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ECOLOGICAL ASSESSMENT OF FRESHWATER SNAIL SPECIES IN RIVER BENUE AT IBI SITE, TARABA STATE, NIGERIA

By

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Abstract

Water snail species are aquatic invertebrates found in freshwater and other aquatic environments worldwide and several factors such as physical, chemical and biological factors affects their ecology. This study was carried out to identify the freshwater snail species in River Benue at Ibi site; to determine their abundance, diversity and analyze the physicochemical properties influencing their population. Freshwater snail species and water samples were collected from November 2024 to January 2025, analysed in-situ and others taken to the laboratory for identification and analysis. The result showed that 267 snail species were collected and 10 species were identified from various families. The highest abundance was recorded in November (150). The Viviparidae family was the most abundance having higher number of species (2, 20%) and individuals (144, 53.93%). The Shannon–Weiner diversity index showed that the month with highest number of snail species were recorded in November with a value of 1.235 and evenness (0.768), while the most diverse month was seen in the month of January with a value of 1.216. The water remained colourless throughout the period, with pH, temperature, turbidity, dissolved oxygen, conductivity and total dissolved solids ranging from 6.75 to 7.45, 21.53 to 29.23°C, 0.25 NTU, 5.96 to 6.32 mg/L, 63.20 to 85.97 mg/L and 29.13 to 39.73 mg/L, respectively. This research serves as a baseline study for freshwater snail species in the River Benue at Ibi site and it shows the dynamic nature of the river ecosystem and the importance of environmental factors in shaping freshwater snail species populations. It is observed that regular monitoring of water quality parameters such as pH, water temperature, dissolved oxygen, electrical conductivity, and total dissolved solids should be conducted to identify potential threats early and maintain the health of the river ecosystem.

Keywords: *Abundance, Ecology, Snail species, Physicochemical, Water quality, River*

INTRODUCTION

Water bodies are natural or artificial formations that contain and store water (Akhtar *et al*., 2021). The most common water bodies include rivers, lakes, ponds, and wetlands (Xiong *et al*., 2022). They play a crucial role in maintaining ecological balance, supporting biodiversity, and providing various resources necessary for human survival and economic activities (Vörösmarty *et al*., 2018; Ahmed *et al*., 2022). The availability and quality of water resources are critical for sustaining life and supporting various economic activities. Over time, these water bodies have also been utilized for fishing, transportation, and as a source of renewable energy through hydropower (Rahman *et al*., 2022).

Snails are aquatic invertebrates belonging to the class Gastropoda that may be found in freshwater and other aquatic environments worldwide (Pyron and Brown, 2015). Snails play a vital role in nutrient cycling, helping to break down organic matter and contribute to the health of the ecosystem. They are essential to food webs, the cycling of nutrients, and the assessment of water quality (Johnson *et al*., 2013).

Several factors such as physical, chemical and biological factors affects the ecology of freshwater snails (Bagalwa *et al*., 2024). Temperature, food availability, parasites, predators,

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rainfall, sedimentation patterns, changes in water flow and nutrient availability all affect the distribution and quantity of snails and can modify substrate availability for snail colonization and reproduction (Bennett *et al*., 2015).

Freshwater snails face a grave threat of extinction, particularly those inhabiting streams and rivers. Their diversity and abundance have significantly declined, with over 60 species believed to be extinct. This decline is particularly concerning as certain freshwater snails act as disease vectors to humans and animals (Dogara *et al*., 2020).

Freshwater snails are key bioindicators of aquatic ecosystem health. Understanding the factors that influence their distribution and population dynamics can provide valuable insights into the health of the Benue river ecosystem. By investigating the ecological conditions that support or limit snail populations, this study will contribute to the development of effective management strategies aimed at improving water quality and reducing the transmission of waterborne diseases. The findings from this research will have broader implications for biodiversity conservation and environmental management in the region. This study will provide scientific data that can inform conservation efforts, policy-making, and sustainable management practices in Benue River and similar freshwater systems.

