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Assessment of freshwater snails in relation to physicochemical parameters in a rural river, Southeast Nigeria

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ABSTRACT. Freshwater snails play a major role in the transmission of some waterborne parasites as well as in understanding ecosystem health. Freshwater snails of a rural river were assessed in relation to some physicochemical parameters. The study was carried out between January and June 2022 in three stations. The water samples were collected and analysed using standard methods while the snails were collected by sweeping the sediments and aquatic macrophytes with a hand net and picking snails off the sediments and macrophytes with hand. One-way Analysis of Variance was used to ascertain significant differences in the physicochemical parameters among the stations while correlation analysis was used to relate the snails' abundance to the physicochemical parameters. 531 snails of medical and veterinary importance from three species were recorded. The order of abundance was *Melanoides tuberculata* >*Lanistes varicus* > *Lymnaea natalensis*. Most of the snails were recorded in station 3 despite the intensity of human activities and between March and April 2022. The composition, abundance, and distribution of the freshwater snails were influenced by a combination of environmental and anthropogenic factors which in turn were influenced by season. This study showed that Ikwu River is a potential flashpoint for a myriad of water-borne diseases. Knowledge of the distribution of freshwater snails and the factors regulating them will help in their control and the water-borne parasites associated with them.

Keywords: health implication, human activities, season, snails, water quality

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1. Introduction

Water quality is determined by comparing the physical, chemical and biological parameters of water with set acceptable limits and used for the determination of the suitability of water for human use or ecosystem health (Anyanwu, 2012; Khatri and Tyagi, 2014). Degradation of river water quality can result from various anthropogenic activities carried out in and around a river (Shultana and Khan, 2022; Zhou et al., 2022). Consequently, it can change the physical, chemical, and biological components of a river. Evaluation of physicochemical parameters has been used in the assessment of water quality (Anyanwu et al., 2023). However, assessing water quality in relation to aquatic biota helps to identify impacts that are not captured by physicochemical assessment (Abdelkarim, 2020). Studies on freshwater snails in relation to water quality are becoming an important area of research interest (Oloyede et al., 2017).

Freshwater snails are of the class Gastropoda; found virtually in all continents except the Antarctic and Artic waterbodies (Strong et al., 2011; Pyron and Brown, 2015). Nwoko et al. (2022) reported that 57 freshwater snail species have gone into extinct globally out of about 4000 species. Freshwater snails are of public and veterinary health significance since they are intermediate hosts of some water-borne parasites (Madsen and Hung, 2015). *Lanistes varicus* is not a vector of schistosomes but is a predator and potential biocontrol agent for *Biomphalaria pfeifferi* and *Bulinus truncatus* (Anto and Bimi, 2017). Anorue et al. (2021) observed that *La. varicus* act as repository and intermediate hosts for some parasitic nematodes and trematodes while *Melanoides* species is the intermediate host for a number of parasitic humans and rodents diseases (Emil and Sofía, 2012). On the other hand, *Lymnaea natalensis* is the obligatory intermediate host for Fasciola parasites (Brown, 1994) and is the Lymnaeid snail with

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the widest spread in Africa particularly in sub-Saharan Africa (Shettima et al., 2020). The global distribution of the diseases is associated with the distribution of freshwater snails (Dejon Agobé et al., 2022), which is also influenced by the physicochemical characteristics of the waterbody (Nwoko et al., 2023). Previous studies have shown that certain biotic and abiotic conditions affect the distribution and habitat requirement of freshwater snails in Africa (Gouvras et al., 2017; Oloyede et al., 2017; Yigezu et al., 2018; Rabone et al., 2019; Chimbari et al., 2020).

In each aquatic ecosystem, prevailing local environmental and biotic conditions influence the composition and abundance of freshwater snails due to environmental variability in different ecological zones (Abdulkadir et al., 2017; Oso and Odaibo, 2021; Dogara et al., 2022). Freshwater snail control has been identified to be the most efficient means of minimizing the incidence of schistosomiasis (Sokolow et al., 2016). Knowledge about the composition, abundance and distribution of freshwater snails is therefore necessary for a proper understanding of the disease epidemiology (Rabone et al., 2019; Dejon Agobé et al., 2022). Anyanwu and Jerry (2017) had previously reported the abundance of freshwater snails in Ikwu River.

