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Spatiotemporal distribution of benthic Macroinvertebrate of Kafin Gana Dam, Jigawa State, Nigeria

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Abstract
The seasonal distribution and composition of benthic Macro invertebrates in Kafin Gana wetland Jigawa State, Nigeria were documented over a one-year period from September 2020 to August 2021. Soft bottom sediment samples were collected from the five sampling station using a FUD grab sampler with a 0.063m² area. The sediment was sieved through a 0.5 mm mesh using reservoir water, and benthic macro invertebrates were preserved in 10% formalin solution. In the lab, preserved specimens were sorted, identified, counted, and enumerated on a clean white tray. The findings reveal species from three phyla namely: Mollusca, Annelida, and Arthropoda and five classes (Bivalve, Gastropoda, Clitellata, Insecta, and Malacostraca). A total of 826 individuals across the phyla were recorded with Melanoids tuberculata being the most frequently recorded species with 52% frequency of occurrence. The least occurring were Elmidae sp and Hydrophylus triangularies having (0.5%) occurrence each. Only Chironomus showed significant (p>0.05) spatial and seasonal variation in Kafin Gana Dam. This study reveals the changes in abundance and community structure across the stations. This study also clearly revealed that Kafin Gana Lake has a moderate health status, an indication that the water quality has not been compromised.

Keywords: Benthic, Macro invertebrate, spatiotemporal, Wetland, Sediment.

INTRODUCTION
Water is an essential resource for sustainability of life on earth. It is the most vital requirement after oxygen, as its constant supply is needed to replenish the fluids lost through normal physiological activities such as respiration, perspiration and urination (Mu'azu *et al.*, 2019).Dams have always been extensively polluted throughout the history of human civilization, owing to their easy accessibility to garbage disposal and, in many cases, the lack of a regulatory framework. However, following the industrial revolution, the carrying capacity of water sources to treat wastes was drastically reduced (Uduma *et al.*, 2022). Dam water quality is influenced by anthropogenic activities such as urbanization, industry, and agriculture, as well as natural processes such as precipitation inputs, erosion, and weathering of crustal elements (Uduma *et al.*, 2022).

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Benthic organisms are those organisms that live on or inside the deposit at the bottom of a water body (Andem *et al*., 2012; Okorafor *et al*., 2013). Benthic macro invertebrates (also known as "benthos") are small animals living among stones, logs, sediments and aquatic plants on the bottom of streams, rivers and lakes. They are large enough to see with the naked eye (macro) and have no backbone (invertebrate), and examples include molluscs, annelids, crustaceans, chordates, arthropods, coelenterates and so on (Emeka, 2020). Macrobenthic invertebrate are biological quality elements required for the classification of biological status of the water bodies. (Bagalwa *et al.,* 2019; Mophin & Murugesan, 2014; Okorafor *et al*., 2013). Benthic infaunal community studies provide the 'golden standard' in terms of determining whether or not alterations in benthic communities are occurring and together with sediment, toxicity and chemistry, whether or not such changes are due to toxic contaminants in the sediments. (Andem *et al*., 2012).

Over the last decades there has been a considerable effort to document the ecology, composition, spatial distribution and biodiversity of Macrobenthic invertebrate communities of Nigerian rivers (Okorafor *et al.*, 2013). In polluted aquatic systems, some macrobenthos may be eliminated and some remain abundant due to less competition and/or tolerance to adverse conditions. Considering this aspect, macrobenthic communities play a twofold role: first, they act as a connecting link in the food web and secondly, they purify the polluted water.Further, different soil and water characteristics also have a pronounced influence on the diversity of macrobenthos (Paul and Nadi, 2003; Onkar & Rajwinder, 2017). As these highly sensitive organisms spend most of their lifetime at the same place because of less mobility, the effect of pollution and eutrophication is clearly evident on them (Gupta & Bhagat, 2005; Onkar & Rgwinder, 2017). The objective of the present study was to find the abundance, diversity and seasonal variations of macrobenthic fauna, since the occurrence of many higher organisms is dependent upon them.

