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Diversity of mussels and snails as bio-indicators in the littoral zone of some selected water reservoirs in Katsina state, Nigeria

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Abstract: *Water reservoirs in Katsina state accommodates and protects the entire biodiversity both aquatic and terrestrial ecosystem. Thus, provide enormous socio economic, medical as well as ecological values. The fact that most of these dams are under severe pressure due to anthropogenic activities, there is need for ecological conditions of water to be evaluated. This paper assesses the diversity of mussels and snails in relation to the physicochemical factors of the littoral zone of some selected water reservoirs in Katsina state. Water samples were collected from three points at each of the study areas; Ajd= Ajiwa dam, Ard= Are dam and Sbd= Sabke dam in Batagarawa, Rimi and Mai'adua local government respectively. The species of mussels and snails were collected and taken to laboratory for identification via morphological analysis using relevant guide for mussel's and snail identification systems. Furthermore, standard methods were used to measure the physico-chemical parameters of water in the areas. The SPSS (Version 26.0) was used to compute Analysis of variance (ANOVA) for the biological and physico-chemical parameters of the water, while Spearman's correlational table and Principle Component Analysis (PCA) were plotted using PAST (version 3.25). The finding revealed three species of mussels namely; Unio. tumidus, U. crassus, Aspatharia hartmanni and A. wahlbergi are prominently presence in all the three study areas. The Aspatharia hartmanni is found to be the most diverse in the study areas. And A. hartmanni could be used as indicator species. Similarly, the presences of Melanoides tuberculata as intermediate host of a parasites. Thus, to device possible parasites control regular surveys on be undertaken in the areas.*

Keywords**:** *Mussel, snail, physicochemical parameters, Biotic indicators, dams*

INTRODUCTION

Acknowledgement
The authors thank Tertiary Education Trust Fund (TETFund) Abuja Nigeria for the research grant and the Management of Federal College of Education Katsina for facilitating the prompt approval of the grant. Our appreciation also go to the managements of Ajiwa, Are and Sabke water reservoirs in Rimi, Batagarawa and Mai'adua local government areas respectively, Katsina state, Nigeria for all the support received during the research.

Introduction

Biological indicators are species, species assemblages, or communities whose presence, abundance, and condition are indicative of a particular set of environmental conditions (Shannon, 2004; Paulov, 1977) further explain that Freshwater bio-indicators are animals and plants that can be used to determine the state of health of freshwater habitats. Some creatures are very sensitive to water-borne pollutants while others less so. Changes in the abundance and diversity of these animals can be used as a measuring tool to determine water quality. Bio-indicator organisms typically live in freshwater and so are subject to the changes in pollutant load. They are often more effective than laboratory-based measuring tools as they are unable to escape the effects of the pollutants, since they are more sensitive than most meters and are cheaper to use. Warner; (1991) view that one of the biggest problems in using laboratory probes or taking water samples is that water quality is not static, it changes constantly and pollution loads may vary from high to immeasurably low. Water meters can only record water quality at one point in time and often fail to assess fluctuations in water quality.

In the era of modern science and new technology, mankind is adopting novel approaches to deal with the problems at hand, such as high population density and urbanization which has changed our environment to a polluted one. It's not easy to deal with this problem with complex and costly equipment. Bio-indicators are playing a major role in reducing the pollution and to check it timely without any environmental hazard (Trishala et al., 2016).

During the past decades the ecology and ecotoxicology of amphibians started to get attention (Cowman et al., 2000). Amphibians are vertebrates in the class Amphibian that includes frogs, toads, salamanders, newts, and caecilians (wormlike amphibians). They constitute part of biotic component of an ecosystem (Alford et al 1999). They play several roles; as Amphibians provide valuable services to human societies. They also provide food and medicine, have the potential to affect the spread of disease, and find ways into our homes, hearts, and art, contributing to cultural services that are important for social, spiritual, and psychological wellbeing (White, 1999). Amphibians also support the other ecosystem services through changes in decomposition, and primary production. While it is clear that, as a large class of vertebrates, amphibians contribute to ecosystem services, much research remains to understand the extent of their roles (Daniel et al., 2014).

Amphibians are of great ecological importance and can be found in all forest age classes. Many amphibian species utilize both aquatic and upland habitats throughout their life-cycle, therefore, they are considered good indicators of habitat quality (Habitat diversity, habitat connectivity, water quality). Amphibians also play a key role in food webs and nutrient cycling as they are both prey (eaten by fish, mammals, birds, and reptiles) and predators (eating insects, snails, slugs, worms, and in some cases, small mammals). The presence of forest salamanders has also been positively correlated to soil building processes (Best and Welsh, 2014).