Therefore, this study was aimed at assessing the composition, abundance and distribution of freshwater snails in Ikwu River, Umuahia, Nigeria in relation to some physicochemical parameters.

2. Materials and Methods

2.1. Study area and sampling stations

The study was carried out in Ikwu River, which is located in Umuire Community along Umuahia – Uzoakoli Road, Umuahia, South-east Nigeria within 5°34′11.988″ – 5°34′48.000″N and 7°28′44.400″ - 7°28′52.764″E (Fig. 1). Ikwu River went through Umuire and Umuegwu Okpula communities and discharge into the Imo River Basin. The three stations were selected based on accessibility and observed anthropogenic activities. Station 1 was the reference site, located upstream on the right along Umuahia – Uzoakoli Road. The shoreline was covered by rich assemblage of aquatic macrophytes while the sediment was muddy. Signs of periodic watering of cattle were the only activities observed around the station during the study. Station 2, located on the left side of Umuahia – Uzoakoli Road was about 350 meters downstream of Station 1. The aquatic macrophytes on the shoreline were scanty while the sediment was sandy. A number of activities were observed some distances upstream of Station 2 - bathing, washing of cars, motorcycles and tricycles, washing of fruits and vegetables, children swimming, extraction of drinking water and later sand mining from the onset of rains. Station 3, located within Umuire community is a major source of water for most domestic activities. It is about 430 meters downstream of Station 2. There are rich assemblages of aquatic macrophytes on the banks and the sediment was a mixture of mud, coarse stones and gravels. Observed human activities were extraction of drinking water, washing of clothes, bathing, swimming and sand mining as the rains increased. Heaps of solid wastes were dumped on the bank of Ikwu River while stormwater from Umuire community also discharges into this station after rainfall events. Open defection was also very common around this station even though it is their major source of water for most activities.

2.2. Samples collection and analyses

Ikwu River was sampled monthly for physicochemical parameters and freshwater snails from January to June 2022.

Water Samples

Samples were collected with a 1 litre water sampler, stored in pre-cleaned 1litre plastic bottle and transported in ice chests to the laboratory for analysis. Water temperature, flow velocity, depth, pH, electrical conductivity and total dissolved solids were determined in-situ while dissolved oxygen, chemical oxygen demand, phosphate, nitrate, sulphate and calcium were determined in the laboratory. The parameters were analyzed using standard methods described by American Public Health Association (APHA) (2017).

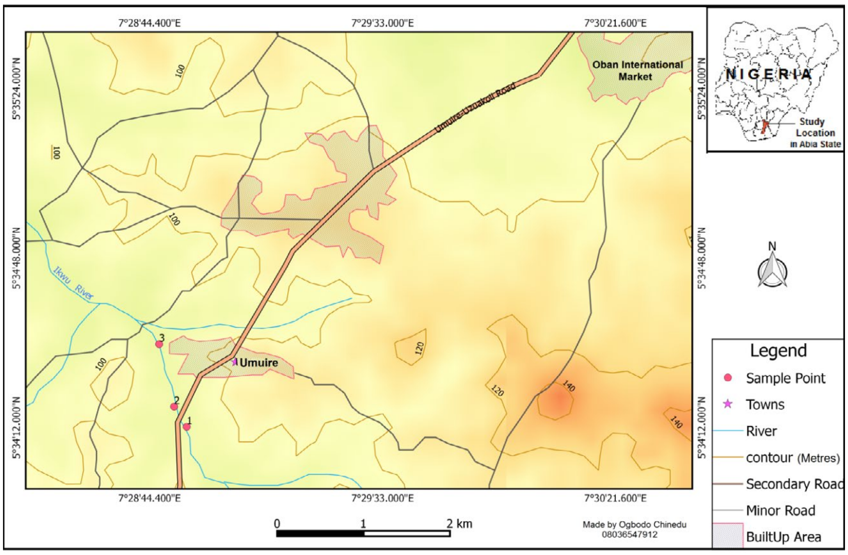

Fig.1. Sampling stations of Ikwu River, Umuahia, Nigeria.