There is a limited information on how these species respond to the altered environmental conditions in Benue River at Ibi site. Human activities, such as agricultural runoff, pollution, and habitat alteration, may be altering the ecological balance of Benue River. Hence, this study will focus on the ecological impact of freshwater snail populations in Benue River at Ibi site

The objectives of this study were to: identify the freshwater snails in Benue River at Ibi site, determine the abundance and diversity of freshwater snail species in Benue River at Ibi site and analyze the physicochemical properties influencing freshwater snail populations in Benue River at Ibi site.

MATERIALS AND METHODS

Study Area

The site selected for the study is the Benue River at Ibi site in Ibi Local Government Area of Taraba State, Nigeria (fig.1). Ibi Local Government Area is one of the sixteen Local Government Areas in Taraba State. It covers a total area of 2,672 Km^2 and extends between latitude 80^o, 19’ north of the equator and 90^o, 51 east of the Greenwich meridian. The town is located on the south bank of the Benue River, opposite the influence of the much smaller Shemankar River. Both the Taraba River and the Donga River flow into the Benue within the local government area. Ibi local government has two seasons, the rainy season which extends from April to October and the dry season which lasts for five months extending November and March, the annual rainfall ranges between 1,058 mm and 1,300 mm with a temperature range of 28^{o}C and 39^{o}C. The major occupation of the community in the studied area is fishing which is characterized by annual Nwonyo festival (Ogunremi *et al*., 2023). The aquatic habitats are surrounded by local communities, and they serve as an important source of water for surrounding rural communities for various purposes such as domestic use, irrigation, livestock watering, fishing, recreation and alike.

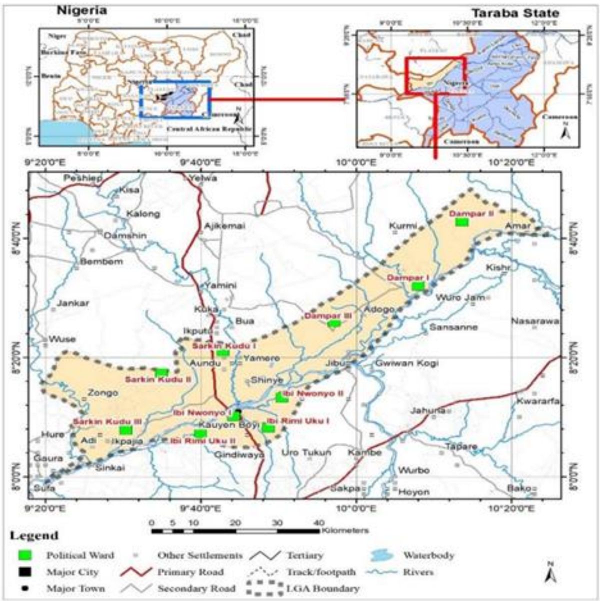

Fig. 1: Map of Nigeria showing Taraba state

Sample Collection

Freshwater snail samples were collected using scoop net and handpicking methods described by Okita *et al.* (2020). The snails were collected once every 3 month from November 2024 to January 2025 in 3 stations. Samples were collected with a long-handled snail sieve net (mesh size 3 mm – 4 mm). Snails were often seen near the edges of slightly deep waters or lodging in plant materials. The snails often come out in search of food from 8 am - 12 pm (a total of 4 hours). The sieve net was dragged through the water thereby collecting snails clinging to the aquatic plants. Where sieve net could not be used, snails were handpicked with gloved hands, placed in pre-labelled plastic specimen bottles and taken to Federal University Wukari Biology Laboratory for identification.

Sample Identification

The snail samples were sorted and then morphologically identified into their respective species as described by Bagalwa *et al*. (2024). The snails were counted to determine the number of each snail species collected per station.

Determination of Physicochemical Parameters of the Water

The surface water sample was collected from the sampling site by simple dipping. The sample of the water collected was transported to the laboratory for chemical analysis (Bagalwa *et al*., 2015). Power of Hydrogen/pH, Turbidity/Water transparency, Surface water temperature, Electrical conductivity and Total dissolved solids were determined on-site (APHA. 2005). Turbidity was measured in-situ with the aid of a Secchi disc of 20cm diameter with black and white quarters attached to a calibrated cord (cm). The pH of the surface water was determined in-situ with a pocket size pH meter. Surface water temperature, electrical conductivity and total dissolved solids were determined in-situ with

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EC/TDS/Temp COMBO meter. The methods of APHA (1992) was used for the determination of dissolved oxygen (DO) and biochemical oxygen demand (BOD) of the freshwater body.

