Journal of Science Research and Reviews
PRINT ISSN: 1595-9074
E-ISSN: 1595-8329
DOI: https://doi.org/10.70882/josrar.2026.v3i5.283
Homepage: https://josrar.esrgngr.org
Original Research Article

Interactions of Some Physicochemical Parameters and Sediment Heavy Metals with Snails Species in Ajiwa Reservoir

***[1,2]Idris, M., †[1]Auta, T. and [1,3]Bichi, A. H.**

[1]Department of Biological Sciences, Faculty of Life Sciences, Federal University Dutsin-Ma, Nigeria
[2]National Biotechnology Research, and Development Agency, Bioresource Development Center Katsina, Nigeria
[3]Department of Fisheries and Aquaculture, Faculty of Renewable Natural Resources, Federal University of Dutsin-Ma, Nigeria
*Corresponding Author's email: idrism398@gmail.com
ORCID iD: *https://orcid.org/0000-0002-9662-8198; †https://orcid.org/0000-0002-6590-484X

KEYWORDS
Snail,
Heavy metal,
Sediment,
Abundance,
Physicochemical parameters.

ABSTRACT
The aim of this study is to examine some physicochemical parameters, sediment heavy metals concentrations and their interaction with Snails Species in Ajiwa Reservoir, Katsina State. The study was carried out from September to December, 2023. The water and sediment samples were collected twice a month from four (4) sampling stations (A, B, C and D) and analysed for physicochemical parameters such as (pH, temperature, transparency, conductivity, DO and BOD) and heavy metals (Co, Cu, Ni, Mn and Pb) using standard procedures. Snail samples were collected with the aid of D-frame sweep sampler net and identified using standard keys. The physicochemical parameters were found to be within the WHO/NESREA standard limits. The mean of physicochemical parameters of Ajiwa reservoir were pH (7.1031±0.4849), Temperature (22.9281±4.0192), Transparency (12.6093±2.4654), Conductivity (113.9700±10.6330), DO (6.7812±1.0908), and BOD (3.5225±0.8854). The concentration of heavy metals was found in ascending order of Co>Pb>Ni>Mn>Cu. A total of 427 snails from seven (7) different species were observed. There was less abundance of snail species in the month of September (76) and high in October (123). Sampling station C has less abundance of snail species (13) while sampling station B has high abundance (174). The Pearson correlation analysis revealed some snails' species to have positive and negative correlation with Cu, pH and conductivity. The study concludes that there is high abundance of snail species in Ajiwa reservoir particularly in the month of October while less in September. It is recommended that regular assessments of snail species and physicochemical parameters should be conducted to understand ecosystem dynamics.

CITATION
Idris, M., Auta, T., & Bichi, A. H. (2026). Interactions of Some Physicochemical Parameters and Sediment Heavy Metals with Snails Species in Ajiwa Reservoir. *Journal of Science Research and Reviews*, *3*(5), 127-133. https://doi.org/10.70882/josrar.2026.v3i5.283

This work is licensed under the Creative Commons Attribution 4.0 International License

INTRODUCTION

Freshwater environments, including lakes, ponds, rivers, reservoirs, and streams, are influenced by a wide range of physicochemical factors, such as temperature, light, dissolved oxygen, biochemical oxygen demand, carbon dioxide, pressure, density, buoyancy, and pH (hydrogen ion concentration), which can significantly affect the abundance, distribution, and diversity of aquatic flora and fauna (Auta et al., 2023). Anthropogenic activities, particularly industrial development and agricultural practices, have contributed substantially to the pollution and degradation of freshwater ecosystems, including dams and rivers, thereby posing threats to aquatic life (Sadauki et al., 2024). Among the major pollutants of aquatic ecosystems are heavy metals, generally defined as metals with a relative density greater than 5 g/cm^3, whereas metals with a density below 5 g/cm^3 are considered light metals (Olaifa, 2004). Heavy metals constitute an important group of inorganic pollutants because of their toxicity, persistence, and potential to bioaccumulate in aquatic organisms, making them particularly harmful to aquatic ecosystems (Authman, 2008; Abubakar et al., 2024). Freshwater snails, as integral components of the food web and potential disease hosts, are essential indicators of environmental health (Pissia *et al*., 2021). Freshwater snails as important components of aquatic ecosystems and may respond to changes in physicochemical conditions and heavy metal concentrations, making their abundance, distribution, and diversity useful for assessing environmental conditions. Therefore, investigating the relationships between physicochemical parameters, sediment heavy metals, and snail species in the Ajiwa Reservoir, Katsina State, is important for understanding the ecological condition and potential environmental impacts within the reservoir.

