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Research Article

Abundance and Distribution of Benthic Macro-Invertebrates of Luhu Dam, Michika, Adamawa State, Nigeria

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ABSTRACT

The study uses benthic macroinvertebrates as indicators to assess water quality in the Luhu Mini Dam, Michika, Adamawa State. The study involves the collection of benthic macroinvertebrate samples over six months, utilizing the Van Veen grab method for sampling and preservation in formalin. Upon transportation to the laboratory, the samples were identified and subjected to statistical analysis, including the Shannon and Weiner Index, Margalef's Index, Simpson's diversity Index, and Pielou's Evenness. The study aims to provide fundamental information on the health of the Luhu Mini Dam and to understand the water quality and pollution status, thereby informing necessary management measures. The distribution and diversity of species across three different stations. A total of 462 individuals representing 20 taxa from 3 phyla were collected. Station 1 yielded 16 taxa and 162 individuals, station 2 had 17 taxa and 201 individuals, and station 3 had 17 taxa and 99 individuals. The diversity indices revealed variation in the number of species across stations, with stations 3 and 2 having the highest number of species, while station 1 had the lowest. The general diversity (H') was highest at station 3, followed by stations 1 and 2, whereas station 3 also exhibited the highest Evenness index (E). Moreover, the taxa richness index, as calculated by Margalef's Index (d), peaked at station 3. Simpson's dominance index showed that Station 2 exhibited the highest dominance, followed by Station 1 and Station 3. These findings provide valuable insights into the distribution and diversity of species across different biotopes.

Keywords: Species Richness, Diversity, Water Quality, Physicochemical Parameters, Lakes

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INTRODUCTION

Lakes have been an integral part of natural ecosystems for hundreds of years, but only a select few remain unaffected by human activity (Fabian *et al*., 2023). The sixth objective of the United Nations is centered on ensuring access to clean water and hygiene, which is crucial for achieving the Sustainable Development Goals (SDGs) and transforming our world by 2030which is vital for achieving the Sustainable Development Goals (SDGs) and global transformation by 2030. Water quality plays a pivotal role due to its direct implications on human health, well-being, fish production, and the overall health of aquatic ecosystems. Water quality is influenced by a myriad of factors that have a significant impact on the composition, diversity, production, and physiological well-being of native flora and fauna in aquatic environments (Boyd, 1982).

With only 2.5% of the Earth's water classified as freshwater, there is a growing apprehension regarding the diminishing freshwater resources resulting from pollutants originating from both point and non-point sources. This concern is supported by evidence from Ipinmoroti *et al*. (2018), Jenyo-Oni and Oladele (2016), and Iyiola (2015). Pollution negatively impacts the physical, chemical, and microbial composition of water, making it unsuitable for the survival of fish, livestock, and other organisms. (Rodrigues and Cunha, 2017; Dwivedi and Pandey, 2002). Due to variations in pollutant concentration over time and location, traditional physical and chemical monitoring methods face limitations. Therefore, the use of a biological approach, such as monitoring organisms like benthos for pollution detection, has shown promise (Adeyemo *et al*., 2008). Freshwater macroinvertebrates, which are defined as animals lacking a backbone and commonly inhabitants of sediment or attached to rocks and debris in aquatic systems, play a crucial role in assessing the health of freshwater ecosystems. Bioassessment procedures are rooted in the idea that benthic communities respond either negatively or positively to changes in habitat and water superiority resulting from anthropogenic disturbances, serving as comprehensive indicators of stream health. Bioassessment involves evaluating the condition of a waterbody through biological surveys and direct measurements of the resident biota. Freshwater macroinvertebrates are commonly used due to the simplicity of the equipment required for their sampling and their localized response to stream conditions. These organisms play essential ecological roles in functions such as decomposition, nutrient cycling, and their position in aquatic food webs. Insects often dominate benthic macroinvertebrate communities due to the aquatic nature of the early stages of many terrestrial insects that live in water. While previous studies have utilized macroinvertebrates to assess the impact of specific sources of pollution in aquatic environments, there is a lack of information regarding the use of benthic macroinvertebrates as indices of water quality in the Luhu Mini Dam, Michika, Adamawa State. The present study seeks to deliver ultimate information on the welfare of the Luhu Mini Dam using benthic macroinvertebrates as indicators, to understand water quality and pollution status to inform necessary management measures.