Data Analysis

The data generated from the study was analyzed using Statistical Package for Social Sciences (SPSS) software, version 20. Percentages were used to express the frequency of distribution of freshwater snails with respect to species and sampling sites. One-way Analysis of Variance (ANOVA) was calculated to show a significant difference between the distribution and abundance of the freshwater snails across sampling sites. ANOVA was also used to show the significant difference between physicochemical factors and the sampling sites. Pearson's Correlation Coefficient was determined to show the direction (positive or negative) and magnitude (weak, moderate or strong) of the relationship between the snail population and physicochemical factors. The level of significance was determined at 5% ($P<0.05$) and 95% confidence limit.

RESULTS

Species Richness and Abundance of Freshwater Snails in River Benue at Ibi

Table 1, it shows the species richness and abundance of freshwater snails collected in River Benue at Ibi site from November 2024 to January 2025, showing 10 species from various families. These include *Viviparous contectus*, *Viviparous viviparous*, *Bithynia tentaculate*, *Bulinus globosus*, *Physosis africanus*, *Achatina achatina*, *Tritons trumpet*, *Lanistes libycus*, *Melanoides tuberculata* and *Potamopyrgus cilatus*. The total number of snails collected over the three months was 267, with the highest abundance recorded in November (150), followed by January (61) and December (56). In November, *Viviparous viviparous* (61) and *Bithynia tentaculata* (50) were the most dominant species. In December, *Physopsis africanus* appeared in large numbers (40). In January, *Viviparous viviparous* appeared in large numbers (52). Rare species like *Achatina achatina*, *Triton's trumpet*, *Lanistes libycus*, *Potamopyrgus cilatus*, and *Melanoides tuberculata* were recorded in very low numbers (1–2).

Percentage Abundance of Freshwater Snails Collected From River Benue at Ibi Site

Table 2, it shows the percentage abundance of freshwater snails collected in River Benue at Ibi site. The Viviparidae family were the most dominant, represented by 2 species (20%) and 144 individuals (53.93%). This was followed by Bithyniidae family with 1 specie (10%) and 50 individuals (18.73%). All the other family had 1 specie (10%). Physidae had 40 individuals (14.98%), Planorbidae had 26 individuals (9.74%), Achatinidae and Cymatiidae or Ranevidea had 2 individuals each (0.75%), Ampullaridae, Tateidae and Thiaridae had 1 individual each (0.35%).

Diversity, Richness and Evenness of Freshwater Snails Collected in River Benue at Ibi Site

Table 3, it shows the diversity, richness and evenness of freshwater snails collected in Benue River at Ibi site. Freshwater snails collected in November had the highest Shannon–Weiner diversity index (1.235) and evenness (0.768), indicating a more balanced distribution of species. Freshwater snails collected in January had the highest Margalef index (1.216), reflecting the presence of more species.

Physicochemical Parameters of River Benue at Ibi Site

Table 4, it shows the physicochemical parameters of water from River Benue at Ibi site from November 2024 to January 2025. The water remained colourless throughout the period, with pH values ranging from slightly acidic in November (6.92) and December (6.75) to mildly alkaline in January (7.45). Water temperature varied significantly as it increased from 21.53°C in November to 29.23°C in December, then slightly decreased to 28.6°C in January. Turbidity values remained relatively stable at around 0.25 NTU. Dissolved oxygen levels gradually decreased from 6.32 mg/L in November to 5.96 mg/L in January. Conductivity increased from 63.20 mg/L in November to 85.97 mg/L in December before slightly dropping to 79.77 mg/L in January. Total dissolved solids were highest in December (39.73 mg/L), with lower values in November (29.13 mg/L) and January (31.37 mg/L).