Amphibian species are considered important biological indicators of the health of an ecosystem because they live in both aquatic and terrestrial environments (Pough, 2007). The distribution of these organisms is partly determined by the land cover heterogeneity and the microhabitat availability (Wells, 2007). They are sensitive to environmental changes and pollutants partly because they absorb water and oxygen directly through the skin (Boyking, 2013).

In Africa, rapid urban growth since the 1960s has put pressure on the available water within the area surrounding the towns and cities. The problem is aggravated by the open dump nature of disposing waste especially in the slum areas of most African cities. The illegal dumping of solid waste has led to the problem of polluting the land as well as the near-by water bodies to serve both irrigation and domestic needs. Drainages, gutters and other water passages were turn to be refusing collection centers thus causing flood, the uncontrolled waste disposal can also cause pollution of water and subsequently could aid the transmission of water-borne infections such as typhoid, cholera, gastro enteritis among others (Mato, 1999; Hammer, 2003).

Water pollution is the release of substances into bodies of water that makes water unsafe for human use and disrupts aquatic ecosystems. Water pollution can be caused by a plethora of different contaminants, including toxic waste, petroleum, and disease-causing microorganisms (Britannica, 2022). Contamination of water reservoirs by substances harmful to living things, water is necessary to life on earth. All organisms contain it; some live in it; some drink it. Plants and animals require water that is moderately pure, and they cannot survive if their water is loaded with toxic chemicals or harmful microorganisms. If severe, water pollution can kill large numbers of fish, birds, and other animals, in some cases killing all members of a species in an affected area. Pollution makes waters unpleasant to look at, to smell, and to swim in. Fish and shellfish harvested from polluted waters may be unsafe to eat. People who ingest polluted water can become ill, and, with prolonged exposure, may develop cancers or bear children with birth defects.

The pollution of rivers and dams with chemical contaminants has become one of the most critical environmental problems of the century. Chemical pollution entering rivers and dams can be classified according to the nature of its sources: point pollution and nonpoint pollution. Point pollution involves pollution from a single concentrated source that can be identified, such as an outfall pipe from a factory or refinery. Nonpoint pollution involves pollution from dispersed sources that cannot be precisely identified, such as runoff from agricultural or mining operations or seepage from septic tanks or sewage drain fields (Hart, 2008). Bio surveys may identify pollution problems that are difficult or expensive to detect using chemical testing procedures (Karr, 1981). Thus, of water bodies, apart from economic, veterinary health and various benefits derives from the organisms (Sanu et al., 2020).

The population of Katsina state has been estimated to be 5,801,584 as at 2006 (Federal Republic of Nigeria, 2009) and considering the households and industrial needs, the total daily water requirement is voluminous. The dams used in this study supply Katsina state and its environs with potable water and some communities around the dams use the untreated water for drinking, laundry, irrigation and other domestic purposes. There is an increasing commercial, residential and infrastructural development due to the population growth and urban expansion and this directly affect the amount of water required and increase on potential water pollutant which most likely end in those water reservoirs of the state.

The Freshwater mussels of the family Unionidae are a important element of aquatic ecosystems and offer crucial ecosystem functions and services (Vaughn 2017). However, their populations are in decline worldwide and majority of unionid species are either threatened or endangered (Zieritz et al. 2017). Accurate species identification and taxonomy are essential for a proper inventory of the molluscan fauna from different regions and for the development of conservation strategies (Olga et al., 2017).

Mussels and snails are sensitive to environmental changes and pollutants partly because they absorb water and oxygen directly through their gills and skin. Bio-indicators are animals and plants that can be used to determine the state of health of aquatic habitats. They are very sensitive to water-borne pollutants. Therefore, Changes in the abundance and diversity of these animals can be used as a measuring tool to determine water quality.

The objectives of the study are to; 1) Assess the biological and physico-chemical parameters of the selected water reservoirs of Katsina State 2) evaluate the relationship between physico-chemical and biological parameters in the selected water reservoirs of Katsina State 3) assess the diversity of mussel and snail's species in the selected water reservoirs of Katsina State.

Materials and Methods

The data collections were employed through fieldwork survey, personal observations and morphological analyses.

