use for domestic purposes.

Keywords: Macrobenthic Invertebrates, Owena Reservoir, *Melanoides tuberculata*

Introduction

The freshwater ecosystems serve as home to various organisms including macro-benthic invertebrates; they play different ecological roles in nutrient recycling and food web. Macro-benthos is organisms that live at the bottom of a water column and are visible to the naked eye. Examples are crustaceans, mollusks, polychaetes, and arthropods. They live in all types of freshwater substrates from soft mud to rocky bottoms.

Macro-benthic invertebrates have well known sensitivity and quick responses to environmental degradation. These organisms act as biological indicators (Varsh, 2013); they help maintain the health of water ecosystem by eating bacteria and decaying plants and animals (Orth *et al.,* 1982).

Macrobenthic invertebrates are often used for sediment quality assessment both in marine and freshwater environment; their abundance and diversity depict the changing environmental condition. The presence or absence of macro-benthic invertebrates has been used as good indicator of both periodic and persistent impact of anthropogenic influences to river condition and other aquatic environment.

Different groups of macro invertebrates have different tolerances to pollution, which means they can serve as useful indicators of water quality. These organisms are differently sensitive to fluctuations of many biotic and abiotic factors. Such organisms have specific requirements in terms of physical and chemical conditions. Consequently, the changes in the macro-benthic invertebrates' community structure have been commonly used as an indicator of the condition of an aquatic system (Armitage *et al.,* 1983). Changes in the presence or absence, numbers, morphology, physiology or behaviour of these organisms can indicate that the physico-chemical conditions of the water are beyond their preferred units (Kenney *et al.,* 2009).

Like any other ecosystems in the world, there is decline in the resources due to human activities in which the reservoir has been subjected to since inception and this will cause serious threats to biodiversity of the reservoir if not properly managed. In view of this, the study will assess the diversity, composition and abundance of macro-benthic invertebrates in the reservoir. The research output will serve as baseline data that will help the authorities know the possible effects of current human activities and encourage them to come up with measures to

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help conserve and preserve the environment, as well as the different species present.

Materials and Methods

The Study Area

Owena reservoir is constructed along Owena River in 1966. The river is a major river which is located in the suburb of Owena town in Ifedore Local Government Area of Ondo-State. It is located between latitude 70 15`N, longitude 50 5`E and latitude 70 4`N, longitude 40 47`E in Western Nigeria (Fig. 1). The reservoir was designed by the State Government but was taken over by the Federal Government of Nigeria through the Benin-Owena River Basin Authority, wherewith it was reviewed in its design to include apart from the supply of portable water, fisheries exploitation, irrigation of agricultural lands and hydro-electric power generation. The reservoir is about 300m long and 9m in its deepest part, and it impounds about 36.25 million cm^3 gross capacity of freshwater, covering an area of approximately 7.38 km^2 at the normal water level.