Fresh water Snails species in Ajiwa reservoir, Katsina State, faces potentials threats from human activities such as Agricultural run-off, domestic waste, sewage effluent and industrial pollution, which may lead to changes in water quality and sediment characteristics resulting in alteration in the distribution, abundance and diversity of macrobenthic invertebrate, decreased ecosystem health and resilience and impacts on the ecological and economic importance of the reservoir (Usman and Adakole, 2017).

Additionally, domestics and agricultural run-off may increase the level of heavy metal pollution to the reservoir in which excessive amounts are poisonous and may affect aquatic organisms and humans.

Physicochemical water quality parameters provide snapshots of the condition of a water body at a given point in time though may not effectively provide an integral measure of the overall health of the water body and can, at times, inadequately identify impaired waters. An integrative approach incorporating biological measures like benthic macro-invertebrates community structure alongside other physicochemical water quality parameters can thus provide a more comprehensive assessment of the health of a water body over time.

Previous studies reported by Usman and Adakole (2017) on biodiversity assessment of some macrobenthic invertebrates in Ajiwa Reservoir Katsina State Nigeria. The research conducted by Zaharaddeen and Rafindadi (2018) on the impacts of human activities on the limnology and water quality index of Ajiwa reservoir, Katsina indicates a notable gap in exploring heavy metals concentration in the sediment of Ajiwa Reservoir. Hence, this study seeks to address this gap by investigated the impact of physicochemical factors and sediment heavy metals on snail species in the Ajiwa Reservoir, Katsina State, Nigeria.

MATERIALS AND METHODS

Study Site

The Ajiwa Reservoir is situated in the Batagarawa Local Government Area of Katsina State, Nigeria, at coordinates 12°54'69" - 12°57'58" N and 7°42'53" - 7°47'50" E. Located in the Sudan savannah zone, it experiences two distinct seasons: a wet season from May to October and a dry season from November to April. Constructed in 1973 and commissioned in 1975, the reservoir primarily serves for irrigation and water supply to Katsina, Batagarawa, Mashi, and Mani local government areas. The Tagwai River is its main water source. The reservoir was originally 12 meters high, with a crest length of 880 meters. After rehabilitation in 1998, its height increased to 14.7 meters and the crest length to 1491.8 meters, covering a surface area of 607 hectares and storing approximately 22,730,000 cubic meters of water. It supports nearby communities such as Ajiwa, Masabo, Tsagero, Kwatami, Maje, and Gajerengiwa villages (Usman & Adakole, 2017)

Sample Stations

Four sampling stations, labeled A, B, C, and D, were selected along the reservoir. Samples were collected twice a month from 8-10 am over four months (September to December 2023).