Study areas: The study was conducted in three water reservoirs (Figure 1) found in three Local Government Areas of Katsina state; namely Batagarawa, Rimi and Mai'adua. The dams are situated along latitudes and longitudes (Table 1). The samplings were carried out between January to July 2023. Are dam situated in Rimi local government area Katsina state, was constructed and commissioned by the federal government in 1970's with capacity of 100 million square meters. The sole purpose of constructing the Dam is to impound enough volume of water for dry season, farming, fishing and other domestic activities (Muazu, Musa and Babangida, 2020). Sabke dam located in Mai adua local government area of the state with a water capacity of 31.60 million cubic meters of water, an area of 7.7km² is covered by the reservoir covering an area of 7.7 million square (770ha) meters at full capacity and 1000 hectares size of area of cultivation (Bala, and Abdullahi, 2011).. Ajiwa Dam located in Batagarawa local government area of the state with a reservoir capacity of 22.7cm^{3} with a depth of 14.7m, 300 hectares size of area under cultivation and also provides portable drinking water to the nearby communities (Akinjogunla and Shu'aibu, 1998).

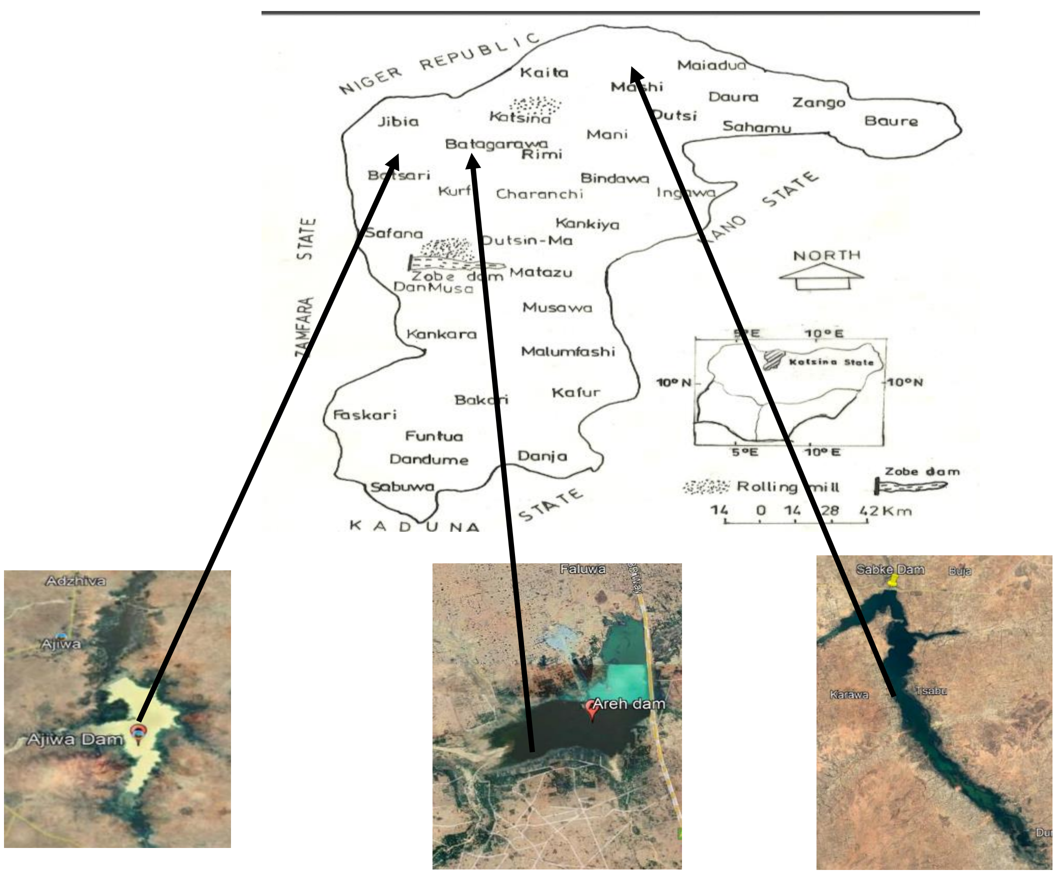
Table 1: List of the study areas with their coordinates (Google Earth, 2023)

Study area	Latitude	Longitude
Ajiwa dam	12°56'5.16"N	7°45'18.91"E
Are dam	12°46'38.75"N	7°41'35.88"E
Sabke dam	13° 3'34.95"N	8° 9'31.57"E

Physico-chemical parameters measurements: The instruments used in measuring abiotic factors are pH meter, thermometer, oxygen meter, turbidimeter, glasswares, analar grade reagents and deionised water solution, atomic absorption spectrophotometry (AAS) and chemicals such as perchloric acid (Standard Analytical Procedures, 1999). Mussels and snails were collected in plastic containers and taken to laboratory for identification through the use of morphological analysis using relevant materials such as magnifying glass, guide for mussel's identification system (Zhadin's, 1938; Huber, 2010; MolluscaBase eds, 2023) and guide for identification of snail (Brown, 1994).