Table 1: Species Richness and Abundance of Freshwater Snails Collected in River Benue at Ibi Site from November 2024 to January 2025

Family	Snail species	November	December	January	Total
Viviparidae	*Viviparous contectus*	28	1	2	**31**
	Viviparous viviparous	61	0	52	**113**
Bithyniidae	*Bithynia tentaculata*	50	0	0	**50**
Planorbidae	*Bulinus globosus*	11	15	0	**26**
Physidae	*Physosis africanus*	0	40	0	**40**
Achatinidae	*Acahatina acahatina*	0	0	2	**2**
Cymatiidae or Ranevidea	*Tritons trumpet*	0	0	2	**2**
Ampullaridae	*Lanistes libycus*	0	0	1	**1**
Tateidae	*Potamopyrgus cilatus*	0	0	1	**1**

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Thiaridae	*Melanoides tuberculata*	0	0	1	**1**
Total		**150**	**56**	**61**	**267**
No of species		**4**	**3**	**7**	

Table 2: Percentage Abundance of Freshwater Snails Collected in River Benue at Ibi Site

Family	**Number of Species**	**Percentage of Species**	**Number of Individual**	**Percentage of Individual**
Viviparidae	2	20	144	53.93
Bithyniidae	1	10	50	18.73
Planorbidae	1	10	26	9.74
Physidae	1	10	40	14.98
Achatinidae	1	10	2	0.75
Cymatiidae or Ranevidea	1	10	2	0.75
Ampullaridae	1	10	1	0.35
Tateidae	1	10	1	0.35
Thiaridae	1	10	1	0.35
Total	**10**	**100**	**267**	**100**

Table 3: Diversity, Richness and Evenness of Freshwater Snails Collected in River Benue at Ibi Site

Family	**November**	**December**	**January**
Shannon–Weiner Diversity Index (H')	1.235	0.663	0.667
Margalef Index (D)	0.798	0.497	1.216
Evenness (E)	0.768	0.603	0.372

Table 4: Physicochemical Parameters of Water from November 2024 to January 2025

Parameter	**November**	**December**	**January**
Colour	Colourless	Colourless	Colourless
pH	6.92±0.33	6.75±0.39	7.45±0.39
Temperature (℃)	21.53±2.74	29.23±0.06	28.6±1.13
Turbidity (NTU)	0.25±0.06	0.25±0.04	0.24±0.04
Dissolved oxygen (mg/L)	6.32±0.33	6.15±0.27	5.96±0.06
Conductivity (µs/cm)	63.20±3.29	85.97±19.71	79.77±1.00
Total dissolved solids (mg/L)	29.13±1.11	39.73±10.60	31.37±3.19