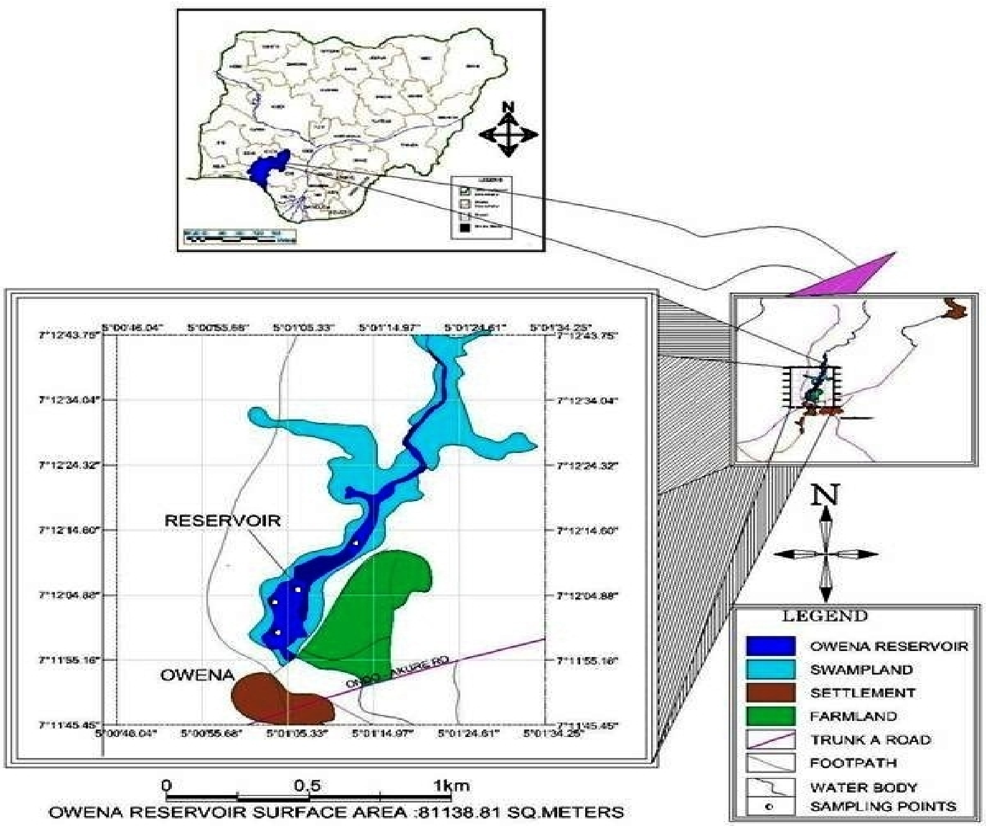

Fig. 1: Map of Owena reservoir.

Sample Collection

Sediment samples were collected over a period of three months; February-April, 2014. Samples were collected randomly in triplicate from the study area using Van veen grab of 0.6 m^2 which was lowered into the bottom of the reservoir by the aid of strong ropes attached to it, on the top of a canoe. On board, the grab was opened above a plastic bucket and the sample was gently removed. The surface characteristic of the samples were examined before sieving (Davide and Marco, 2010).

Each bottom soil sample was diluted in a considerable amount of water, and then sieved (0.5mm mesh size) in order to remove fine particle and extraneous matter. The sieved materials were fixed in labeled plastic container containing 10% formalin solution about three times the quantity of sample. This was later transported to the laboratory of the department of Fisheries and Aquaculture Technology, Akure, Nigeria where it was kept for two days before sorting. The sorting of the organisms was done by picking each organisms and placing it in different containers according to their taxonomic groups (Davide and Marco, 2010).

Each of the organisms was examined using a microscope and identification was done to species level based on their external morphology using the identification keys prepared by IOWATER (2005) and Kohl (2005). Numerical abundance of each macro-benthic invertebrate was done by individual counting and the species percentage occurrence was calculated. Species diversity and richness of the benthic macro-invertebrates were determined using the Shannon Weiner's index of species diversity (H), Evenness (E_H) and Dominance (D) of species.

The physico-chemical parameters such as temperature (°C), Dissolved oxygen (DO) and Nitrate (NO_3) was measured in-situ. Mercury-in-glass thermometer inserted in water at a depth of 10cm and left for 3 minutes was used to measure the water temperature. The dissolved oxygen was measured using a digital YSI 550D meter and the nitrate values were obtained using Hanna multi-parameter model number Hi9828.

Statistical Analysis

The values of the water parameters were subjected to analysis of variance (ANOVA), correlations, mean and standard deviation.

Result

Species composition and relative

A total of 128 macro-benthic invertebrates belonging to 5 species were found in Owena reservoir as shown in Table 1. These organisms belong to two phyla; Arthropoda and Mullusca with four (4) indentified species belong to mollusca and one (1) species belongs to arthropoda. The monthly distribution revealed that the highest abundance of the macro-benthic invertebrates occur in February (53), then March (39) with the least in April (36) however, the most abundance species throughout the study period is *Melanoides tuberculata* (80).

