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Influence of Physicochemical Parameters on the Biodiversity Indices of Fresh Water Snails in Selected Rivers of Osun State, Nigeria

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Abstract

Studies have investigated the influence of environmental factors on distribution of vectors of parasites of public health importance but little is known on the role of these factors on the biodiversity indices of the vectors. This study is therefore set to assess the role of physicochemical parameters on biodiversity indices of fresh water snails. The study was carried out in three randomly selected communities across the three senatorial regions of Osun state namely Ere Ijesha, Ede and Erin-Osun. Through reports from community members, a mostly visited river from each community was selected. Three contact points with evident human water contact were identified for snail and water sampling. Morphological identification of snails was done. Physicochemical parameters of water were measured while snail biodiversity indices were determined using Shannon index, snail richness and abundance. Relationship between continuous variables was determined using Spearman's correlation. There is a significant difference between pH values of Ere Ijesa and Erin Osun while Ede and Erin Osun also show a significant difference in their chloride concentration. A significant positive correlation was observed between pH and diversity (correlation coefficient (rho)= 0.64, P<0.05), pH and Bulinus abundance (rho= 0.68, P< 0.05), chloride and snail richness (rho= -0.65, P< 0.05), chloride and diversity (rho= -0.88, P< 0.01), BOD and snail richness (rho= -0.78, P < 0.05), BOD and diversity (rho= -0.64, P<0.05) COD and snail richness (rho= -0.61, P< 0.05). Ede had highest diversity index while Ere Ijesa had highest Bulinus abundance. Erin Osun was the least in terms of snail richness, diversity and Bulinus abundance. Snail diversity, snail richness and Bulinus abundance significantly differ across the sampling locations (P< 0.01). Physicochemical parameters such as pH, chloride content, BOD and COD have significant role to play in fresh water snail richness, snail diversity and Bulinus abundance.

Keywords: *Fresh water snail, Physicochemical parameters, snail richness, snail diversity, Bulinus abundance*

Introduction

Freshwater snails play a significant role in public and veterinary health as some serve as intermediate hosts of blood fluke trematodes and nematodes (Madsen & Hung, 2014). For instance, intermediate host snails of Schistosomes are predominantly found in fresh water

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bodies with the biological, physical and chemical components of such water bodies impacting on the life cycle of the inhabiting snails (Alexandre *et al*., 2005; Tawanda *et al*., 2021). Various studies have documented the role of environmental factors in determining the distribution and abundance of the fresh water snails that host schistosome parasites. Such factors include physicochemical parameters of water such as water temperature, turbidity, pH, water velocity, heavy metals, nitrate, dissolved oxygen (DO), biochemical demand (BOD) etc.(Anouk *et al*., 2017; Ofulla *et al*., 2013; Wendelin *et al*., 2014). Other influencing climatic factors on the snail host include climatic conditions; such as humidity, precipitation, wind speed and air temperature (Monde, 2016; Onyekachi *et al*., 2022). For interventions targeting water borne diseases such as schistosomiasis to be effective, it must therefore rely on deep understanding of host-parasite-environment interactions.

Schistosomes are obligate parasites that require intermediate snail host which enables the larva stage of the parasites complete their lifecycle so as to sustain their infection transmission potential (Mamed, 2010). The snail host responsible for the transmission of schistosomiasis belong to the genus *Bulinus*, *Biomphalaria* and *Oncomelenia*. Although, as far as schistosomiasis is concerned in Africa, only two of these genera namely *Biomphalaria* and *Bulinus* are of significance since out of various species of the parasite, only Schistosoma mansoni and *Schistosoma haematobium* with snail hosts *Biomphalaria* and *Bulinus* respectively are predominantly found in the continent (Linda *et al.*, 2018). Its therefore very important to give attention to these fresh water snails that are capable of promoting transmission of water borne diseases among the vulnerable populations (WHO, 2010).

Although, several studies have looked into the influence of various environmental factors on distribution of vectors of parasites of public health importance in different ecological zones, these factors have either been inconsistently reported or vary across different ecological zones. Understanding the transmission dynamics of the vector borne infection in a particular ecological zone thus requires an understanding of the significant environmental data of such area that may contribute to spatial and temporal transmission of the infection. A better understanding of the factors affecting the distribution and habitat preferences of intermediate snail hosts is crucial for the effective control and elimination of snail-borne diseases**.** Hence, the need to ascertain those influencing factors in the distribution of vector snails in various ecological zones therefore becomes imperative. This study was therefore carried out to identify the influence of physicochemical factors on biodiversity indices of fresh water snails in Osun State.

Materials and Methods

Study Design

The study employed a descriptive cross-sectional design to investigate the role of physicochemical factors of selected rivers on snail richness, diversity and bulinus abundance.