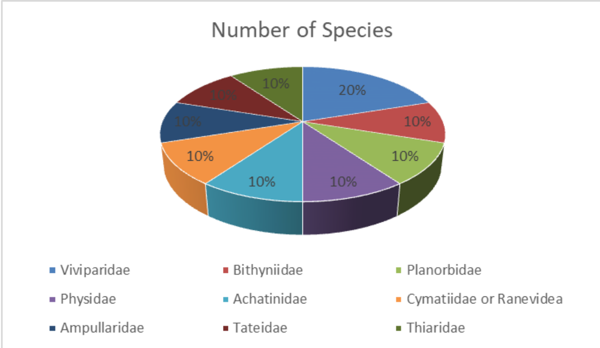

Fig. I: Percentage number of species in River Benue

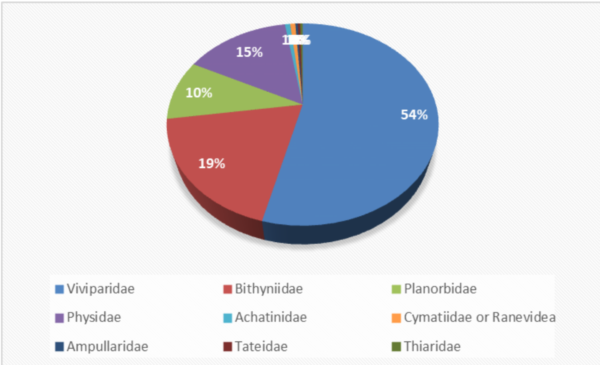

Fig. 2: Percentage Abundance of Individual family

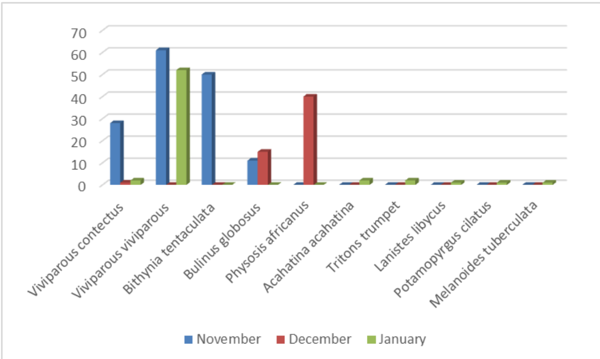

Fig. 3: Total number of species collected in the months of November, 2024 to January, 2025.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

Snail distribution is highly influenced by environmental variables such as rainfall that was why the abundance of the snails in November were higher than the others. A total number of 267 snails were collected and 10 freshwater snail species were identified from river Benue, while previous studies have reported similar patterns of dominance and

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exclusivity among freshwater snail species. The study by Bagalwa *et al*. (2024) recorded 1,356 snails belonging to seven genera and seven species in Lake Kivu, DR Congo side. Tukur *et al*. (2024) documented a total of 311 snails representing three distinct species. A study by Dogara *et al*. (2020) recorded a total of 2,027 fresh water snails belonging to ten species. Abdulkadir *et al*. (2017) recorded a total of 4,206 freshwater snails belonging to seven genera and seven species.

In November, *Viviparous viviparous* dominated the population with 61 individuals followed by *Bithynia tentaculata* (50 individuals), *Viviparous contectus* (28 individuals) and *Bulinus globosus* (11 individuals). The month of December showed larger numbers in *Physopsis africanus* (40 individuals) followed by *Bulinus globosus* (15 individuals). In January, *Viviparous viviparous* became the most abundant species (52 individuals), and *Viviparous contectus* had small numbers (2 individuals). *Achatina achatina*, *Triton's trumpet*, *Lanistes libycus*, *Potamopyrgus cilatus*, and *Melanoides tuberculata* were very low (1–2 individuals). This shows that other new species came in January and there was an introduction of an invasive species.

Freshwater snails in November had the highest Shannon–Weiner diversity index (1.235) and evenness (0.768), while those in January had the highest Margalef index (1.216). The low values of Shannon–Weiner diversity index in relation to the snails of public health importance in the Benue River at Ibi site can be linked to pollution level of the river. A value of this index above three (3) indicates clean water, whereas values lower than three indicates pollution, and the higher the value, the greater the diversity (Thakur *et al*., 2013).

The most invasive snail species in this study is *Potamopyrgus cilatus*. The invasive nature of *P. cilatus* could be attributed to its high reproductive capacity and adaptability to varying environmental conditions (Lydeard and Cummings, 2019). Additionally, *P. cilatus* has a high tolerance for a wide range of physicochemical conditions. Studies have shown that this species can outcompete native snails for resources, alter nutrient cycling, and reduce biodiversity in invaded habitats (Husa *et al*., 2024). Its low abundance in this study suggests it may be in the early stages of invasion, but its presence signals potential ecological risks if conditions favor its proliferation.

The findings of this study were similar to those reported in the work of Tukur *et al*. (2024) where the highest dominance was observed in the first month of their research (August) with 122 individuals and then decreased to 37 individuals in November. Studies by Okeke *et al*. (2016) and Silver *et al*. (2022) reported the highest dominance of *Acathina fulica* in their study and considered *A. fulica* as the most invasive snail species which varies with this work. The seasonal variation observed could be attributed to changes in water temperature, food availability, or reproductive cycles. The dominance of specific species at different times shows the dynamic nature of the river ecosystem and the need for ongoing monitoring to better understand population fluctuations and environmental factors affecting snail diversity.