Tab. 1: Species composition and Relative abundance of Macro-benthic invertebrates.

S/N	Phylum	Class	Family	Species	Months			Total
					February	March	April	
1	Arthropoda	Insecta	Chironomidae	*Chironomus* larvae	10	6	8	24
2	Mollusca	Gastropoda	Thiandae	*Melanoides tuberculata*	32	27	21	80
3	Mollusca	Gastropoda	Physidae	*Physa waterlotti*	3	1	2	6
4	Mollusca	Gastropoda	Planorbidae	*Bulinus globossus*	7	1	4	12
5	Mollusca	Gastropoda	Lymnaeidae	*Lymnea natalensis*	1	4	1	6
				Total	53	39	36	

The percentage composition of macro-benthic invertebrates collected from the reservoir showed 62% were *Melanoides tuberculata*, 19% were *Chironomus* larva, 5% were *Lymnea natalensis*, 9% were *Bulinus globossus* while 5% were *Physa waterlotti*. Also, the soil composition examination revealed that the reservoir had 70% sand, clay – 22% and silt -8%

Species diversity, evenness and dominance

The result of species diversity, Evenness and Dominance obtained from the reservoir are shown in Table 2. The Shannon Weiner's diversity index showed that the highest value was recorded in April (H=1.151), followed by February (H=1.126) with the least index in March (H = 0.965). Also, Evenness index highest value was recorded in April (E_H =0.717), then February (E_H =0.696) and March with the least index value (E_H=0.601). Similar, the highest value for Dominance index (D =1.116) was recorded in April, followed by March (D=1.092), then February (D=1.008) having the least index value.

Tab. 2: Diversity indices values of macro-benthic invertebrates obtained in Owena Reservoir.

Indices	February	March	April
Shannon-Weiner's Index (H)	1.126	0.965	1.151
Evenness Index (E)	0.696	0.601	0.717
Dominance (D)	1.008	1.092	1.116

Physico-chemical parameters

The temperature of the reservoir during the study period range between 25.98-31.82°C and the pH was between 6.70-7.59. The highest values of temperature and pH were obtained in Feb (31.82±0.11°C and 7.59±0.12 respectively). Also, the Dissolved oxygen values ranged between 6.63-7.89mg/l while the Nitrate value range between 0.34-1.21mg/l. The highest values of dissolved oxygen (7.89±0.38mg/l) and nitrate (1.21±0.57mg/l) was obtained in April as shown in Fig. 2. The correlation analysis showed that temperature exhibit a negative relationship with dissolved oxygen (r^2=-0.911) and nitrate (r^2=0.983). Also, *Melanoides tuberculata* and *Lynmea natalensis* have negative correlation with DO (r^2=-0.836 and r^2=-0.592 respectively) and Nitrate (r^2=-0.896 and r^2=-0.490 respectively).

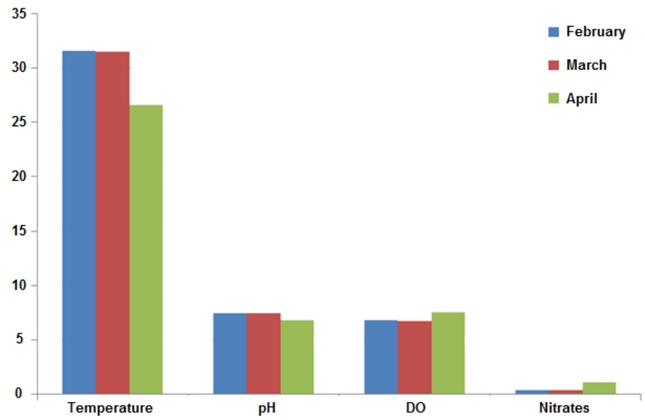

Fig. 2: The physico-chemical parameters of the reservoir during the study period.