Aquatic Snail Samples

Samples of aquatic snails were collected from the three selected stations. Sampling was carried out along the shoreline and bottom sediment at each site. Snails were collected by passing a dip net (30 cm × 40 cm) five times through the upper surface of sediment, water and vegetation at a depth of 20 cm. The snails attached to the macrophytes and on top of the sediments were carefully removed by hand. All collected snails were kept in pre-labelled plastic containers and preserved with 10% formalin. In the laboratory, the snails were sorted, counted and identified according to Brown (1994) and Ibrahim et al. (1999). The number, types, and sizes in relation to stations and months were recorded.

2.3. Statistical Analysis

The physicochemical results were summarized using the Descriptive Statistic Package of Microsoft Excel. One-way ANOVA was used to test for significant differences in the physicochemical parameters and freshwater snails among the stations and Tukey pairwise comparisons test was performed to determine the location of significant difference ($P < 0.05$). Correlation analysis was used to evaluate the relationship between the physicochemical parameters and the freshwater snails.

3. Results

3.1. Water Quality

The summary of the physicochemical parameters recorded in Ikwu River is presented in Table 1. One-way ANOVA showed that there were no significant differences ($p > 0.05$) in all the parameters evaluated except flow velocity.

The water temperatures ranged between 19.50°C and 25.9°C. The highest temperature was recorded in station 3 (March 2022) while the lowest was recorded in station 1 (May 2022).

The flow velocity was moderate; ranging from 0.12 - 0.48m/s. The highest flow velocity was recorded in station 3 (January 2022) while the lowest was in station 2 (February 2022). Station 3 had values that were significantly ($p < 0.05$) higher than the other stations.

The depth ranged between 15.30 and 90.00cm. Station 2 had the highest depth in May 2022 while station 3 had the least in January 2022. Station 2 generally had higher values though not significant.

The pH values ranged between 6.1 and 8.7. The highest pH values were recorded in stations 1 (May 2022) and 2 (June 2022) while the lowest were also recorded in stations 1 (January 2022) and 2 (March 2022). Some of the values were within the acceptable limit (6.5 – 8.5) set by Federal Ministry of Environment (FMEnv.) (2011).

Table 1. Summary of some physico-chemical parameters of Ikwu River, Umuahia, Nigeria