MATERIALS AND METHOD

Study Area

Kafin Gana Dam is located at Kafin Gana Town Birnin Kudu Local Government Area of Jigawa State. Kafin Gana is located at the latitude 11°03.00'N ad 90°21.0'E, it is Sudan Savannah as an ecological zone of Nigeria. The Dam was primarily established for irrigation purpose. It has a surface area of 121ha(Miga & Yusif, 2018).

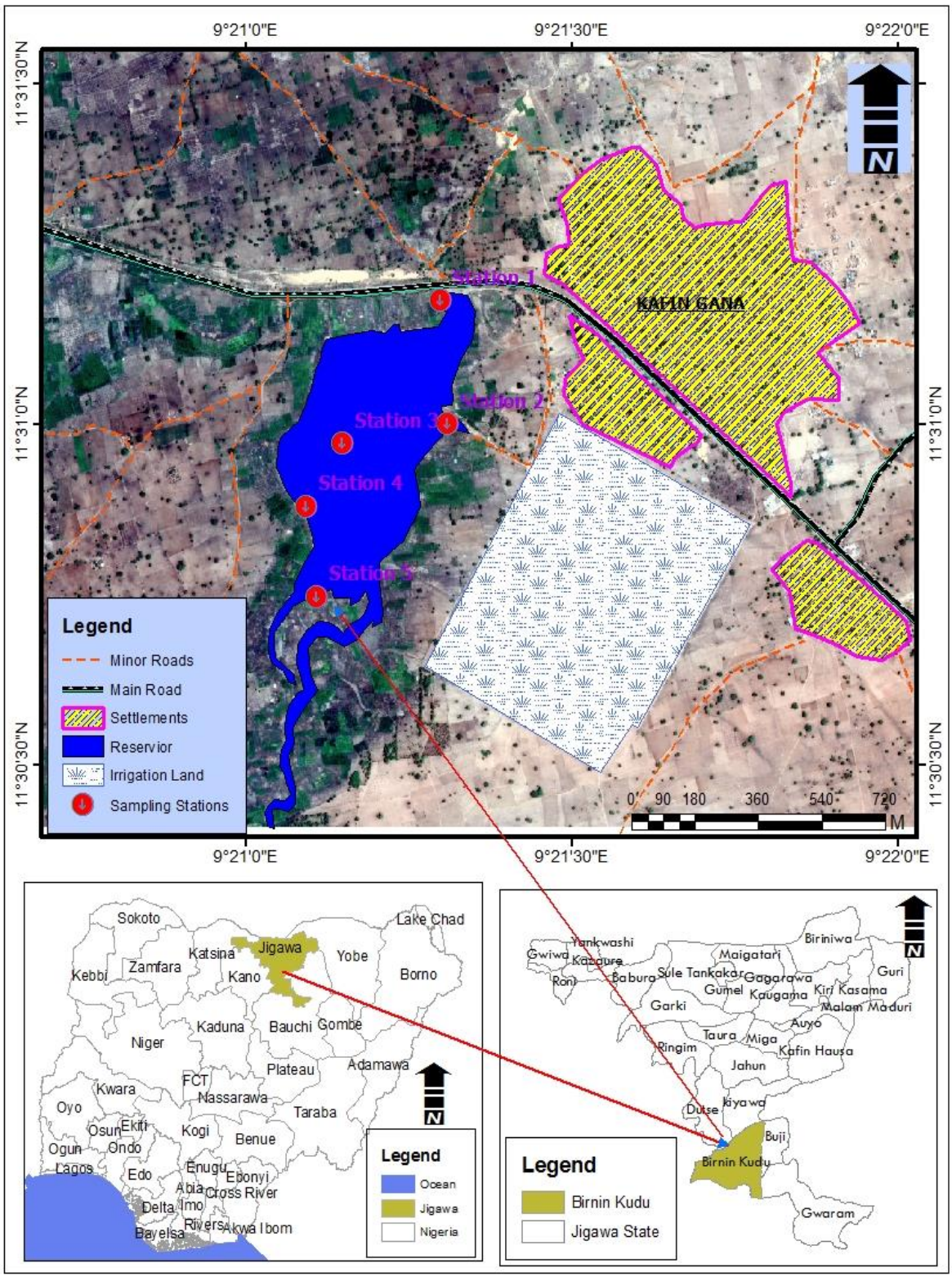

Figure 1. Map of Kafin Gana Dam, Birnin Kudu, Jigawa State showing the sampling Station (Source: Geography Department, ABU Zaria).