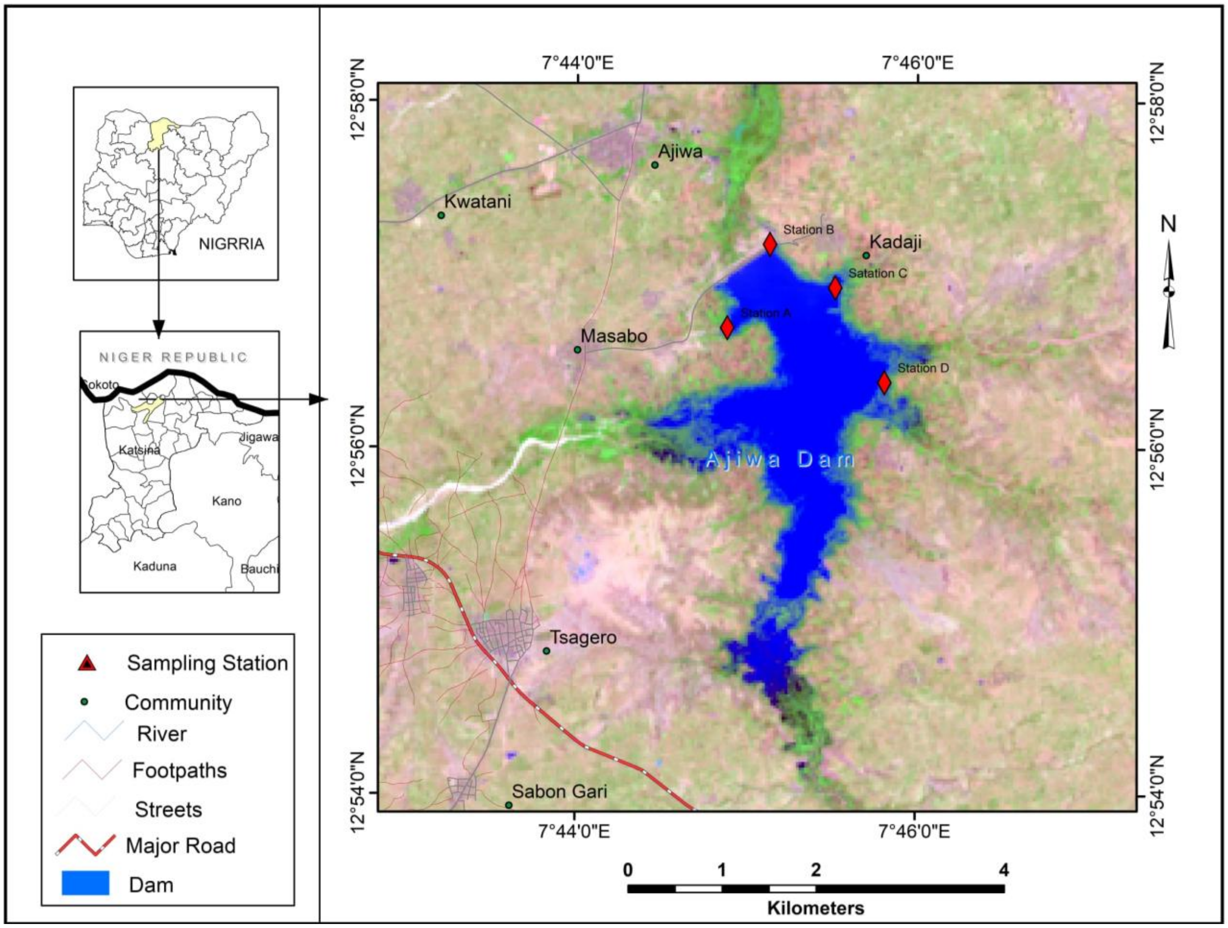

Figure 1: Map of Ajiwa Reservoir showing different sampling stations (FUDMA, 2024)

Sample Collection
Water samples were collected in sterilized bottles from four stations. Each bottle was rinsed multiple times with the water to be sampled. Water was collected at the surface by sliding the bottle against the water current to ensure an undisturbed flow. The bottles were labelled and taken to the laboratory for analysis (Usman, 2016).

Analysis of Physicochemical Parameters
Water temperature, pH, and dissolved oxygen were measured *in situ* using a thermometer, pocket-sized pH meter, and Auto-cal dissolved oxygen analyser, respectively. Transparency and electrical conductivity were measured using a Secchi Disc and conductivity meter (Hanna Model EC 215), respectively (USEPA, 2016). Biochemical oxygen demand (BOD) was determined by incubating samples for five days at 20°C and using the Winkler method. BOD was calculated as BOD = (D1 − D2), where D1 is the initial dissolved oxygen and D2 is the dissolved oxygen after five days (Gupta, 2001).