Parameters	STN 1 Mean ± SEM	STN 2 Mean ± SEM	STN 3 Mean ± SEM	P- value	FMEnv 2011
Water Temperature (°C)	22.22 ± 0.10 (19.5 - 25.0)	22.50 ± 1.03 (19.7 - 25.7)	23.33 ± 0.97 (20.0 - 25.9)	F = 0.33 P > 0.05	-
Flow Velocity (m/s)	0.25 ± 0.03[a] (0.18 - 0.37)	0.20 ± 0.03[a] (0.12 - 0.35)	0.38 ± 0.04[b] (0.26 - 0.48)	F = 8.06 P < 0.05	-
Depth (cm)	34.57 ± 10.55 (18.5 - 85.0)	42.73 ± 10.77 (25.6 - 90.0)	38.12 ± 10.66 (15.3 - 84.0)	F = 0.14 P > 0.05	-
pH	7.07 ± 0.52 (6.1 - 8.7)	7.13 ± 0.48 (6.1 - 8.7)	7.10 ± 0.48 (6.2 - 8.6)	F = 0.004 p >0.05	6.6-8.5
Electrical Conductivity (EC) (μS/cm)	102.0 ± 9.37 (66.0 - 130.0)	98.33 ± 6.30 (76.0 - 118.0)	96.33 ± 7.96 (66.0 - 119.0)	F =0.13 p > 0.05	-
Total Dissolved Solids (TDS) (mg/l)	50.4 ± 5.69 (33.0 - 65.0)	48.2 ± 3.71 (38.0 - 59.0)	47.2 ± 4.69 (33.0 - 59.0)	F = 0.01 p >0.05	-
Dissolved Oxygen (mg/l)	5.45 ± 0.72 (3.0 - 7.8)	4.43 ± 0.77 (2.7 - 7.4)	4.30 ± 0.69 (2.0 - 7.0)	F = 0.75 p > 0.05	6
Biochemical Oxygen Demand (mg/l)	2.08 ± 0.27 (1.2 - 3.0)	2.12 ± 0.16 (1.5 - 2.7)	2.5 ± 0.26 (1.7 - 3.3)	F = 0.98 p > 0.05	3
Chemical Oxygen Demand (mg/l)	19.88 ± 1.17 (16.3 - 23.2)	20.63 ± 4.39 (10.4 - 40.8)	17.58 ± 1.92 (10.4 - 23.2)	F = 0.31 p > 0.05	30
Phosphate (mg/l)	0.40 ± 0.12 (0.10 - 0.83)	0.26 ± 0.07 (0.11 - 0.53)	0.26 ± 0.05 (0.11 - 0.47)	F = 0.88 p > 0.05	3.5
Nitrate (mg/l)	1.12 ± 0.45 (0.48 - 3.36)	1.10 ± 0.41 (0.15 - 2.98)	0.99 ± 0.31 (0.27 - 2.37)	F = 0.06 p > 0.05	9.1
Sulphate (mg/l)	0.33 ± 0.13 (0.03 - 0.77)	0.34 ± 0.14 (0.05 - 0.77)	0.29 ± 0.10 (0.06 - 0.62)	F = 0.06 p > 0.05	100
Calcium (mg/l)	3.21 ± 0.28 (2.05 - 4.01)	3.02 ± 0.21 (2.22 - 3.65)	3.08 ± 0.32 (1.87 - 4.17)	F = 0.13 p > 0.05	180

Note: a, b = Means with different superscripts across the rows are significantly different at $p < 0.05$; SEM = Standard Error of Mean; FMEnv. (2011) - National Environmental (Surface and Groundwater Quality Control) Regulations

The electrical conductivity (EC) values ranged between 66 and 130 µS/cm. The highest EC value was recorded in station 1 (February 2022) while the lowest were recorded in stations 1 and 3 in May 2022. The values were generally higher in the dry months (January to April 2022).

The TDS values ranged between 33.0 and 65.0mg/l. TDS followed the same trend as electrical conductivity. The highest value was recorded in station 1 (February 2022) while the lowest were recorded in stations 1 and 3 (May 2022). The values were generally higher in the dry months (January to April 2022).

The DO values ranged between 2.0 and 7.8 mg/l. The highest DO was recorded in station 1 (April 2022) while the lowest was recorded in station 3 (May 2022). Relatively higher values were recorded in station 1 and in the dry months (January to April 2022). Most of the values were lower than the acceptable limit (6 mg/l) set by FMEnv. (2011).

The Biochemical Oxgyen Demand (BOD) values ranged from 1.2 to 3.3 mg/l. The highest was recorded in station 3 (January 2022) while the lowest was recorded in station 1 (March 2022). The values decreased between January and March 2022 while all the values were within acceptable limit (3mg/l) set by FMEnv (2011) except in station 3 (January 2022).

The Chemical Oxgyen Demand (COD) values ranged between 10.4 and 40.8 mg/l. The highest value was recorded in station 2 (May 2022) while the lowest were recorded in stations 2 and 3 (March 2022). The values were generally lower between January and March 2022 and within the acceptable limit (30 mg/l) set by FMEnv (2011) except in station 2 (May 2022).

Phosphate values ranged between 0.10 and 0.83 mg/l. The highest value was recorded in station 1 (January 2022) while the lowest was recorded in station 1 (April 2022). The values generally decreased from January to March 2022 and increased again with the onset of the rains. All the values were within the acceptable limit (3.5 mg/l) set by FMEnv (2011).