Sampling Stations

Five sampling stations were selected based on the anthropogenic activities around the dam. The sampling areas were named as **Station 1**, with coordinate Latitude: 11'31"08.9"N and Longitude: 009'21"9.0"E **Station 2**, with coordinate Latitude: 11'31"5.3"N and Longitude: 009'21"17.8"E. **Station 3**, with coordinates of latitude 11^{0}30"58.8"N and longitude

009021"09.06"E. **Station 4**, with coordinate Latitude 11030"52.9"N and Longitude: 009021"04.8"E and **Station 5**, with coordinates Latitude 11030"44.9"N and Longitude 009021"06.6"E.

Sampling of Benthos

Sampling was carried out aboard a wooden boat (**Canoe)** boat pointed at both ends and propelled by one paddle man (Covering both the dry and rainy seasons) for one annual cycles (Sept.2020 –August2021) along the five stations. Samples of soft bottom sediment at each sampling station were collected using a FUD grab (Bottom sampler) of 0.063m^2 area (0.25m × 0.25m). The grabbed samples were sieved through a 0.5 mm mesh sieve using the reservoir water. Then benthic macroinvertebrates found were removed using a pair of forceps and preserved inside a specimen bottle in 10% formalin solution. In the laboratory, the preserved specimens of the recorded macro invertebrates were transferred into a clean white enamel tray for sorting, identification, counting and enumeration. Identification was made by the use of different freshwater identification guides (Grisé, 2008; Voshell, 2002).

Statistical Analysis

The spatial and temporal distribution pattern of Macro benthic invertebrate was carried out using Analysis of variance (Anova). The biotic index of Kafin Gana Dam, was estimated using, Shannon-wiener index (H), equitability (J) and Simpson's diversity index (D) were used in the calculation of species richness, diversity and evenness using the following formulae.

Shannon index (H)

$$H' = -\sum_{i=1}^{s} \text{Pi ln (Pi)}$$

Where p_i = proportion of the individual i-th species in a whole community, (ln) = natural logarithm of pi, (S) = number of species in a community.

Pielou's Evenness (J) of a community, was used to measure the level of equitability of a given species.

$$J = \frac{H'}{\ln(s)}$$

Where; (H') = value of Shannon wiener index, (Ln(s)) = natural log of the species (natural number of species)

Simpson's diversity index formula

$$D = 1 - \left(\frac{\Sigma n(n-1)}{N(N-1)}\right)$$

Where: (n). = total number of organism of a particular species, (N) = total number of organism of all species, (Σ) = sum of, and (D) = is Simpson's index.

RESULTS

Macrobenthic Composition and Distribution

Through the period of study Sept. 2020- August 2021 a total of eleven (11) Macrobenthic species were recorded from Kafin Gana Dam (Table 2), belonging to three phyla (Mollusca, Annelida and Arthropoda) five classes (Bivalvia, Gastropoda, Clitellata, Insecta and Malacostraca). A total of 826 individual Macro benthic invertebrates, an abundance of the species range from the lowest value of Riffle beetle and scavenger beetle having 0.5% occurrence with four (4) individuals each occurring in stations 2,4and 5 and stations 1, 4 and

5 respectively. *Melanoides tuberculata* was the most dominant species occurring in both five stations, with 425 (52%) individuals.

Variation of Benthic Macro invertebrate with stations and seasons

In this study table 1 and Figures 2 and 3 below the result shows that Bivalve is significant with season at 5% ($p < 0.05$) the result indicates that there is a difference in the occurrence of bivalve with season. The result also signifies that Bivalve was significant with stations at 10% level (p-value; 0.075) Chironomous shows a significant difference with stations at 5% level ($p < 0.05$). Similarly, the Scavenger beetle shows a significance difference with the season (p- value: 0.041), hence, it indicates a difference in scavenger beetle occurrence in dry and rainy seasons. In contrast to Chironomous this indicates a significance Difference between seasons and Stations, with P-value of 0.009 and 0.041 respectively.