The morphologic analysis: This required visual examination of each specimen, observing the shell shape, the basic umbo sculpture types base on Zieritz et al. (2015) and morphology of tooth of the mussels. Similarly, physical identification of snail includes; overall shape of the shell; in term of ratio of height and breadth or flattened, direction in which the shell is coiled, colour and colour pattern of a shell, shell thickness and translucence and surface sheen, texture and sculpting (Eversham, 2018).

Statistically, both descriptive and inferential statistics were accomplished on the data; Using SPSS (Version 26.0) the means and standard deviations were computed. While ANOVA were used to test the significant differences between biological and physicochemical parameters indicators of the water reservoirs. Similarly, the relationships within the biological and physicochemical factors were analysed using Spearman's correlational table and Principle Component Analysis (PCA) plots using PAST (version 3.25).



Ajiwa dam Are dam Sabke dam

Figure 1: the map of Katsina State showing the location of the dams used in the study

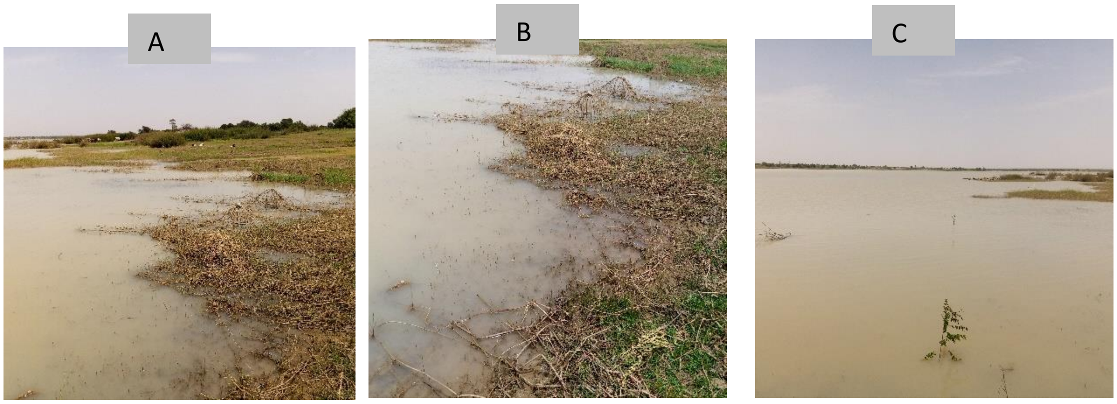


Plate 1: Pictures showing three littoral zones; (A) Ajiwa dam (B) Are dam (C) Sabke dam

Results

The results of the bio-physicochemical data collected from three water reservoirs showed variations in the physicochemical parameters and different diversity and abundance of the mussels and snails:

Morphological features of mussels and snails

On the morphology of mussels, the general shell shape of all the species collected and analyzed may be divided in two forms in accordance with Zhadin's (1938) system, i.e., wedge-shaped for U. *tumidus* and oval for U. *crassus*. However, *Aspatharia hartmanni* appears oblong in shape and *Aspatharia wahlbergi* have in addition to wedge-shaped features (Huber, 2010; MolluscaBase eds, 2023) (Figure 2A–E). The thorough examination of all mussels and clams collected three basic umbo sculpture types have been identified that correspond to the Unio species from Zhadin's (1938) system.

For the mussels, the umbo sculpture showing 'double-looped'; U. tumidus sculpture (Figure 2C) and that of U. crassus 'wrinkled' consisting of interrupted concentric ribs and knobs (Figure 2E).

Tooth morphology reveals teeth of U. tumidus and U. crassus they are thicker, more rugged, peg-like and compressed with the lateral teeth being frequently curved. The teeth in U. tumidus are separated, with the inner pseudocardinal tooth projecting further outward than the outer tooth though they may also occur merged as a single tooth. However, in U. crassus, the outer and inner pseudocardinal teeth of the left valve are generally separated with similar lengths and points of projection, but at times the inner one is higher than the outer pseudocardinal tooth (Figure 2D–E).