The nitrate values ranged between 0.15 and 3.36mg/l. The highest value was recorded in station 1 (January 2022) as in phosphate while the lowest was recorded in station 2 (February 2022). All the values were within the acceptable limit (9.1 mg/l) set by FMEnv (2011).

The sulphate values ranged between 0.03 and 0.77mg/l. The highest value was recorded in station 2 (May 2022) while the lowest was recorded in station 1 (April 2022). The values decreased from January to April 2022 and increased from the onset of rains in May 2022. All the values were within the acceptable limit (100 mg/l) set by FMEnv (2011).

The calcium values ranged between 2.05 and 4.17 mg/l. The highest value was recorded in station 3 (April 2022) while the lowest was also recorded in station 3 (May 2022). The dry months (January to April 2022) were relatively higher. All the values recorded were within the acceptable limit (180 mg/l) set by FMEnv (2011).

3.2. Composition, abundance and distribution of freshwater snail species

The spatial composition, abundance, and distribution of freshwater snails collected from the Ikwu River are presented in Table 2. A total of 531 freshwater snails were collected from three families. The composition was made up of three species - *Lanistes varicus* (4.0 - 38.0 mm), *Melanoides tuberculata* (6.0 – 29.0 mm) and *Lymnaea natalensis* (13mm). The most abundant species was *M. tuberculata* with 476 individuals, contributing 89.64% of the freshwater snails. *La. varicus* was the next with 54 individuals (10.17%) and *L. natalensis* (1, 0.19%). *La. varicus* recorded the highest number of individuals in station 3 and the lowest in station 1, *M. tuberculata* also recorded the highest number of individuals in station 3 and the lowest in station 2. On the other hand, *L. natalensis* recorded only 1 species in station 3.

The monthly composition, abundance, and distribution of the snails are presented in Table 3. The highest abundance was recorded in March 2022 (190, 35.78%) while the lowest was recorded in May 2022 (27, 5.08%). *La. varicus* recorded the highest number of individuals in April 2022 and none were recorded in May and June 2022. *M. tuberculata* recorded the highest number of individuals in March 2022 and the lowest in May 2022. On the other hand, *L. natalensis* was only recorded in April 2022.

3.3. Relationship between physicochemical parameters and freshwater snails

Correlation coefficient analysis showed that some physicochemical parameters influenced the abundance and distribution of the freshwater snails in the different stations. The freshwater snails had a positive and significant correlation ($p < 0.05$) with sulphate (0.581) in station 1. In station 2, the positive significant ($p < 0.05$) correlations were with electrical conductivity (0.874), total dissolved solids (0.878), dissolved oxygen (0.826), nitrate (0.661), and calcium (0.849). The negative significant correlations were with pH (-0.847), chemical oxygen demand (-0.573), sulphate (-0.869),

Table 2. Spatial composition, abundance, and distribution of freshwater snails

Family	Taxa	Station 1	Station 2	Station 3	Total	RA (%)
Ampullariidae	*La. varicus*	5	22	27	54	10.17
Thiaridae	*M. tuberculata*	188	100	188	476	89.64
Lymnaeidae	*L. natalensis*	0	0	1	1	0.19
	Total	193	122	216	531	100

Note: RA = Relative Abundance

Table 3. Monthly composition, abundance, and distribution of Freshwater snails

Taxa/Month	*La. varicus*	*M. tuberculata*	*L. natalensis*	Total	RA (%)
January 2022	6	63	0	69	13.00
February 2022	3	47	0	50	9.42
March 2022	21	169	0	190	35.78
April 2022	24	84	1	109	20.53
May 2022	0	27	0	27	5.08
June 2022	0	86	**0**	86	16.2
Total	**54**	**476**	**1**	**531**	**100.0**

Note: RA = Relative Abundance.

and depth (-0.778). Then in station 3, the freshwater snails correlated positively and significantly with water temperature and negatively and significantly ($p < 0.05$) with chemical oxygen demand (-0.618), phosphate (-0.685), and flow velocity (-0.636). The magnitude of the correlation coefficient determines the strength of the association.