Table 1: Temporal and Seasonal Variation of Benthic Macro Invertebrate in Kafin Gana Dam, Jigawa State

	Biv	GS	Leech	GWB	chir	LS	Shrimp	R B	RBL	S B	CG
Seasons											
Rainy	95	39	25	13	24	23	9	4	4	4	159
Dry	43	18	20	10	40	27	2	0	1	0	266
P-value	0.009	0.538	0.689	0.587	0.172	0.602	0.203	0.078	0.165	0.040	0.00
Stations											
1	20	13	17	3	5	10	1	0	1	1	58
2	28	6	8	3	6	6	3	1	0	0	64
3	18	16	10	3	1	6	0	0	0	0	82
4	35	8	4	7	25	10	6	1	3	1	139
5	37	14	6	7	23	18	1	2	1	2	82
***p*-value**	0.075	0.219		0.571	0.00	0.232	0.349	0.169	0.169	0.450	0.041

P > 0.05 is significantly different

Bivalvia, GS; gilled snail; GWB; Giant Water bug; chir. Chironomous; LS, lung snail; RB, Riffle beetle; RBL. Riffle beetle larvae; SB. Scavenger beetle; CG; cynogastropoda.

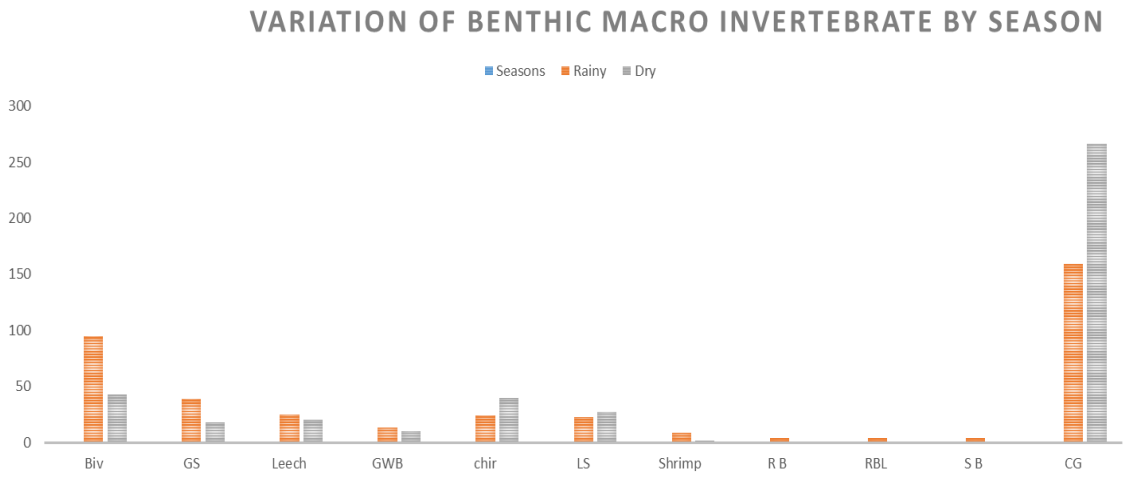

Figure 1. Variation of benthic macro invertebrate by season in Kafin Gana Dam, Jigawa State