MATERIALS AND METHODS

Area of the Study

The study site is Luhu Dam positioned in Michika LGA of Adamawa state, the dam is situated at precisely latitude 10.61^0 N and latitude 13.38^0 E. Luhu Dam is a man-made for aquaculture, particularly for recharging the fishponds. It covers an appraised area of about 3320sq meters with a rough depth of about 6 meters with its sources from the mountains of Wambirmi and the nearby farmlands.

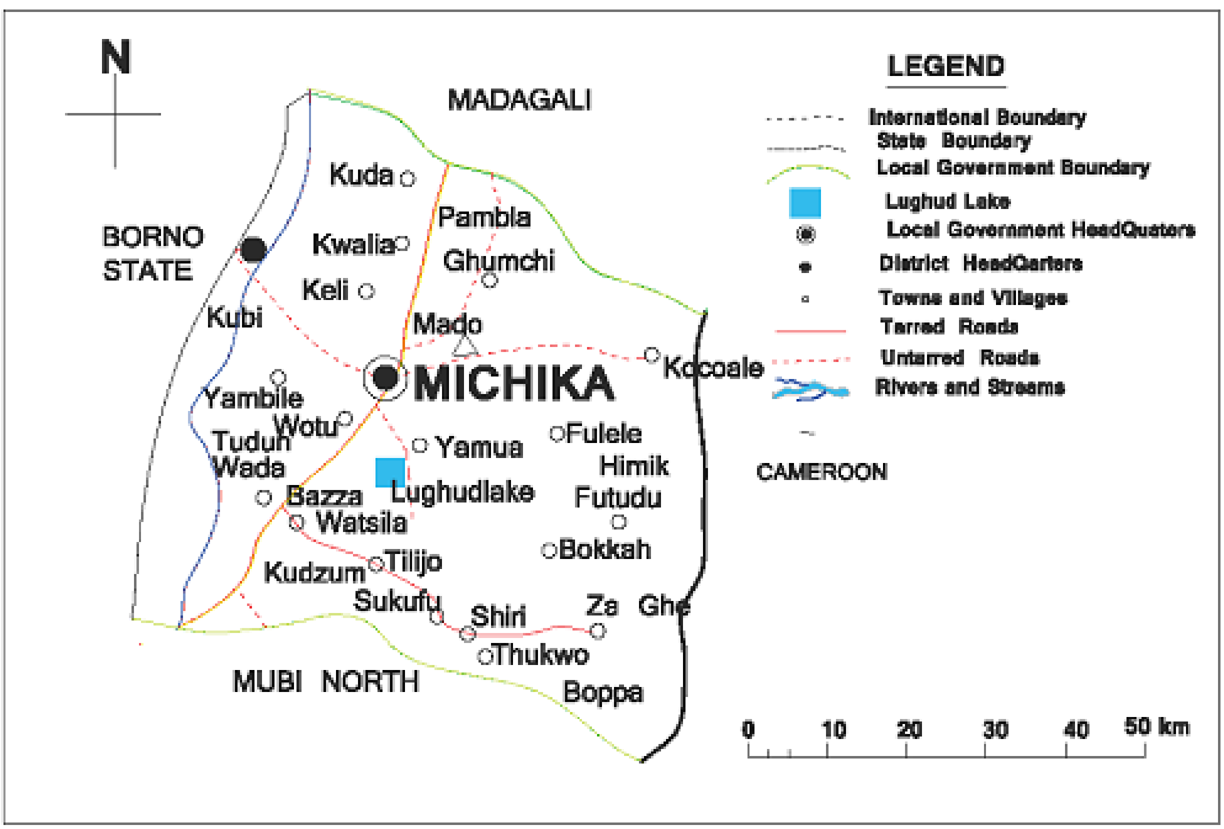

Fig.1 Map of Michika Local Government Area displaying the position of Luhu Mini-Dam

Benthic Macro Invertebrate collection
During the six months from July to January 2020, a fortnightly sampling method of collecting benthic macroinvertebrates using Van Veen's grab, which covers an area of 0.5 m2 was employed, to collect sediment samples from various stations. To preserve the macro-invertebrate samples, the method outlined by Barbou (1999) was followed and and the samples were transported in labeled polythene bags to the laboratory. Once in the lab, each sediment sample was diluted with water, washed thrice, and sieved using mesh sizes of 2 mm, 1 mm, and 0.5 mm. The residues from the sieves were sorted using a Binocular microscope (American Optical Corporation model 570) and preserved using 4 % formalin in labeled small glass containers as described by Barbou (1999). Individual organisms were identified using an Olympus Vanox Research Microscope Model 230485 (Mag. 50-500x) with a combination of techniques.