The variation in richness and abundance across different months was also found in various studies. Bagalwa *et al*. (2024) found that *Biomphalaria pfeifferi* had the highest abundance (50.8 %) and *Segmentorbis kempi* had the least abundance (0.1 %). Tukur *et al*. (2024) found that *Acathina fulica* exhibited the highest abundance (129 individuals), while *Pomacea bridgesii* displayed the lowest abundance (66 individuals). Olkeba *et al*. (2020) found that *Bulinus globosus* (31.7%) was the most abundant snail species. Dogara *et al*. (2020) identified *Melanoides tuberculata* to have highest abundance of 1553(76.6%). Abdulkadir *et al*. (2017) observed that *Melanoides tuberculata* (66.4%) have the highest abundance and *Physa sp* (0.1%) has the least abundance. This distribution pattern could be attributed to variations in environmental conditions, habitat preferences, or ecological interactions among snail species. Alhassan *et al*. (2020) reported low Shannon–Weiner diversity index of 0.97 and 1.02 of freshwater snails in Kubanni reservoir and weir/sediment trap, Zaria, Nigeria.

The physicochemical parameters of Benue River at Ibi site including colour, pH, temperature, turbidity, dissolved oxygen, conductivity, and total dissolved solids were evaluated. In this study, the water was consistently colourless across all the months. Colourless water typically suggests the absence of significant organic matter, algae, or pollutants that could impart colour.

The pH values of water range from 6.75 to 7.45. The lowest pH (6.75) was recorded in December while the highest pH (7.45) was observed in January, indicating that the water is slightly acidic to neutral. A moderate pH of 6.92 was observed in November which suggests near-neutral conditions. Dogara *et al*. (2020) reported pH of 7.0 and 8.1 at sites with vegetation cover and lotic water sites, respectively. The study by Alhassan *et al*. (2020) reported pH of 9.22 and 9.05 for water from Kubanni reservoir and Weir/sediment trap, respectively which are higher than those observed in this current study. Other studies have identified pH values between 5.0 and 9.3 as being optimal for the survival of snails (Wanjala *et al*., 2013; Amoah *et al*., 2017).

The temperature increases from 21.53°C in November to 29.23°C in December and slightly decreases to 28.6°C in January. Higher temperatures in December and January could reduce the solubility of oxygen. Temperature fluctuations can also affect the reproductive cycles and behavior of aquatic organisms. The study by Alhassan *et al*. (2020) reported similar range of temperatures of 27.13 and 27.45°C for water from Kubanni reservoir and Weir/sediment trap, respectively. Similarly, Dogara *et al*. (2020) found that the water temperature of an earth dam in Northern Nigeria ranged between 26.4 °C and 29.7 °C. Ronald and Bello (2024) reported temperature of 25.2 to 25.9°C from Ibi River, Taraba State. Water temperature is the main determining parameter of the abundance of snails. Studies have observed that water temperature was positively correlated with the abundance of snails (Wanjala *et al*., 2013; Amoah *et al*., 2017). Increasing water temperature may play an important role in host snail habitat by ensuring the availability of food and aquatic weeds

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and/or enriching the microhabitat of juvenile snails (Wanjala *et al*., 2013).

Turbidity measures the clarity of water and is influenced by suspended particles such as silt, clay, algae, and organic matter. Turbidity in this work remains relatively stable, with values of 0.25 NTU in November, 0.25 NTU in December, and 0.24 NTU in January. These low values indicate clear water with minimal suspended particles. Low turbidity is generally favorable for aquatic ecosystems, as it allows sunlight to penetrate the water, supporting photosynthesis in aquatic plants. However, extremely low turbidity could also indicate a lack of nutrients necessary for plant growth. The lower values of turbidity recorded in this study might have accounted for the relative freshwater snail abundance (Dogara *et al*., 2020).