Study Area

The study was carried out in three communities namely Ere Ijesha, Ede and Erin-Ile randomly selected from the three senatorial districts in the State viz Osun West, Osun East and Osun central. The sampling communities are made of rain-forest with abundant trees and grasses. The communities consist mainly of Yorubas and major occupations among them are farming and trading. The geographic coordinates of the sampling points are represented in Table 1.0 below. Through reports from community members, a mostly visited river from each community was selected and three contact points with evident human water contact were identified for snail and water sampling

Table 1: GPS information of the sampling locations in Ere Ijesa, Ede and Erin Osun

Ere Ijesa river	Coordinates (Long, Lat)	Ede river	Coordinates (Long, Lat)	Erin Osun river	Coordinates (Long, Lat)
SP 1	7.7358, 4.7735	SP 1	7.7472, 4.4360	SP 1	7.8197, 4.4805
SP 2	7.7354, 4.7772	SP 2	7.7453, 4.4364	SP 2	7.8197, 4.4743
SP 3	7.7381, 4.7744	SP 3	7.7455, 4.4408	SP 3	7.8679, 4.4957

**SP= sampling point*

Water Sampling

Grab sample of water was collected from each sampling point making a total of three grabs per sampling location. The three grab samples were independently analyzed for physicochemical parameters and an average value was recorded. Parameters measured include pH, temperature, water conductivity, turbidity, total hardness, dissolved oxygen (DO), Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Nitrate, Chloride and Total dissolved solids (TDS) using standard procedures.

Snail Sampling

Sampling of snails was carried out during both wet and dry seasons for a period of one year. Collection of snails at each sampling point was carried out using both manual search and scooping net. The snails were collected in a specific identified sampling point throughout the sampling period to avoid bias in sampling. The snails captured were then cleaned with water, counted and later transferred into the specimen container for morphological identification of various snail species obtained.

Morphological Identification of Snails

Based on previous methodology (Usman *et al.*, 2019), snail identification was carried out at Obafemi Awolowo University Museum using shell morphology. This was achieved by holding the snail shell with the apex (pointed edge) pointing upward and checking for aperture opening. The sculptural markings on the snail shell were also considered during identification. Other shell components that were considered during identification include number of whorls, shape of the shell, type of apex (sharp or blunt) and shape of the peristome on the aperture.

Biodiversity indices measurement

Shannon Index (H)

Shannon Index (H) which was used to assess the diversity of the snails was calculated using reference materials (Anderson *et al.*, 2023; Igbani, 2018; Ryan, 2022; *Student Handout 1A : How to Calculate Biodiversity*, n.d.)**.** The higher the value of *H*, the higher the diversity of species in a particular community

$$H = -\sum_{i=1}^{s} Pi \ln Pi \quad \text{where:}$$

H= Shannon Index

p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N),

ln is the natural log
Σ is the sum of the calculations
s is the number of species.

Richness: Richness which is the number of species counted in a given unit of area is represented as: ***R= Number of species/Area***
Specie Abundance: Specie abundance which is the total number of individual species (Isi) divided by total number of species population (∑ Nsi) multiplied by hundred is represented as:

Specie Abundance (%) = Isi/∑Nsi X 100
Where, Isi = Total Number of individual specie
∑ Nsi = Total Number of species population.

Specie abundance measures the number of individuals within each species found in the same environment.

Results

Biodiversity indices of fresh water snails across the sampling locations
The results of snail population and their biodiversity indices in all the sampling locations are presented in table 2 and 3 below. Out of a total number of 51 snails obtained over the sampling period, Erin Ijesa returned highest number of snails which is 34 (66.7%) with majority of the snails from this site (88.2%) being obtained during the dry season. Ede had a total number of 11(21.6%) with majority (63.6%) obtained in dry season while Erin Osun returned the lowest number, 6 (11.8%) with majority (83.3%) been obtained during the dry season. Snail diversity, richness and *Bulinus* abundance significantly differ across the sampling locations. In terms of snail diversity, Ede had highest diversity index (1.732) followed by Ere Ijesha (1.540). Ere Ijesa had highest *Bulinus* abundance (82.4%) followed by Ede (17.6%) while Erin Osun was the least in terms of snail richness (3), diversity index (1.040) and *Bulinus* abundance (0%).