Data Analysis
Biological indices such as Shannon and Weiner index (H1); Margalef's index (d); Simpson's diversity index (1-D) andPielou's Evenness (J') were used to analyze the data.

Shannon- Weiner diversity Index (H^1) = $-\sum[(ni/N)\times\ln(ni/N)]$. Where: H^1= Diversity index, ni= total number of individuals belonging to ith species. N = total number of individuals for the site, ln= the natural log of the number.

Margalef-value is the measure of species richness. It is expressed as d= S-1/lnN. Where: d= Margalef value, S=number species collected in a sample, N= total number of individuals in the sample.

Pielou's Index: Measures how evenly the species are distributed in a sample community. It is expressed as J= H^1/ Hmax. Where: J= diversity evenness or Equitability index, H^1= calculated Shannon –Weiner diversity index (Shannon- Weiner).

Hmax = lnS. S= total number of species in a population ln= natural log of number.

Simpson dominance Index (D) = $\sum(n/N)^2$. Where: n= the number of species in the ith species N= Total number of individuals

RESULTS
In the three stations studied, the macro benthic invertebrate samples collected from these biotopes were scrutinized to assess the taxa composition, distribution, abundance, diversity, and dominance. The results obtained are used to appraise the water quality of the dam.

Composition, Distribution, Abundance and Dominance of Macro Benthic Invertebrates
The distribution of species, their abundance, and overall composition are detailed in Table 1. In total, 462 individuals across 20 taxa from 3 phyla were collected. Station 1 yielded 16 taxa and 162 individuals, while station 2 had 17 taxa and 201 individuals, and station 3 had 17 taxa and 99 individuals.

The diversity catalogues for different biotopes are presented in Table 2, showing how the sum of species varies across stations. Station 3 and 2 had the highest number of species, each with 17 taxa, while station 1 had the lowest, with 16 taxa. Station 3 was leading in terms of general diversity (H'), followed by stations 1 and 2 respectively. Station 3 also had the highest Evenness index (E), followed by station 1 and then Station 2. The taxa richness index, as calculated by Margalef's Index (d), peaked at station 3 (3.48), followed by station 2 (3.02) and station 1 (2.94). When considering Simpson's dominance index in the three stations, it is evident that station 2 exhibited the highest value at 0.209, followed by station 1 at 0.141, and station 3 with the lowest value of 0.077.

Table 1: Study Stations from Michika Dam showing Abundance and Distribution of Benthic Macro-Invertebrates

Species	Station 1	Station 2	Station 3
PHYLUM ANNELIDA	-	-	-
Class: Oligochaeta	-	-	-
Order Plesiopora	-	-	-
Family: Naididae	-	-	-
Genus: Nais	-	-	-
Species: *Nais sp*	8	5	4
Class:Clitellata	-	-	-
Order: Haplotaxida	-	-	-
Family: Lumbricidae	-	-	-

1Genus: Eiseniella	-	-	-
Species:*Eiseniella tetradra*	6	4	4
PHYLUM ARTHROPODA	-	-	-
Class: Insecta	-	-	-
Order: Trichoptera	-	-	-
Family: Hydroptiloidea	-	-	-
Genus: Agraylea	-	-	-
Species: *Agraylea Sp.*	0	13	4
Family: Siphlonuridae	-	-	-
Genus: Siphlonurus	-	-	-
Species: *Siphlonura Sp.*	1	2	3
Family: Baetidae	-	-	-
Genus: Cloeon	-	-	-
Species: *Cloeon simplex*	5	2	2
Genus: Baetis	-	-	-
Species: *Baetis sp*	8	4	0
Family: Hydrophilidae	-	-	-
Genus: Philhydrus	-	-	-
Species: *P. pectoralis*	4	16	5
Family: Dytiscidae	-	-	-
Genus: Dytiscus	-	-	-
Species: *Dytiscus vertifolis*	6	0	1
Family: Elmidae	-	-	-
Genus: Dubiraphia	-	-	-
Species: *Dubiraphia sp.*	0	29	9
Order: Diptera	-	-	-
Family: Chironomidae	-	-	-
Genus: Ablabesmyla	-	-	-
Species: *Ablabesmyla sp*	9	0	9
Genus: Chironomus	-	-	-
Species: *C. fractilobus*	29	10	9
Genus: Pentaneura	-	-	-
Species: *Pentaneura sp*	49	82	15
Genus: Cardiocladius	-	-	-
Species: *Cardiocladius Sp.*	0	2	1
Genus: Tendipes	-	-	-
Species: *Tendipes tentans*	4	1	0
Family: Culicidae	-	-	-
Genus: Culex	-	-	-
Species: *Culex Sp.*	10	12	5
Order: Odonata	-	-	-
Suborder Anisoptera	-	-	-
Family: Corbuliidae	-	-	-