Dissolved oxygen (DO) is essential for the survival of aquatic organisms, as it supports respiration. The DO levels in this dataset decrease slightly from 6.32 mg/L in November to 5.96 mg/L in December. This decline could be due to higher temperatures in December and January, which reduce oxygen solubility. Low DO levels can lead to hypoxia, affecting fish and other organisms. Ronald and Bello (2024) reported dissolved oxygen of 0.1 to 3.0 mg/L in Ibi River. The variation in DO in the water could be related to high temperature, high rate of decomposition, and high consumption of dissolved oxygen through respiration by aquatic organisms (Alhassan *et al*., 2020). The results of this study are in line with the findings of Alhassan (2015), who reported a significant mean monthly variation in DO and influence of temperature on such variation. DO of 6.76 and 5.63 mg/l was observed for water from Kubanni reservoir and Weir/sediment trap, respectively (Alhassan *et al*., 2020)

Conductivity measures the water's ability to conduct electrical current, which is influenced by the concentration of dissolved ions such as salts and minerals. Conductivity increases from 63.20 µs/cm in November to 85.97 µs/cm in December and then decreases slightly to 79.77 µs/cm in January. Conductivity levels below 50 µs/cm are regarded as low; those between 50 and 600 µs/cm are medium, whereas those above 600 µs/cm are high (Anago *et al*., 2014). The conductivity values in this study fall within the range of 50 and 600 µs/cm and as a result are medium. Higher mean conductivity values were recorded in Kubanni and Weir/sediment trap (157.42 and 201.92 µs/cm) indicating that the conductivity level of both the water bodies is intermediate (Alhassan *et al*., 2020). The increase could lead to a decrease in dissolved oxygen which negatively influences the abundance of snails (Salawu and Odaibo, 2012).

TDS levels peak in December at 39.73 mg/L, compared to 29.13 mg/L in November and 31.37 mg/L in January. While the TDS levels are relatively low and within safe limits, the spike in December warrants attention. High TDS can affect water taste, clarity, and suitability for aquatic life. Total Dissolved Solids (TDS) has been reported to impair water clarity and reduce the passage of light, causing water bodies to heat rapidly and increase heat retention capacity (Environmental Protection Agency, EPA, 2012). High TDS can lead to oxygen depletion, a situation that leads to asphyxiation in the aquatic habitat and reduced abundance of some species of snails (Salawu and Odaibo, 2012). Studies by Dogara *et al*. (2020) showed that physico-chemical factors were found to be negatively associated with snail abundance but not statistically significant include pH and dissolved oxygen levels. Total dissolved solids did not show any relationship with freshwater snail abundance in Warwade dam. The work of Alhassan *et al*. (2020) reported TDS of 77.50 and 102.75 ppm in water from Kubanni reservoir and Weir/sediment trap, respectively. A significant variation of TDS can be a result of slight differences in anthropogenic activities such as dumping of refuse, irrigation, grazing, fishing, washing, and bathing observed at the catchment and in the water bodies (Alhassan *et al*., 2020).

CONCLUSION

This study serves as a baseline study for freshwater snail in river Benue at Ibi site. The study was conducted from November 2024 to January 2025 and the results revealed significant insights into the species richness, abundance, and diversity of freshwater snails, as well as the physicochemical parameters influencing their populations. The water remained colourless throughout the study period, with pH values ranging from slightly acidic to mildly alkaline, temperature fluctuations were significant, turbidity remained low, conductivity and total dissolved solids showed variations. The study highlights the dynamic nature of the river ecosystem and the importance of environmental factors in shaping freshwater snail populations.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

i. Regular monitoring of water quality parameters such as pH, temperature, dissolved oxygen, conductivity, and total dissolved solids should be conducted to identify potential threats early and maintain the health of the river ecosystem.
ii. Efforts should be made to reduce agricultural runoff, the use of herbicides/pesticides and other human activities that introduce pollutants into the river.
iii. Conservation programs should focus on preserving the habitats of rare and endangered snail species.
iv. More detailed studies should be conducted to understand how seasonal changes affect water quality and snail species abundance.
v. Given the low Shannon diversity index values of the freshwater snails, which indicate potential pollution, measures should be taken to reduce pollution levels in the river.
vi. Long-term ecological studies should be conducted to monitor changes in snail populations and their responses to environmental changes.

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