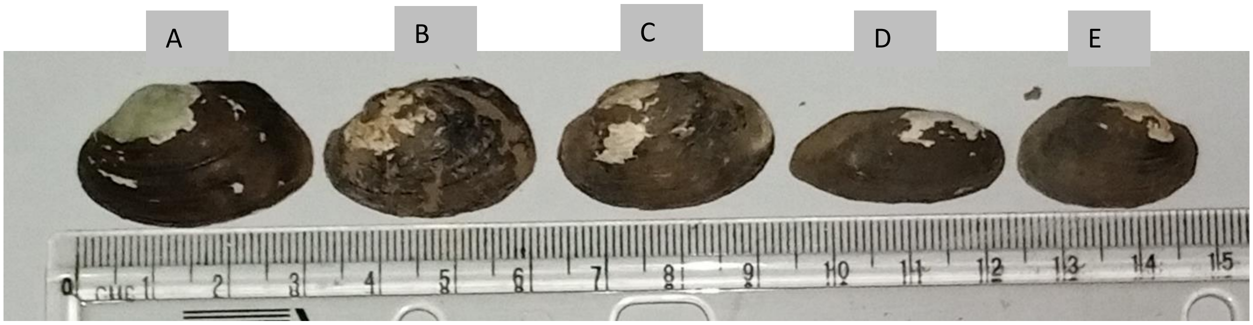


Figure 2(A&B, C to E): Mussel's shell shape of Unio species based on Zhadin's (1938) system A&B= *Aspatharia wahlbergi* C= *Unio tumidus* D= *Aspatharia hartmanni* E= *Unio crassus.*

The morphological features were used to identify the snail's collection based on *Pila ovata* and *Melanoides tuberculate* (Oliver, 1804; Brown, 1994) (Figure 3A–B).

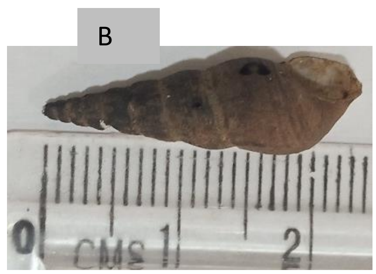


Figure 3: A= *Pila ovata* B= *Melanoides tuberculate* (Sanu et al., 2020)

Biological and physico-chemical parameters of the areas

The means and standard deviations of 13 biological and physicochemical parameters measured; mussel, snail, pH, T, DO, Turbid, WD, TDS, Ca, Fe, Mg, Cl and NO_3. Twelve (12) of the parameters showed significant differences ($p < 0.05$) among the study areas; Ajiwa, Are and Sabke dams. However, Mg showed no significant differences ($p < 0.05$) (Table 2).

Table 2: Biological and physicochemical parameters

Biological parameters	**Ajd**	**Ard**	**Sbd**	**p-values**
Mussel (org/10m^2)*	1.500±1.049^b	15.330±2.160^a	16.330±6.055^a	0.014
Snail (org/10m^2)*	0.0^b	18.830±10.420^a	7.830±4.167^b	0.002
Physicochemical parameters				
pH*	8.200±0.155^c	7.250±0.404^b	6.550±0.152^a	0.000
T (Celsius)*	23.417±0.319^a	22.400±0.872^b	24.033±0.197^a	0.001
DO (mg/L)*	5.300±0.167^c	7.667±1.031^b	9.517±0.471^a	0.000
Turbid (FAU)	49.817±0.319^a	3.983±0.519^b	3.367±0.350^c	0.000
WD (cm)*	2.850±0.105^c	9.833±4.792^b	35.500±4.183^a	0.000
TDS (mg/L)*	88.980±6.202^a	69.933±6.433^b	53.633±1.109^c	0.000
Ca (mg/L)*	46.860±2.029^b	52.948±7.878^b	59.950±1.419^a	0.000
Fe (mg/L)*	0.710±0.027^a	0.668±0.052^a	0.573±0.045^b	0.000
Mg (mg/L)	3.243±0.094^a	3.167±0.154^a	3.167±0.186^a	0.602
Cl (mg/L)*	61.840±9.162^a	49.783±15.058^a	19.733±0.437^b	0.000
NO_3 (mg/L)*	0.183±0.034^c	4.858±3.858^b	14.083±1.417^a	0.000

Note. means and standard deviations of the areas; Ajd: Ajiwa, Ard: Are and Sbd: Sabke in relation to biological and physicochemical parameters, mussel; snail; pH: water pH; T: water temperature; DO: dissolved oxygen; Turbid: Turbidity of water; WD: water depth; TDS: total dissolve solid; Ca: Calcium; Fe: Iron; Mg: Magnesium; Cl: Chloride; NO_3: nitrate. while * signified significant difference ($p < 0.05$) among the study areas. The mean ± SD, represented that the higher the values, the higher the biological and physicochemical parameters and vice versa. Those values with different superscript letters (a to c) across row showed significant different at $p < 0.05$.