Genus: Oxygaster	-	-	-
Species: *Oxygaster curtisil*	5	3	1
Family: Aeshnidae	-	-	-
Genus: Aeshna	-	-	-
Species: *Aeshna sp*	4	1	0
Suborder: Zygoptera	-	-	-
Family: Lestidae	-	-	-
Genus: Lestes	-	-	-
Species: *Lestes sp*	10	0	6
Family: Coenagrionidae	-	-	-
Genus: Enallagma	-	-	-
Species: *Enallagma sp.*	4	8	9
Phylum: Mollusca	-	-	-
Class: Gastropoda	-	-	-
Order: Mesogastropoda	-	-	-
Family: Pomatiopsidae	-	-	-
species: *O. hupensis*	0	7	12
TOTAL	162	201	99

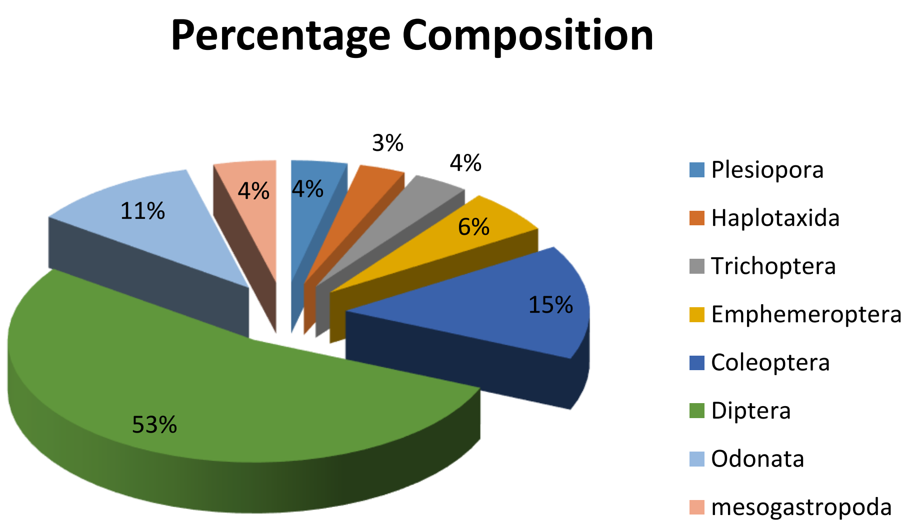

Fig. 2: Composition of Macro-Benthic Invertebrates of Michika Dam at the Order Level

Table 2: Diversity Indices

	Stations		
	1	2	3
Taxa	16	17	17
Number of individuals	162	201	99
Margalef's Index	2.94	3.02	3.48
General diversity	2.32	2.09	2.59
Evenness	0.84	0.74	0.91
Dominance	0.141	0.209	0.077

Table 3: Biotic Catalogues for Assessment of the Water Quality in the three Stations

Stations	Simple biotic index	Ephemeroptera index	Trichoptera index
1	Good (20)	Good (14)	Poor (0)
2	Excellent (23)	Good (8)	Good (13)
3	Go/od (19)	Good (5)	Moderate (4)