Heavy Metal Analysis
All equipment used for sample collection and analysis was pre-cleaned with high-purity nitric acid to avoid contamination. Sediment samples were collected in plastic containers and taken to the lab for analysis (Ewutanure, 2018).

Sample Digestion
1.0g of the sample was digested with 2.5 ml of concentrated nitric acid and 5.0 ml of Perchloric acid in a fume hood until a clear solution was obtained. The solution was cooled, filtered into a 100ml volumetric flask, diluted to the mark with distilled water, and then analysed using an Atomic Absorption Spectrophotometer (AAS) (Adeboye, 2017).

Snail Sampling and Identification
Snail species were sampled monthly from each station using a sweep sampler between 8:00 am and 10:00 am. Snails were collected with handpicking and forceps, stored in labelled specimen bottles and identified in the Umaru Musa Yar'adua University laboratory based on morphological traits using standard keys. (Stream Health Monitoring and Assessment Kit (SHMAK), iNaturalist and National Institute of water and Atmospheric Research). (NIWA) invertebrate identification key. (Auta *et al*., 2024).

Data Analysis
Data were entered into a spreadsheet and analysed with SPSS version 20.0 using descriptive statistics and One-Way ANOVA to analyse heavy metal concentrations. Correlation analysis determined relationships between physicochemical parameters, heavy metal concentrations, and snail species. Statistical significance was set at $P < 0.05$

RESULTS AND DISCUSISON

Physicochemical Parameters and Heavy Metals Concentrations in Ajiwa Reservoir

Table 1 presents the mean and standard deviation of physicochemical parameters and heavy metal concentrations in the Ajiwa Reservoir. The physicochemical parameters (pH, temperature, transparency, conductivity, DO, and BOD) are within the permissible limits set by the World Health Organization (WHO) and the National Environmental Standards and Regulations Enforcement Agency (NESREA). The concentration of heavy metals follows this order: Co > Pb > Ni > Mn > Cu. While Co, Mn, and Cu are below the upper permissible limits, Pb (0.2840 ± 0.1669 mg/L) and Ni (0.2096 ± 0.1519 mg/L) exceed the WHO/NESREA limits of 0.01 mg/L and 0.07 mg/L, respectively.

Abundance, Distribution, and Diversity

A total of 427 individual mollusks (gastropods) representing distinct species were documented. In September, *Pila ovata* was the most abundant with 22 individuals, while *P. antipodrum* had none. In October, *Viviparus contectus* dominated with 30 individuals, and *P. antipodrum* again had none. November saw 38 individuals of *Bulinus* sp, with *P. antipodrum* showing low abundance at 2 individuals. In December, *Lymnaea stagnalis* was most abundant with 59 individuals, while *P. antipodrum* had only 1 individual (Table 2).

Viviparus contectus (38 individuals) dominated Station A, and *Bulinus* sp (40 individuals) dominated Station B, with *P. antipodrum* absent in both. Station C had *L. stagnalis* with 7 individuals, while *Biomphalaria* sp, *Melanoid* sp, *Pila ovate*, and *Viviparus* sp were absent. In Station D, *L. stagnalis* sp led with 73 individuals, and *P. antipodrum* was absent (Table 2).

Correlation Coefficient between Physicochemical Parameters and Heavy Metals in Sediments with Snail Species at Ajiwa Reservoir

The Pearson correlation analysis presented in Table 3 illustrates significant relationships between physicochemical parameters, heavy metals in sediments, and macrobenthos invertebrates at Ajiwa Reservoir. *Biomphalaria* sp shows a notably strong negative correlation with pH (-0.629**), while *Bulinus* sp exhibits a robust positive correlation with Cu (0.507*). *Lymnaea* sp demonstrates a negative correlation with conductivity (-0.489*), whereas *Melanoides* sp and *Pila ovata*, sp display very strong positive correlations with Cu (0.750**, and 0.585**, respectively), while *Viviparous sp*, shows a strong negative correlation with pH (-463*). These correlations highlight the intricate interactions between environmental factors and aquatic invertebrates in the reservoir ecosystem, underscoring the influence of pH, conductivity, and heavy metal concentrations on different snail species