Discussion

The macro-benthic invertebrate of Owena reservoir is characterized by low diversity; two phyla (Mollusca and Arthropoda) and five species (*Melanoides tuberculata, Physa waterlotti, Bulinus globossus*, *Lymnaea natalensis* and *Chironomus larvae*) as shown in Table 1. This is common to some water bodies in Nigeria, for example, low diversity was observed by Udebuanan *et al*. (2015) in Okhuo River and Edward and Ugwumba (2011) in Agbe River. In Ikpoba river and Calabar river similar result of low diversity was observed (Edokpayi *et al.,* 2000; Ogbeibu, 2001). They attributed this low diversity to some physico-chemical conditions such as fast flow rate of water, high pH, low dissolved oxygen and low conductivity. These factors can possibly disrupt the life cycle of these organisms, reproductive cycle, food chain and migrations or imposed physiological stress on the macro-invertebrate (Adakole and Annune, 2003). However, in Owena reservoir, the low diversity observed could be as a result of other factors than physico-chemical conditions of the water such as habitat preference, habitat disturbances and food availability as the fishermen regularly clear the waterways of aquatic plants for smooth sailing of their boats. The roots of aquatic plants are known to serve as shelter, direct and indirect food source to macro-benthic invertebrates. Odum (1971) reported that diversity tends to be low in physically controlled systems such as ponds and reservoirs. Also, Lodge (1991) and Newman (1991) stated that Macrobenthic distribution is often affected by the availability of food and shelter rather than the physical and chemical parameters.

The reservoir is further characterized by having Mollusca as the most diverse and abundant macro-benthic invertebrates. This could be as a result of the quality of the environment and the nature of the sediment. According to Victor and Onomivbori (1996), the quality of an aquatic ecosystem depends on environmental factors, which in turn can influence the structuring of aquatic communities. A similar result was obtained by Mustapha and Yakubu (2015) in Oyun reservoir, Nigeria. Furthermore, Asibor (2015) observed mollusca as the dominant macro-benthic invertebrates in Asejire reservoir, Nigeria and Shailendra *et al.,* (2013) recorded similar result in Kunda River, India. Also, Edward and Ugwumba (2011) recorded mollusc as the highest numerical abundant macro-benthic invertebrate in Agbe Reservoir, Nigeria.

The most abundant species of the mollusc present in the reservoir is *Melanoides tuberculata* (Fig. 2) which is known to inhabit stable water bodies such as rivers, dams, streams, lakes and levees with low flow rates. Furthermore, it is known to live in environments with diverse amount of euthrophication and is tolerant to harsh conditions such as low oxygen concentration, high levels of pollutants and periods of drought (Vogler *et al.,* 2012). Other species of mollusc present in the reservoir includes; *Physa waterlotti, Bulinus globossus* and *Lymnaea natalensis.* According to Dillon (2000), *M. tuberculata* can coexist with various snail fauna if there is an opportunity for them to adapt to one another, for instance *M. tuberculata* populations of Africa coexist with *Biomphalaria* as well as *Bulinus spp* and *Lymnaea natalensis.*

Several investigations showed that *M. tuberculata* is most abundant and widely distributed in the freshwater systems of the Western Nigeria and other tropical countries. Edward and Ugwumba (2011) observed that *M. tuberculata* have the highest percentage composition in Agbe reservoir, Nigeria. Also, Andem *et al.,* (2012) observed M. tuberculata as the highest mullusc in Ona River, Nigeria. In the main channel of Lake Nasser, Egypt, M. tuberculata was found to be the second abundant mollusc species (Soad and Hesham, 2014). In addition, authors such as Asibor (2015) and Shailendra *et al* (2013) confirm the presence of the mollusk in Asejire reservoir, Nigeria and Kunda River, India.