Associations within the biological and water physicochemical factors

The result of the correlation matrix of biological factors such as mussel and snail depicted significant strong positive correlation (r2 = 0.800) between mussel and Snail. The correlation with physicochemical parameters showed mussel to have significant medium negative correlation (r^2 = > -0.639 ; $p < 0.05$) with pH, Turbid, TDS and Fe. And positive medium correlation (r^2 = < 0.600; $p < 0.05$) with WD and NO_3. However, snail correlated negatively and positively (r^2 = < - 0.611; $p < 0.05$) with Turbid and WD respectively. The water physico-chemical parameters such as pH revealed significant negative strong correlation (r^2 = - 0.811; $p < 0.05$) with DO, WD and Ca and strong positive correlation (r^2 = 0.802; $p < 0.05$) with Turbid, TDS and Fe. While Temp showed negative medium correlation (r^2 = < - 0.691; $p < 0.05$) with Cl. Additionally, there is strong negative correlation (r^2 = - 0.869; $p < 0.05$) of DO with Turbid, TDS and Fe, but positive strong correlations (r^2 = > 0.832; $p < 0.05$) existed DO with WD and Ca. In the other hand, Turbid significantly correlated negatively (r2 = > - 0.669; $p < 0.05$). Furthermore, WD positively correlated (r2 = > 0.832; $p < 0.05$) with DO. While TDS correlated significantly (r2 = > 0.879; $p < 0.05$) with WD. Moreover, Ca showed significant strong but negative correlations (r2 = > - 0.819; $p < 0.05$) with TDS. Again, Fe revealed significant positive correlation (r2 < - 0.655; $p < 0.05$) with Cl. In the same vain NO3 significantly correlated negatively (r2 = > - 0.726; $p < 0.05$) with Cl (Table 3).

Table 3: Correlational matrix of physicochemical and biological parameters

	Mussel	**Snail**	**pH**	**Temp**	**DO**	**Turbid**	**WD**	**TDS**	**Ca**	**Fe**	**Mg**	**Cl**
Mussel												
Snail	**0.800**											
pH	**-0.639**	-0.555										
Temp	-0.124	-0.192	-0.514									
DO	0.549	0.574	**-0.894**	0.561								
Turbid	**-0.645**	**-0.615**	**0.883**	-0.485	**-0.869**							
WD	**0.752**	**0.611**	**-0.811**	0.344	**0.832**	**-0.803**						
TDS	**-0.674**	-0.589	**0.881**	-0.484	**-0.919**	**0.874**	**-0.879**					
Ca	0.500	0.525	**-0.916**	0.556	**0.884**	**-0.891**	**0.716**	**-0.819**				
Fe	**-0.635**	-0.579	**0.802**	-0.501	**-0.870**	**0.732**	**-0.864**	**0.826**	**-0.759**			
Mg	-0.495	-0.329	0.182	0.046	-0.061	0.208	-0.235	0.173	-0.007	0.284		
Cl	-0.262	-0.231	0.746	**-0.691**	**-0.744**	**0.764**	**-0.684**	**0.733**	**-0.821**	**0.655**	-0.173	
NO3	**0.609**	0.568	**-0.841**	0.466	**0.906**	**-0.799**	**0.866**	**-0.848**	**0.845**	**-0.850**	-0.158	**-0.726**

Spearman's correlation for the analysis of physicochemical and biological parameters in the three study areas; Ajiwa, Are and Sabke dams of Katsina state. Mussel, Snail, pH, Temperature = Temp, Dissolved Oxygen = DO, Turiidity = Turbid, Water depth = WD, Total Dissolved Solid = TDS, Calcium = Ca, Iron = Fe, Maganesium = Mg, Chloride = Cl, Nitrate = NO_3 The **bolded** r-values in the table showed medium or significant correlation between or among the parameters at $p < 0.05$.

Museels and snails community structure and composition in the study areas

Analysis of museels and snails community structure and composition in the samples collected from the study areas. Generally, the *Aspatharia hartmanni* recorded H = 2.578 and D = 0.912 which showed the highest Simpson and Shannon diversity respectively (Table 4). Thus, alpha diversity indicated that the two species had higher contribution in terms of richness and evenness in the study areas. The evenness index of species is higher in *Melanoides tuberculate* with index value = 0.917. Furthermore, the **Brillouin** richness index of species is higher in *Aspatharia hartmanni* having index value = 2.339. However, the dominance indices show ***Pila ovata*** to have 0.165 which is weighted toward the abundance of the commonest species.