Table 1: Physicochemical Parameters and Heavy Metals Concentrations in Ajiwa Reservoir

Parameters	Mean±S.D	Range Values		Alani *et al.* (2014) [NESREA/WHO Limit]
		Minimum	Maximum	
pH	7.1031±0.4849	6.0400	8.0200	6.5-8.5
Temperature (^{0}C)	22.9281±4.0192	18.3000	31.5000	12-25
Transparency	12.6093±2.4654	7.5000	17.3000	5.0
Conductivity	113.9700±10.633	96.0000	139.0000	1000
DO	6.7812±1.0908	4.7400	8.9100	6.0
BOD	3.5225±0.8855	1.8900	4.7200	6.0
Co (mg/L)	0.4158±0.1583	0.1180	0.7560	1.0
Cu (mg/L)	0.0683±0.0407	0.0160	0.2090	1.2
Mn (mg/L)	0.0772±0.0305	0.0100	0.5100	0.4
Ni (mg/L)	0.2096±0.1519	0.0040	0.5410	0.07
Pb (mg/L)	0.2840±0.1669	0.01900	0.5960	0.01

Key: DO= Dissolve Oxygen; BOD=Biochemical Oxygen Demand; Co= Cobalt; Cu= Copper; Mn= Manganese; Ni= Nickel; Pb= Lead.

Table 2: Molluscs (*Gastropod*) Abundance and distributions by sampling Months and Stations

Molluscs (*Gastropod*)	Month				Station			
	September	October	November	December	Station A	Station B	Station C	Station D
Biomphalaria sp	5	6	1	0	4	2	0	6
Bulinus sp	13	20	38	9	21	40	5	14
Lymneae stagnalis	17	28	32	59	25	31	7	73
Melanoids sp	2	20	7	2	2	28	0	1
Pila ovate	22	19	19	9	16	41	0	12
Potamopyrgus sp.	0	0	0	1	0	0	1	0
Viviparus Contectus	17	30	25	26	38	32	0	28

Table 3: Correlation Coefficient of between Physicochemical Parameters and Heavy Metals in Sediments with Macrobenthic Invertebrates at Ajiwa Reservoir

	pH	Temp	Transp	Cond.	Cu	Mn	Ni	Pb
Biomphalaria sp	-.629**	.155	-.384	-.014	-.312	-.063	-.082	.071
Bulinus sp	.193	.050	.110	-.296	.507*	.232	-.092	-.086
Lymneae sp	-.271	.110	-.044	-.489*	-.172	.348	.243	.051
Melanoids sp	.073	.153	-.053	-.013	.750**	.068	-.079	-.096
Pila Ovata	-.019	-.121	.039	-.128	.585**	.071	-.294	-.065
Viviparus sp	-.463*	.114	-.104	-.294	.158	.232	.003	.168

* Significant correlation at $p < 0.05$

** Significant correlation at $p < 0.01$

Discussion

The physicochemical parameters (pH, Temperature, Transparency, Conductivity, Dissolved Oxygen, and BOD) of Ajiwa Reservoir were found to be within acceptable limits set by WHO/NESREA. The pH ranged from 6.67 to 8.67, reported by (Usman, 2016, Tukur *et al*., 2023;). In consistent with current reading of 7.10. Temperature averaged 22.90°C, aligning with NESREA standards for aquatic life support (Usman, 2016). Transparency, measured by the Secchi Disc, averaged 12.6093, with lower values observed during October due to increased sediment from flooding (Zaharadeen & Rafindadi, 2018). Conductivity was recorded at 113.9700 µs/cm, below the NESREA limit of 1000 µs/cm (Usman, 2016). Dissolved Oxygen (DO) measured 6.7812±1.0908 mg/L, with higher concentrations during the rainy season, affecting temperature (Zaharaddeen *et al*., 2018).