4. Discussion

The abundance of freshwater snails is influenced by the physico chemistry of the snail habitats (Usman et al., 2017) and in combination with other environmental factors (Urude et al., 2021). The water temperature values were attributed to season. The lowest value in station 1 (May 2022) was due to a heavy rainfall event during sampling and the highest in station 3 (March 2022) was due to little or no rain and high temperatures during the dry season. Air temperatures have been reported to influence water temperatures (Park et al., 2016).The water temperature had a moderate positive and significant correlation with the snails in station 1. Water temperature influences the survival, fecundity, and reproduction rate of freshwater snails (Walz et al., 2015). Snails tolerate a wide range of ambient temperatures but the most favourable range is between 14 and 32°C (McCreesh and Booth, 2014). The values recorded in this study were within the range.

The flow velocity values were moderate. The flow velocity in station 3 was significantly higher than in stations 1 and 2. Freshwater snails thrive within a narrow flow velocity tolerance range. Flow velocity had moderate negative correlation with the freshwater snails in station 3. This suggested that they may be dislodged and washed away by high velocity observed in station 3 (Perez et al., 2011; Maes et al., 2021; Min et al., 2022; Daniel et al., 2024). Perez et al. (2011) also reported that increased stream velocity reduced the shell length. Shorter mean shell lengths were recorded in station 3 among *La. varicus* and *M. tuberculata* in most of the sampling months.

The depth was also influenced by season. The highest in station 2 (May 2022) was due to a heavy rainfall event during sampling while the least in station 3 (January 2022) was due to little or no rain in the dry season. Station 2 generally had higher values though not significant. Water depth was highly and negatively correlated with snail abundance in station 2. Water depth regulates freshwater snails' distribution because they usually occur in shallow water near the shores in relation to food, shelter and light (Min et al., 2022); occurring rarely at depths higher than 1.5-2.0 m (Walz et al., 2015).

The pH was slightly acidic to slightly alkaline and influenced by season. The lowest values recorded in stations 1 (January and March 2022) and 2 (March 2022) may be attributed to dry season and human activities while the highest recorded in stations 1 (May and June 2022) and 2 (June 2022) were due to allochthonous input as a result of the onset of the rains. This trend was also previously observed in Ikwu River by Anyanwu et al. (2023). Some of the values were within the acceptable limit. pH had a high negative and significant correlation with the snails in station 2; though Amawulu and Akpoebiere (2022) recorded positive correlations with *Bu. globosus* and *M. tuberculata* and negative correlation with *L. natalensis*. pH influences the presence and distribution of freshwater snails; though not considered a limiting factor since the snails can adapt to a wide range of pH (Ntonifor and Ajayi, 2007). The slightly alkaline mean values favoured the occurrence of freshwater snails (Ntonifor and Ajayi, 2007; Dogara et al., 2020).

The electrical conductivity (EC) and total dissolved solids (TDS) were moderate and followed the same trend. The values were generally higher in the dry months as observed by Anyanwu et al. (2023). EC and TDS had high positive correlations with the freshwater snails in station 2. Conductivity is a factor that may limit the distribution of snail species and different species of snails live in habitats with wide conductivity differences (Oso and Odaibo, 2021; Amawulu and Akpoebiere, 2022).

Dissolved oxygen is one of the critical parameters that regulate freshwater snails' abundance and distribution (Usman et al., 2017; Abdoulaye Ndione et al., 2020; Manyangadze et al., 2021). Few of the recorded DO values were within the acceptable limit. The lowest DO value recorded in station 3 (May 2022) was due rainfall event on the sampling day while the highest value recorded in station 1 (April 2022) could be due to increased photosynthesis before the onset of rains. Station 1 recorded relatively higher values throughout the study probably due to minimal human activities. Dissolved oxygen had a moderate positive correlation with the snails in station 2, which was in line with Abdoulaye Ndione et al. (2020) and Manyangadze et al. (2021).

Biochemical oxygen demand is another parameter that regulates freshwater snails' abundance and distribution (Abdulkadir et al., 2017). The lowest value recorded in station 1 (March 2022) could be due to minimal human activities while the highest recorded in station 3 (January 2022) could be due to intense human activities around Ikwu River in the station. Station 3 was within Umuire community and witnessed high human activities, especially during the dry season. All the values were within the acceptable limit except for one.