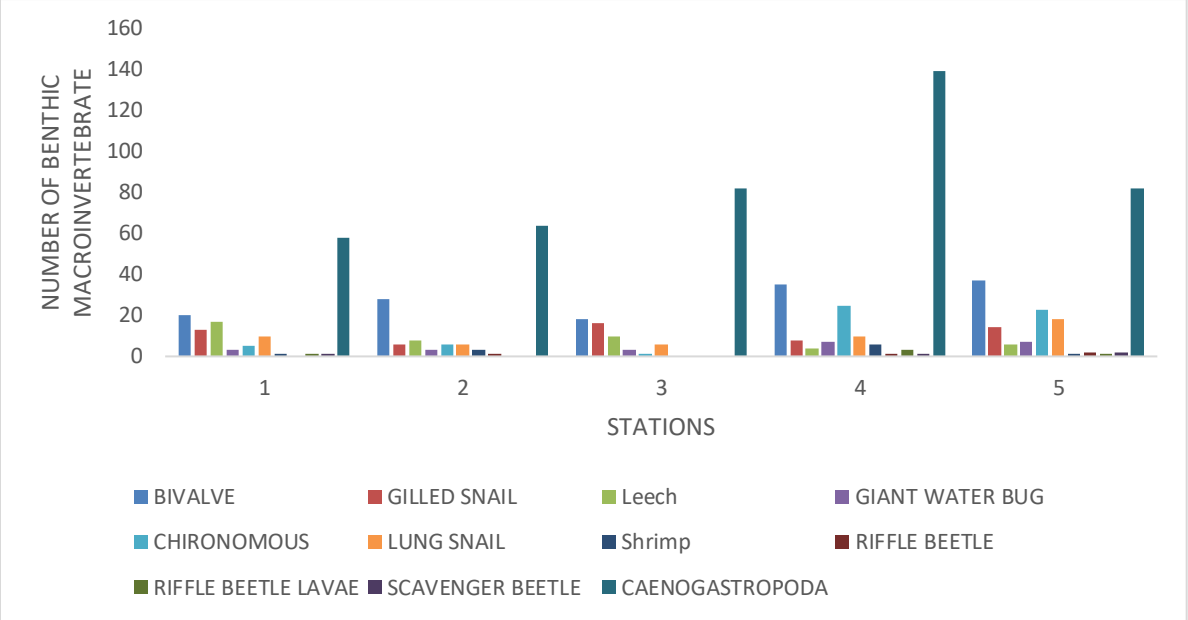

Figure 2. Mean variation of benthic macro invertebrate by stations in Kafin Gana Dam, Jigawa State

Table: 2. Macrobenthos found in Kafin Gana Dam, Jigawa State

Phylum	Class	Order	Family	Species	Common Name
Mollusca	Bivalvia	Unionida	Unionidae	*Pyganodon grandis*	Giant Floater
	Gastropoda	Caenogastropoda	Turitellidae	*Melanoid tuberculata*	Turiform
			Lymnaeidae	*Pomacea bridgessi*	Right Hand Snail
			Physidae	*Physella acuta*	Left Hand Snail
Annelida	Clitellata	Arhynchobdellida	Hirudidae	*Hirudo medicinalis*	Leech
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus sp larva*	Blood Worms
		Coleoptera	Hydrophilidae	*Hydrophylus triangularies*	Water Scavenger Beetle
			Helmidae	*Elmidae spp*	*Riffle Beetle*
				Elmidae lavae	*Riffle Beetle Larvae*
		Hemiptera	Belostomatidae	*Lethocerus americanus*	Giant Water Bug
	Malacostraca	Decapoda	Penaeidae	*Penaeus setiferus*	White Shrimp

Biotic Index of Benthic Macro Invertebrates of Kafin Gana Dam

The relative diversity of the Benthic Macro invertebrate taxa encountered at the different sampling stations is represented in Table 1, the highest species richness was recorded at station 4 followed by station 5, whereas the least species richness was recorded at station 3. Generally station 4 has recorded the maximum density of 239 while, station 2 has recorded the lowest density of 125.

General diversity Shannon Wiener index measures the number of species and number of individuals in each species. A healthy macro invertebrate community should have a Shanon Wiener Diversity index according to welch H'>3represnt unpolluted region H'<1 represent polluted status and 1<H'<3 represents moderate pollution status. In the present study the value of the Shannon index was highest at station 5 with an indices value of 1.723 followed by station 1 and lower at station 3 with an indices value of 1.274. However, in station one the individuals are more evenly distributed followed by station five.

In contrast the pattern was also not similar in Simpson's diversity index (D) where station 1 shows a higher diversity and the remaining station had more or less equal dominance or diversity levels. On the other hand the diversity indices as related to seasons Table 4 shows that Shannon –wiener diversity index and Piolou's equitability (J) were high and more even with the rainy season respectively, in contrast to Simpson's diversity index which had more dominant and diversity in favour of Dry season.