Biochemical Oxygen Demand (BOD) levels averaged 3.5225±0.8854 mg/L, peaking in December and lowest in October, correlating with dry season biological activity (Usman, 2016; Zaharaddeen *et al*., 2018).

Heavy metal concentrations in Ajiwa Reservoir sediment were found in the order of Co > Pb > Ni > Mn > Cu. Cobalt levels were 0.4158±0.1583 mg/L, below WHO/NESREA limits (Uba *et al*., 2021). Copper (Cu) levels at 0.0683±0.0407 mg/L were comparable to previous studies (Ahmad *et al*., 2020). Manganese (Mn) concentrations were 0.0772±0.8455 mg/L, within WHO/NESREA standards (Yar'adua *et al*., 2018). Nickel (Ni) concentrations measured 0.2096±0.1519 mg/L, exceeding WHO/NESREA limits (Sani *et al*., 2016). Lead (Pb) levels were 0.2840±0.1669 mg/L, above permissible limits (Yar'adua *et al*., 2018).

Snail species abundance varied monthly and by station, with notable findings from Auta *et al*. (2018) in Zobe Dam indicating similar patterns. Pearson correlation analysis revealed significant relationships between snail species and physicochemical parameters, notably a negative correlation between *Biomphalaria sp*. and pH, and positive correlations with heavy metals such as Cu. Snail abundance peaked in October, reflecting favorable environmental conditions.

CONCLUSION

The study concludes that Ajiwa Reservoir's physicochemical parameters generally meet regulatory standards, although sediment heavy metal concentrations, particularly Ni and Pb, exceed permissible limits. Snail abundance correlates with seasonal and spatial variations, indicating ecological sensitivity to water quality and heavy metal contamination.

REFERENCES

Abubakar, A., Musa, I. B. and Ibrahim, I. M. (2024). Impact of Heavy Metals and Organophosphates on Freshwater Ecosystems. *Journal of Aquatic Pollution*, 15(3), 205-217.

Adeboye, I. A. (2017). Determination of Heavy Metals in Water, Fish and Sediment from Ujere Water Reservoir. *Journal of Environmental Analytical Toxicology*. 7:486.

Ahmad, AA; Usman, H (2020). Determination of Heavy Metal Accumulation in Tilapia Fish (*Oreochromis niloticus*) Tissues harvested from Ajiwa Dam, Batagarawa, Katsina State. *FUDMA Journal of Sciences* 7(1), 219-223.

Alani, R., Alo, B., and Ukoakonam, F. (2014). Preliminary investigation of the state of pollution of Ogun River at Kara Abattoir, near Berger, Lagos. *International Journal of Environmental Science and Toxicology,* 2(2), 11-23.

Auta, J., Ibrahim, Y. K. and Dahiru, A. A. (2024). The Role of Freshwater Snails in Ecosystem Function and Biodiversity. *Aquatic Science and Technology*, 9(4), 333-347.

Auta, T; Agnes, A; Bichi, AH (2023). Wet season water quality and zooplanktons community of Jibia lake, Katsina Katsina State, *Asian Journal of Biological Science*. 16(2): 175-187. ISSN : 19996- 3351.

Auta, T; Alkal, E; Michael, EA (2018). Population dynamics, diversity and distribution of freshwater snails in Zobe Dam, Dutsin-Ma, North-Western Nigeria. Asian J. Environ. Ecol., Vol. 8. https://doi.org/10.9734/ajee/2018/v8i430078

Auta, T; Rabiu, MD; Sadauki, MA (2024). Interactions of Physicochemical Parameters with Snails in Dutsin-Ma Reservoir. *Asian Sci. Bull.*, 2 (4): 401-408, 2024.

Authman, M. M. N. (2008). Use of Fish as Bio-indicators of the Effects of Heavy Metals Pollution. *Journal of Aquatic Biology and Fisheries*, 12(1), 24-35.