The different species of mollusc observed in the reservoir; *Physa waterlotti, Bulinus globossus* and *Lymnaea natalensis* during the study agreed with several works done by other researchers in Nigeria; such as Okpalla (1961), whose work is on *B. globosus* concluded that this species has a wide distribution in the Northern and Western regions of Nigeria while Cowper (1963) observed that *B. globosus* and *L. natalensis,* are among the species of mullusc known to occur in most parts of Nigeria. Owojori (2004) and Aliu (2006) further observed high abundance of *M. tubaculata, B. globosus* and *L. natalensis* in Opa Reservoir and research ponds at Ile-Ife, Nigeria. In addition, high number of *B. pfeifferi*, *B. globosus*, *L. natalensis* and *M. tuberculate were* collected from Orori river, Bareke river, Osun river, Eleyele and Eko-Endo lakes, by Mofolusho and Benson (2015) during their research work on five sites in south-western Nigeria.

Chironomus larvae belonging to the phylum arthropoda was observed to be the second abundant species in the reservoir (Table 1). Chironomus species are capable of surviving in diverse habitats (such as lakes, ponds, rivers, streams, salt marshes and sewage treatment ponds) and conditions (such as tropics to the arctics). Their presence, absence and quantities of various species in a water body is an indication of water pollution. According to Andem *et al.,* (2012) and Sharma and Chowdhary (2011), Chironomus larvae dominated Ona River, Nigeria and River Tawi, India by constituting 59.7% and 71% respectively of the macro-benthic invertebrates recording in the rivers. In addition, Edokpayi and Osimen (2001) and Oscar *et al.,* (2015) reported that the dominant insect species in Ibiekuma and Okhuo rivers, Nigeria is *Chironomus* sp. Also, Mustapha and Yakubu (2015) and Shailendra *et al.,* (2013) recorded the larvae of chironomus in Oyun reservoir, Nigeria, and Kunda river, India.

The diversity indices result showed that April recorded the higher diversity level as shown in Table 2. Diversity has been considered as a measure of community stability whereby low diversity indicates a stressful environment while high diversity reflects a stress free environment. Mclachlam and Mclachlam, 1971, reported that macro-invertebrate benthic fauna's population dynamics in the tropics may occur at any particular period of the year depending on the predominating set of physico-chemical and biological conditions in the ecosystem. Jayne and Joann (1999) further stated that the dynamics in the population of the bottom dwelling benthic macro- invertebrate fauna within sub-habitats in a major habitat varies with variation in environmental factors of the sediments. The observed result showed that Macro-benthic distribution is often affected by the availability of food, shelter as well as the physical and chemical parameters (Fig.3). Asibor (2015) observed that macro-invertebrate benthic faunal population was higher in the dry season than in the rainy season in most of the species (twenty-one species out of the twenty-eight species) identified. This he attributed to be as a result of seasonal variation in the physico-chemical parameters of the sediments.

Temperature is identified to have a direct effect on aquatic organisms and indirect effect through its influence on other environmental factors such as solubility of mineral and gases including oxygen (Idowu *et al.,* 2013). The increase in water temperature likely to decrease the solubility of oxygen in water; hence the result obtained during the study showed a strong negative correlation between temperature and dissolved oxygen (r=-0.856). Also, the life cycles and population densities of many streams organisms are very much dependent on temperature and any alteration of the average stream temperature by a few degrees could alter the flora and fauna of the river (Jackson *et al*, 1989 as cited by Oscar *et al.,*2015). *M. tuberculata* is known to thrive in a temperature range of 18-32^{o}C which is within the temperature range obtained in the reservoir (as shown in Fig. 3). This further explains the higher percentage of mullusc obtained in the reservoir during the period of study. Similar result was obtained by Sarang and Sharma (2009) on their work on Kishore Sagar Lake, Indian having a temperature range of 18-34^{o}C. Also, most abundance macro-benthic invertebrates obtained by them were Chironomus spp and *M. tuberculata*. A positive correlation was obtained between temperature and all the macro-benthic invertebrates identified. Allen (1951) obtained a positive correlation between benthic life and temperature in Horokiwi stream, New Zealand.