On the Beta diversity, the Principal component analysis (PCA) plot showed that Turbid and TDS were more inclined to Ajd. Whereas, WD, NO3 Ca and DO were closely associated to Sbd. Furthermore, Cl, snail and mussel were more linked to Ard. (Figure 4).

Table 4: Alpha diversity index (* signified the highest index among the species)

	Aspatharia wahlbergi	***Unio tumidus***	***Aspatharia hartmanni***	***Unio crassa***	***Pila ovata***	***Melanoides tuberculate***
Taxa_S	12	11	17	11	12	12
Individuals	55	19	108	17	97	63
Dominance_D	0.109	0.108	0.088	0.114	0.165*	0.0965
Simpson_1-D	0.891	0.892	0.912*	0.886	0.835	0.9035
Shannon_H	2.324	2.306	2.578*	2.282	2.064	2.398
Evenness_e^H/S	0.851	0.912	0.775	0.891	0.656	0.917*
Brillouin	2.025	1.736	2.339*	1.679	1.881	2.119
Menhinick	1.618	2.524	1.636	2.668	1.218	1.512
Margalef	2.745	3.396	3.417	3.53	2.405	2.655
Equitability_J	0.935	0.962	0.909	0.952	0.831	0.965
Fisher_alpha	4.733	10.9	5.67	13.49	3.605	4.396
Berger-Parker	0.163	0.158	0.139	0.177	0.299	0.127
Chao-1	12	13	17.25	18	12.33	12

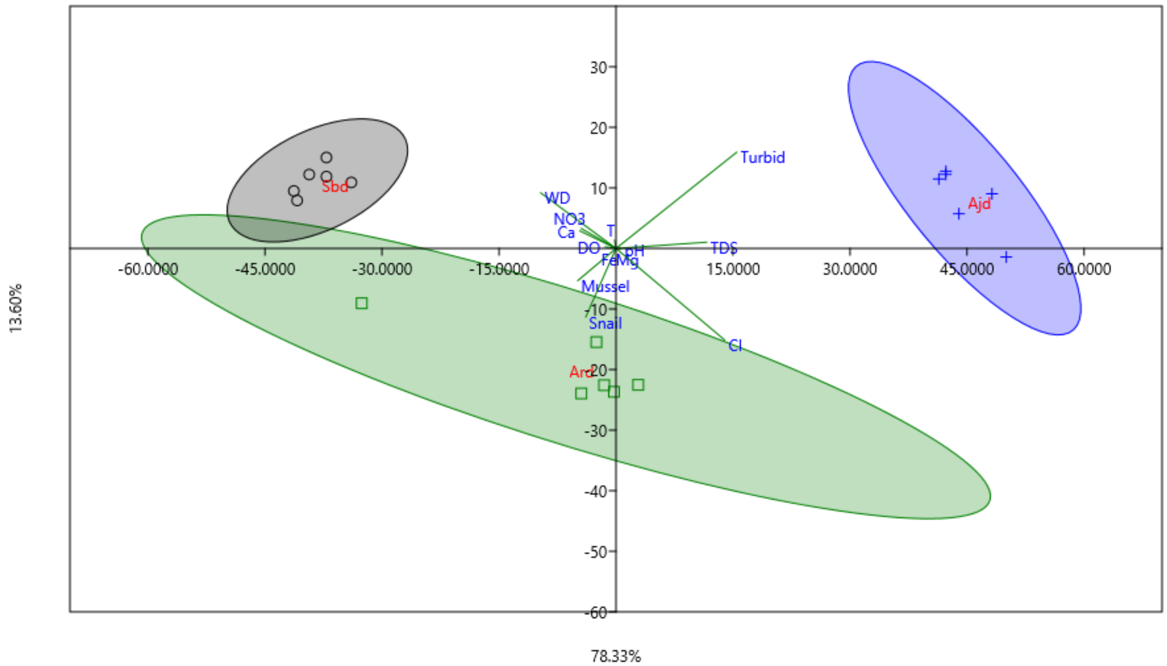


Figure 4: Principal Component Analysis plot of biological and physicochemical parameters of significance different to three areas; Ajiwa = Ajd, Are = Ard and Sabke = Sbd (PCA1 = 78.33% and PCA2 = 13.60%). Mussel, Snail, pH, Temperature = T, Dissolved Oxygen = DO, Turiidity = Turbid, Water depth = WD, Total Dissolved Solid = TDS, Calcium = Ca, Iron = Fe, Chloride = Cl, Nitrate = NO_3. The vector with arrows depicted significant level of correlation; among the parameters and the areas.