The chemical oxygen demand values were low indicating low organic pollution (Li et al., 2018) and within acceptable limit except one. The lowest values recorded in stations 2 and 3 (March 2022) could be due to low input from the environment during the dry season and the highest in station 2 (May 2022) could be due to allochthonous input from rainfall event on that sampling day. Cars, motorcycles, and tricycles are washed upstream of station 2 and car wash effluent usually contains high levels of COD (Odeyemi et al., 2018; Rai et al., 2020; Anyanwu et al., 2022). COD had negative and moderate correlations with the snails in stations 2 and 3 which were different from the trend observed by Olkeba et al. (2020).

Nutrients (phosphate and nitrate) in combination with other parameters influence the abundance and distribution of freshwater snails (El-Khayat et al., 2009; Olkeba et al., 2020). Phosphate values were low, within limit, and also influenced by season. The highest value in station 1 (January 2022) could be due to allochthonous input from the previous wet season and exacerbated by the dry season while the lowest in station 1 (April 2022) could be due to low environmental input. The values generally decreased from January to March 2022 and increased again with the onset of the rains. Phosphate had moderate, negative, and significant correlation with the freshwater snails in station 3 probably due to low concentrations. Mohamed-Assem et al. (2015) recorded very high, positive, and significant correlations with some freshwater snails at higher phosphate concentrations in some streams in Egypt.

Nitrate values were moderate, within acceptable limit, and influenced by season. The highest value recorded in station 1 (January 2022) could be due to allochthonous input from the previous wet season and exacerbated by the dry season. On the other hand, the lowest in station 2 (February 2022) could due to low environmental input. Nitrate had a moderate, positive and significant correlation with the freshwater snails in station 2. Mohamed-Assem et al. (2015) also recorded a positive and significant correlation with some freshwaters snails in some streams in Egypt. Moderate values contribute to the nutrients required to support the freshwater snails but excess nitrate concentrations negatively affect aquatic biota (Dodds and Smith, 2016).

The sulphate values were low, within limit and influenced by season. The highest value recorded in station 2 was attributed to rainfall event during sampling in May 2022 while the lowest in station 1 (April 2022) could be due to low environmenatal input. The values decreased from January to April 2022 and increased from onset of the rains in May 2022. Sulphate had moderate positive and significant correlations with freshwater snails in station 1 and high negative correlation in station 3. Mohamed-Assem et al. (2015) reported that under natural circumstances, a number of environmental factors can work together to influence the abundance and distribution of freshwater snails.

Calcium values were low, within limit and also influenced by season. The highest value recorded in station 3 (April 2022) could be due to concentration as a result of the dry season while the lowest also in station 3 (May 2022) could be due to dilution from rainfall event on that sampling day. The dry months (January to April 2022) were relatively higher. Calcium had high positive correlation with freshwater snails in station 2 but contrary to Dogara et al. (2020). Freshwater snails usually thrive in calcium-rich environment because it is an important parameter necessary for their shell formation (Brodersen and Madsen, 2003, Abdulkadir et al., 2013).