The nitrate level (0.34-1.21mg/l) of the reservoir suggests that if not properly managed, there will be an occurrence of euthrophication caused by high level of organic pollution. This agrees with the classification of Zhang and Chang (1994) as cited by Sarang and Sharma (2009) in their study on oligotrophic, mesotrophic and eutrophic lakes. They reported that in oligotrophic lake phosphorus and nitrogen levels were 0.01 and 0.21 mg/l respectively. While in euthrophic lake phosphorus and nitrogen levels were comparatively much higher (0.019 and 1.45 mg/l). This implies that the concentration of nitrate in the reservoir falls in mesotropic categories. Jumppanen (1976) also reported that the first signs of euthrophication and pollution in some Finnish lakes are usually observed in the status of benthic fauna as the suspended wastes immediately sink to the bottom to decompose and thus causing a change in the benthic organisms. Thus, certain macro-benthic invertebrates such as chironomids can tolerate high organic and toxic pollution. The result further showed a negative correlation between all the macro-benthos and nitrate. Chironomids ability to tolerate poor water quality may be due to the presence of haemoglobin pigment that helps them to obtain atmospheric oxygen. Phosphorus and nitrogen are the basic nutrients which are important to determine the productivity of lakes. Nitrate is attributed mainly due to anthropogenic activities such as runoff water from agricultural lands, industrial wastes, discharge of house hold and municipal sewage from the market place and other effluents containing nitrogen (Royer *et al.,* 2004).

The pH of the water in the reservoir was slightly alkaline (6.70-7.59mg/l), this support the growth of the mollusc which requires an alkaline condition for shell formation. The pH values of water within the range of 6.5–9.0 are suitable for most organisms and fish production (Kamran *et al.,* 2003). The pH of water is important because many biological activities can occur only within a narrow range. Thus, any variation beyond acceptable range could be fatal to a particular organism (Soad and Hesham, 2014). Sharma and Chowdhary (2011) on their work on River Tawi, India observed peak of mullusca density during the month of January, which they attributed to soft, organically rich bottom and alkaline nature of the water. Also, the pH values were alkaline in Lake Nasser ranged between 6.84 and 9.01 as obtained by Soad and Hesham (2014). This could be due to increase in photosynthetic activity hence increasing primary productivity (Hammer, 1971).

DO is an important parameter indicating level of water quality and organic pollution in the water body (Wetzel and Likens, 2006). The DO range of 6.63-7.89mg/l obtained in the reservoir revealed that the water could support aquatic organisms. Similarly, Oyhakilome *et al.,* (2012) obtained the dissolved oxygen of 7.2mg/l in the reservoir. Dissolved Oxygen content plays a vital role in supporting aquatic life and is susceptible to slight environment changes (Shailendra *et al.,* 2013). The seasonal variation of DO depends on other parameters such as temperature and organic matters of the water body. It can be observed that there is a slight increase in dissolved oxygen concentration during the month of April. This is also similar to the observation of Idowu *et al.,* (2013) that temperature increases inversely with dissolved oxygen.

Conclusion

The macro-benthic invertebrates observed in the reservoir are pollution tolerant species, which is an indication that there is need for adequate management practices of the reservoir. Though some of the physico-chemical parameters obtained showed that the water is of good quality except for nitrate that revealed that the reservoir is mesoeutrophic. This type of pollution resulted from anthropogenic activities within and around the reservoir.

The few families of macro-benthic invertebrates obtained during the study may be as a result of short period of the study. As sampling continues more broadly in time, we are certain that more families will be discovered. I thereby recommend that a more comprehensive study should be done by the management in order to know the pollution status of the water which serves the inhabitant in various capacities especially for domestic purpose.

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