DISCUSSION

The composition, abundance, and distribution of macro invertebrates in an aquatic environment are inclined by various factors, such as the physical and biochemical as well as geomorphic characteristics of the ecosystem. Among the dominant taxa—Emphemeptera, Odonata, Coleoptera, and Diptera—Diptera was the most prevalent. Dipterans were found to be the most dominant taxon in terms of both the number of individuals and species, as reported by Townsend (1983), Sharma *et al*. (1993), Ogbeibu and Oribhabor (2002), and Babasolo and Emmanuel (2019). The dominance of dipterans in Luhu Dam and other aquatic ecosystems can be ascribed to their morphological and physiological adaptations to numerous habitats, food availability, and sustained reproduction, as noted by Mbah and Vijime (1989) and Babasolo and Emmanuel (2019). Chironomid larvae are known to dominate aquatic benthic invertebrate communities due to their minimal habitat restrictions, and they have been observed to replace other invertebrate taxa in streams disturbed by anthropogenic activity, as stated by Victor and Ogbeibu (1985). Chironomids were found in all the sampling stations. The principal taxa of dipterans in this study, including *Ablabesmla*, *C. fractilobus*, and *Pentaneura*, have previously been documented in inland water bodies in Nigeria (Ogbeibu, 2001)

The distribution and abundance of the dipterans were influenced by the diverse ecological needs of individual taxa. *Pentaneura sp*. was more commonly found in station 2. Their presence or absence appears to be determined primarily by a preference for high oxygen and shallow water, rather than the type of substratum (Ogbeibu, 2001). Petr (1972) predominantly found them in the well-oxygenated shallow zone of Lake Volta and attributed their high numbers to the presence of ample food supply, rather than a suitable substratum or oxygen concentration. The larvae of *Pentaneura spp*. are hunters commonly located in areas such as the roots of aquatic plants, which provide an abundance of prey organisms including oligochaetes and other chironomid larvae (McLachlan 1969). Their high concentration at stations 2 and 1 confirms the statement above. The study includes a significant representation of both Anisoptera and Zygoptera in terms of abundance and taxa richness. *O. curtilis* and *Lestes sp* are the primary Odonata taxa encountered in this study. When comparing all the taxa obtained with other research by Ekelemu *et al*. (1999), the only species in common is *Enallagma* sp. The biotope was well-populated by annelids; *Eiseniella tetrahedral* and *Nais spp* are the main annelid taxa encountered.

The overall diversity of a community is influenced by various spatial and temporal changes, as noted by Ogbeibu and Oribhabor in 2002. The Shannon-Wiener index being a valuable tool for understanding the distribution of relative abundance, as it provides insight into both the figure of different species and the number of individuals present. The index is expressed as general diversity (H') and Evenness (E). Variations in the general diversity (H') of species were observed across different study stations. Station 3 exhibited high diversity, likely due to its ecological heterogeneity, as indicated by high evenness and low dominance index. Conversely, stations 2 and 3 showed low evenness and high dominance index, suggesting lower ecological heterogeneity. These findings align with Margalef's Index for species richness, reflecting the observed variation in general diversity.

The composition and location of the bottom-dwelling large invertebrates often change in reaction to pollution-related stress expectedly. This forms the foundation for establishing biological standards to assess human-induced impacts (Boyle and Fraleigh, 2003). Gray (1989) categorized the reactions into three specific types: decreased variety, greater prevalence of a single species or group of rapidly reproducing species, and smaller individual sizes. The first two types of changes were evident in the bottom-dwelling data from stations 1 and 2.

The quality of the water at different stations was assessed using various catalogues such as the simple biotic Index, Ephemeroptera Index, and Trichoptera Index. The results showed that stations 3 and 1 had good ratings, with 19 and 20 points, while station 2 had an excellent rating with a total of 23 points according to the simple biotic index. The Ephemeroptera Index indicated that all three stations were good, with 14, 8, and 5 points respectively. The

Trichoptera Index revealed that station 1 had poor quality with 0 points, station 2 had good quality with 13 points, and station 3 had moderate quality with 4 points. These indices provide an overview of the Luhu dam water quality during the sampling intervals in this study.

CONCLUSION

The assessment of the abundance and distribution of benthic macro invertebrates in Luhu Dam, Michika, Adamawa State, Nigeria, serves as a crucial step toward understanding the quality and pollution rank of the dam. These findings will support informed decision-making for the conservation and sustainable management of the Luhu Dam. The study's comprehensive approach to evaluating the health of the dam through benthic macro-invertebrates provides valuable insights that can guide effective measures aimed at maintaining the ecological balance and overall well-being of the dam and its surrounding environment.

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