Table: 3. Spatial biotic index of Benthic Macro Invertebrate of Kafin Gana Dam

	Station 1	Station 2	Station 3	Station 4	Station 5
Si	10	9	7	11	11
N	129	125	136	239	193
Shannon (H')	1.671	1.509	1.274	1.444	1.723
Equitability -J	0.726	0.686	0.655	0.602	0.718
Simpson 1-D	0.744	0.319	0.398	0.373	0.244

S*i* =total number of species N= total number of individuals.

Table 4. Temporal biotic index of benthic Macro Invertebrate of Kafin Gana Dam

	Rainy	**Dry**	**overall**
S*i*	11	9	11
N	399	427	826
Shannon (H')	1.778	1.32	1.60
Equitability –J	0.74	0.604	0.66
Simpson's 1-D	0.396	0.586	0.69

S*i* =total number of species N= total number of individuals.

DISCUSSION

The macro benthic invertebrate composition of Kafin Gana Dam shows a strong similarity in species structure to other Nigerian inland water bodies, as observed in previous studies by Avoaja et al. (2007), Atobatele et al. (2010), Balogun et al. (2011), Adedeji et al. (2012), Abubakar and Yakasai (2015), and Adedeji et al. (2019). This study recorded a total of 826 individual organisms from the lake, categorized into 11 different species of macro benthic invertebrates across three major phyla: Arthropoda, Annelida, and Mollusca. These findings align with observations made by Ahmed et al. (2019) and Adedeji (2019), who suggest that these three phyla are substantial contributors to the macro benthic invertebrate community structure.

The data indicates that Gastropoda are the most abundant class in the lake, followed by Bivalvia, Insecta, Clitellata, and Malacostraca. This distribution pattern aligns with studies from other regions, including those by Usman et al. (2017) in Katsina State, Terso et al. (2017) in Makurdi, Benue State, and Atobatele (2010) in Osun State, which similarly report Gastropoda dominance in aquatic systems. The high representation of Gastropoda could be attributed to favorable environmental conditions in Kafin Gana Dam that support their survival and proliferation.

The biotic index and diversity analysis of macrobenthic invertebrates in Kafin Gana Dam, highlights both spatial and seasonal variations in species richness, abundance, and diversity, which align with findings from other studies in Nigeria and around the world. The highest species richness and density were recorded at station 4 (239 individuals), while station 3 showed the lowest richness, suggesting localized environmental factors affecting community

structure. The Shannon-Wiener diversity index, which indicates ecological health and pollution levels, ranged from 1.723 at station 5 to 1.274 at station 3. These values suggest moderate ecological conditions, as unpolluted regions typically have values above 3, while polluted regions have values below 1 (Welch, 2019). Station 1 had more evenly distributed individuals, contributing to a higher diversity score, a pattern often observed in less disturbed habitats (Ahmed et al., 2020).

These findings reflect similar results from Nigerian water bodies, where varying degrees of pollution and habitat disturbances have led to differing species distributions and diversity levels. For instance, Terso et al. (2017) observed that water bodies with moderate pollution levels often exhibit intermediate diversity indices, as seen in Kafin Gana Dam. Adedeji et al. (2019) noted that such conditions in Nigeria are usually due to organic and inorganic pollution sources, which alter species composition and favor pollution-tolerant species, explaining why species like Melanoides tuberculata are dominant in many Nigerian freshwater systems.

International studies on freshwater benthic diversity provide comparable insights. For example, studies by Abu Sayeed et al. (2018) on river systems in Bangladesh show similar seasonal shifts in diversity and species richness due to varying water flow, temperature, and nutrient influx between wet and dry seasons. In Kafin Gana Dam, the Shannon-Wiener diversity index and Pielou's equitability (J) were higher in the rainy season, likely due to increased water levels, nutrient input, and habitat complexity, which create favorable conditions for diverse invertebrate communities. Conversely, Simpson's diversity index, which reflects dominance, was higher in the dry season, as lower water levels may limit habitat diversity and promote dominance by a few adaptable species, a pattern also noted by Adedeji et al. (2019) and Abu Sayeed et al. (2018).

CONCLUSION

The high representation of Gastropoda could be attributed to favourable environmental conditions in Kafin Gana Dam, that support their survival and proliferation. Differences in diversity indices, like those seen here, can be attributed to environmental conditions such as water quality, habitat structure, and seasonal changes, which are essential factors in community composition.

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