The three freshwater snails recorded were of medical and public health importance. The snails were intermediate hosts of some water-borne parasites. *La. varicus* act as repository and intermediate hosts for some parasitic nematodes and trematodes (Anorue et al., 2021), *M. tuberculata* is the intermediate host for a number of parasitic humans and rodents' diseases (Emil and Sofía, 2012) and *L. natalensis* is the obligatory intermediate host for *Fasciola* parasites (Brown, 1994). The most abundant species was *M. tuberculata*, followed by *La. varicus* and *L. natalensis* being the least. However, a recent study in a freshwater canal in a nearby city (Okigwe, Imo State) reported the dominance of *Bulinus* spp out of the two species recorded (Enwereji et al., 2023). The dominance of *M. tuberculata* in relation to the other species was very remarkable in that the previously dominant species (*Bu. globosus*) was absent. Anyanwu and Jerry (2017) previously reported the dominance of *Bu. globosus* in Ikwu River. The complete absence of *Bu. globosus* could be due to presence of *La. Varicus*, a known biocontrol agent for some *Bulinus* spp (Dida et al., 2014; Anto and Bimi, 2017). This change of dominance was also reported by Dogara et al. (2020) in Warwade dam, Warwade Village, Jigawa State, Nigeria. *Melanoides* spp. is an invasive snail that suppresses the population of other snails around them (Rader et al., 2003; Giovanelli et al., 2005; Jihad and Makawi, 2022). Their success as invaders was attributed to possession of hard protective shell that enables them withstand difficult ecological conditions and predators (Supian and Ikhwannuddin, 2002; Sharma et al., 2013) and parthenogenetic mode of reproduction and fast growth rate (Jihad and Makawi, 2022).

Spatially, station 3 had the highest number of species and abundance despite the high flow velocity. This could be due to abundance of aquatic macrophytes. Abundant macrophytes provide food, spawning ground and refuge for the snails (Min et al., 2022). The sediment type in the station also contributed to the abundance. Muddy sediment mixed stones and gravels in station 3 support large number of species and snails (Anyanwu and Jerry, 2017; Min et al., 2022). Human presence and activities were also factors. Human activities in the station were high due to its proximity to the community; open defecation and wastes dumped by the bank around the station provide a lot of organic matter and nutrient to support the growth of algae that the snails feed on (Min et al., 2022). Station 2 on the other hand, had sparse aquatic macrophytes and sandy bottom sediment which could have affected the abundance apart from higher depth and human activities upstream of the sampling point.

Monthly, the highest abundance and lowest recorded in March 2022 and May 2022 respectively could be attributed to season. Rainfall and temperature were the major climatic conditions that regulate the distribution of freshwater snails (Stensgaard et al., 2013; Manyangadze et al., 2016). Snails need water for survival but too much of it has negative effects on the population (Simoonga et al., 2009). Freshwater snails usually go into aestivation during dry season or harsh conditions (Jiang et al., 2023; Mahalila et al., 2025) and onset of rains allows population build up from snails coming out from aestivation (Aliyu et al., 2018). Hence, *La. varicus* had the highest abundance after early rains in April 2022 and none as the rains increased in May and June 2022. *M. tuberculata* had the highest abundance during late dry season in March 2022 and least in during the wet season in May 2022. *Lymnaea* sp. was recorded after early rains in April 2022. There was a heavy rainfall event on the sampling day of May 2022 which affected the population of snails in that month. Generally, rainfalls negatively affect the populations of aquatic snails (Nwoko et al., 2023; Anorue et al., 2024; Gong et al., 2025). In recent related studies within the region, Anorue et al. (2021) recorded the highest number of aquatic snails between March and April before the onset of rains while Enwereji et al. (2023) recorded a decline in the abundance of the snails from onset of rains in May (619 individuals) to the one of the peaks of wet season in July (369 individuals). Walz et al. (2015) observed that rainfall alters the environmental conditions of freshwater snails in a number of ways. Heavy rainfall events can wash away the snails as a result of high current (Perez et al., 2011; Strong et al., 2011; Daniel et al., 2024). As the rains continue, temporal habitats can be established for the snails that survived desiccation or the ones that were transported into the new habitats by runoffs (Walz et al., 2015).

5. Conclusion

Three freshwater snails of medical importance were recorded in this study, which is an indication that Ikwu River is potential flashpoint for a myriad of water-borne diseases. The most abundant species was *M. tuberculata*, followed by *La. varicus* and *L. natalensis* being the least. Most of the snails were recorded in station 3 despite the intensity of human activities and between March and April, before the onset of the rains. The composition, abundance and distribution of the freshwater snails were influenced by a combination of environmental and anthropogenic factors which in turn was influenced by season. Knowledge of the distribution of freshwater snails and factors regulating them will help in their control and water-borne parasites associated with them.

Conflict of Interest

The Authors hereby declare that there is no conflict of interest between them.

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