Discussion

Mussels and snails in the study areas: The morphological analysis revealed four distinct species of mussels across the three study areas (Ajd, Ard and Sbd) dams. The species include; U. *tumidus,* U. *crassus*, *Aspatharia hartmanni* and *Aspatharia wahlbergi*. The first two species are in accordance with Zhadin's (1938) system of identification and classification. While, Huber (2010); MolluscaBase eds, (2023) identification guides were adopted for the last two species identified. However, according to Brown (1994) two species of snail were (*Pila ovata* and *Melanoides tuberculate*) identified in two areas (Ard and Sbd dams) and absent in the tird area (Ajiwa dam).

Mussels and snails as bio-indicators: The mussels pump water via the incurrent aperture, incurring oxygen and food. They remove zooplankton and phytoplankton, bacteria, spores of fungi and organic matter. (Nichols et al., 2005). On the other hand, the occurrence of *Pila ovata* in abundance may be ascribed to human and animal activities in the dam. And this in line with research finding of Sanu et al

(2020) highlighting their economic importance as herbivores feeding on vegetative biomass which likely affect the standing crop and dispersion of primary producers in the aquatic environment.

The presence of some species of especially snail in some areas and absence in other area, signify some uniqueness of the species in the study areas in question. And feature study on the species may reveal further information on ecological status and roles of species under study. The living organisms such snails could easily be monitored and whose status reflects or predicts the condition(s) of the environment where they are found (Burger, 2006). Thus, invariability use as indicator species. Indicator species are considered to signify the status of the environment and by extension can be used for a larger number of species which can then provide useful data for measurements the condition and transformation of biodiversity of given area (Nguyen, 2007). The indicator species based on their functions; the presence and/or intensity of stressors, that is environmental indicators which could be sentinels: are sensitive species that provide early-warning of the presence of pollutants or to determine the effects of pollutants on biota. The detectors: are species that are endemic to a target area and may exhibit a measurable response to change in their environment; changes in behaviour, mortality or age-class structure. The exploiters: are species whose presence indicates probable disturbance or pollution. They often thrive in polluted areas since their competitors are unable to survive or utilize in the polluted ecosystems or the pollutants. While some species are accumulators: as they accumulate pollutants in large quantities in their body (Mekonen, 2017).

Physico-chemical parameters and their relationship within mussels and snails' species: Water physicochemical parameters such as WD and NO_3 are positively linked with mussels. However, the number of mussels decreases as the level of pH, Turbid, TDS and Fe increases. It is noted that extreme values of pH can cause problems to aquatic fauna; organism may develop skin irritations, ulcers and impaired gill functioning as a result of extremely acid or alkaline water condition (McCaffrey, 2023). This result is contrary to finding of (Tanke and Brett-Surman, 2001) that slow dissolution of these shells tends to release calcium carbonate into the water thereby raising the of pH the water. Similarly, TDS can also envelop aquatic plants as they settle out in low flows, and clog mouthparts and gills of aquatic macroinvertebrates such as mussels (McCaffrey, 2023).

Diversity of museels and snails communities in the study areas: The diversity indices of the museels and snails communities demonstrated that *Aspatharia hartmanni* recorded the highest Simpson and Shannon diversity. Whereas, richness and evenness in the study areas. The evenness index of species is higher in *Melanoides tuberculata*. Thus, the species appear to be a potential bioindicator of the parasite presence, and being first intermediate host of the lung fluke *Paragonimus africanus* and P. *uterobilateralis* (Sanu *et al*., 2020). Their occurrence in Ard and Sbd, although, no cercariae of the parasite seen on the host. The presence of the host on itself may be instrumental toward parasitic infestation of the environment.

Conclusion

Based on the results of the research three species of mussels (U. *tumidus*, U. *crassus*, *Aspatharia hartmanni* and *Aspatharia wahlbergi*) are conspicuously presence across the three study areas. The diversity and abundance of *Aspatharia hartmanni* in the study areas suggested that the species could be used as indicator species. The presence or the intensity of stressors shown by the species is sentinels to be used as environmental indicators. The presences of *Melanoides tuberculata;* intermediate host of trematode parasites in the two areas of study could facilitate the spread of the parasites. Thus, will require further surveys to be undertaken regularly on the host and the parasites in question towards possible control.

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