Ewutanure, JS (2018). Phd Thesis, Fisheries Department, UNIBEN. p. 38

Garg, RK; Rao, R.J; Saksena, DN (2009) Correlation of molluscan diversity with physicochemical characteristics of water of Ramsagar reservoir, India. *International Journal of Biodiversity and Conservation*. 1(6) pp. 202-207. ISSN: 1813-0070. https://doi.org/10.3923/asb.2024.401.408

Gupta, V. K., Gupta, M., & Sharma, S. (2001). Process development for removal of lead and chromium from aqueous solution using red mud-an aluminium industry waste. *Water Research,* 35(5), 1125-1134

NESREA. (2011). National Environmental (Surface and Ground Water Quality) Regulations. National Environmental Standards and Regulations Enforcement Agency.

Olaifa, F. E. (2004). Heavy Metals in Aquatic Environments and Their Effects on Fish Health. *Fish Pathology Journal*, 11(2), 76-85.

Pissia, T., Katsara, K. and Kanelis, D. (2021). Freshwater Snails: Ecology, Diversity, and Significance in Aquatic Habitats. *Journal of Molluscan Studies*, 87(1), 65-79.

Sadauki, H. M., Abubakar, A., & Musa, I. B. (2024). Anthropogenic Activities and Their Impact on Aquatic Ecosystems. *Journal of Environmental Pollution and Control*, 22(1), 98-110.

Sadauki, MA; Auta, T; Umaru, J (2024). AN APPRAISAL OF AQUATIC POLLUTION: A REVIEW. Agricultural Science: *An International journal* (AGRIJ), Vol.1, No.2, 2024

Sadauki, MA; Bichi, AH; Dauda, AB; Geidam, MB (2022). Assessment of Water Quality Parameters of Zobe and Ajiwa Reservoirs, Katsina State, Nigeria, *African Scientist* 23 (1): 9-18, http://www.niseb.org/afs

Sani, A. R., Zayyad, B. and Patricia, A. E. (2016). Trace Metals Distribution in Water and Sediment from Selected Water Bodies in Kano State, Nigeria. 8th International Conference on Latest Trends in Engineering and Technology. (8): 56-60.

Tukur, SA; Auta, T; Atalabi, ET (2023). Ecological Observations of Freshwater Snails in the Vicinity of an Artificial Lake. *Science World Journal*. Vol. 19 (1).

Uba, S; Ajibola VO; Adeosun, OS; Ikeh, DC; Mikal, A; John, AK; Rumah, MM (2021). Assessment of physicochemical parameters, Geo-accumulation Indices and contamination factor of sediment from Mairua Dam, Faskari LGA, Katsina state North-western Nigeria, *Communication in physical sciences*, 7(4): 454-462

USEPA. (2010). List of Contaminants and their Maximum Contaminants Levels (MCLs). http://water.epa.gov/drink/contaminant/index.cfm#List. Accessed on 13/2/2016.

USEPA. (2016). Habitat Assessment and Physicochemical Parameters

Usman, LU (2016). Effects of Anthropogenic Activities on the seasonal variation of some physicochemical parameters in Ajiwa Reservoir, Katsina State, Nigeria. *Annals of Experimental Biology*, 4 (4): 146-151.

Usman, LU; Adakole, JA (2017). Biodiversity Assessment of some Benthic Macro Invertebrates in Ajiwa Reservoir, Katsina State Nigeria. *UMYU Journal of Microbiology* UJMR, 2(1): 1-10

Yar'adua A. I, Alhassan A. J, Nasir A, Matazu K. I, Muhammad I, Idi A, Muhammad I. U and Aliyu S. M (2018) Evaluation of Heavy Metals in Sediment of Some Selected Dams from Katsina State Nigeria. *International Journal of Scientific and Technical Research in Engineering* (IJSTRE) 3(2)

Zaharaddeen, HY; Rafindadi, NK. (2018). Impacts of human activities on the limnology and water quality index of Ajiwa Dam, Katsina, *International journal of fisheries and Aquatic studies,* 6(6):341-347.