Table 2: Seasonal snail population in Ere Ijesa, Ede and Erin Osun

Locations	Rain Season	freq	Dry Season	F
Ere Ijesa	*Bulinus forskali*	2	*Lymnaea Auricularia*	3
	Cleopatra bulinoides	1	*Bulinus jousseeaumei*	1
	Bulinus africanus.	1	*Lymnaea natalensis*	5
		-	*Physella acuta*	2
		-	*Pila globose*	5
		-	*Aplexa waterloti*	4
		-	*Bulinus globose*	3
		-	*Bulinus africanus*	3
		-	*Bulinus forskali*	3
		-	*Bulinus truncates*	1
Ere Ijesa total		**4**		**30**
Ede	*Pomacea paludosa*	3	*Bulinus globosus*	2
	Aplexa waterloti	1	*Potadoma liberiensis*	1
		-	*Bulinus forskali*	1
		-	*Bithynia forcati*	1
		-	*Pomacea canaliculate*	1
		-	*Bellamya unicolor*	1
Ede total		**4**		**7**
Erin Osun	*Cleopatra bulinoids*	1	*Potadoma liberiensis.*	1
		-	*Potadoma melanoides*	2
		-	*Melanoides tuberculate*	2
Erin Osun total		**1**		**5**
Total per season		**9**		**42**
				Total snail sampled=51

*Freq: Frequency

Table 3: Biodiversity indices of Fresh Water Snail across sampling locations in Ere Ijesa, Ede and Erin Osun

	Snail Richness	Shannon index (H_0)	*Bulinus* Abundance
Ere Ijesa	6	1.540	82.0%
Ede	6	1.732	17.6%
Erin Osun	3	1.040	0.0%

Physicochemical Parameters versus Biodiversity indices across the sampling locations

Figures 1, 2, 3, and 4 presents the result of physicochemical parameters, richness, diversity and bulinus abundance of the three sampled rivers. All the physical parameters measured namely turbidity, salinity, conductivity and total dissolved solids (TDS) do not differ significantly across the sampling locations (P= 0.93, 0.34, 0.1 and 0.09 respectively). Conversely, two of the measured chemical parameters namely pH and chloride significantly differ across the sampling locations (P= 0.04 and 0.01 respectively). There is a significant difference between pH values of Ere Ijesa and Erin Osun (P=0.03) while Ede and Erin Osun also show a significant difference in their chloride concentration ($P<0.05$). A significant difference however exists between all the biodiversity indices: diversity ($P<0.05$), richness ($P<0.05$) and bulinus abundance ($P<0.05$) across the sampling points).

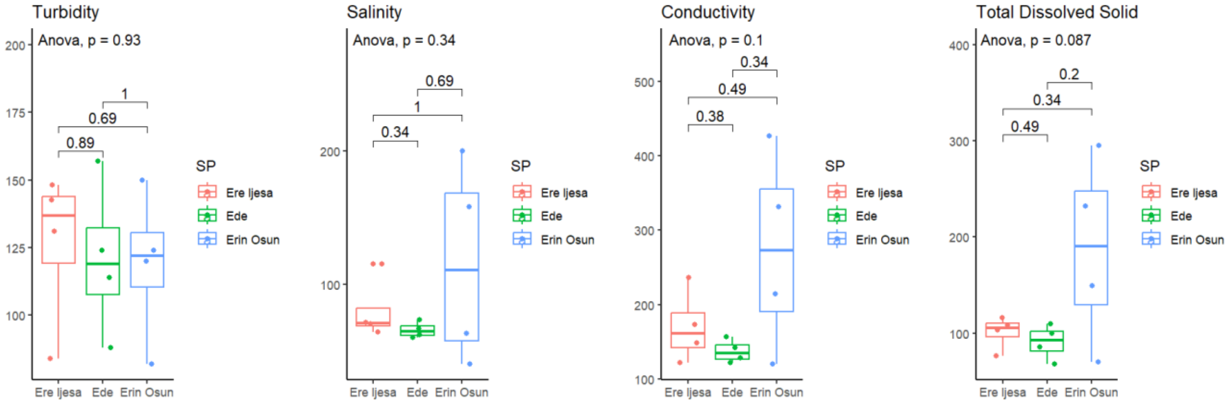

Fig 1: Physical parameters of water samples across Sampling points in Ere Ijesa, Ede and Erin Osun

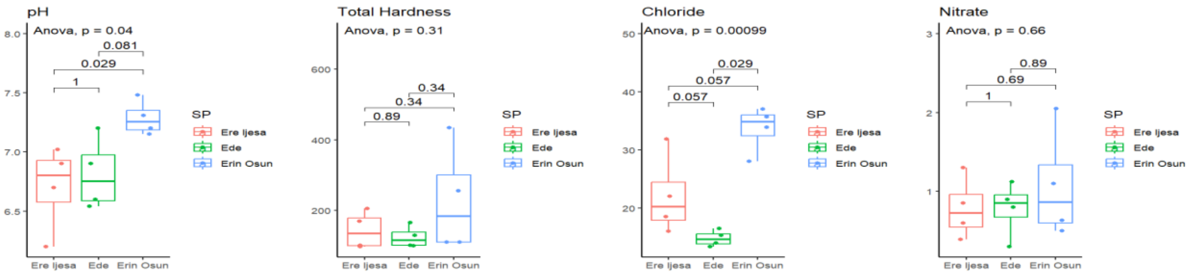

Fig 2: Chemical parameters of water samples across Sampling points

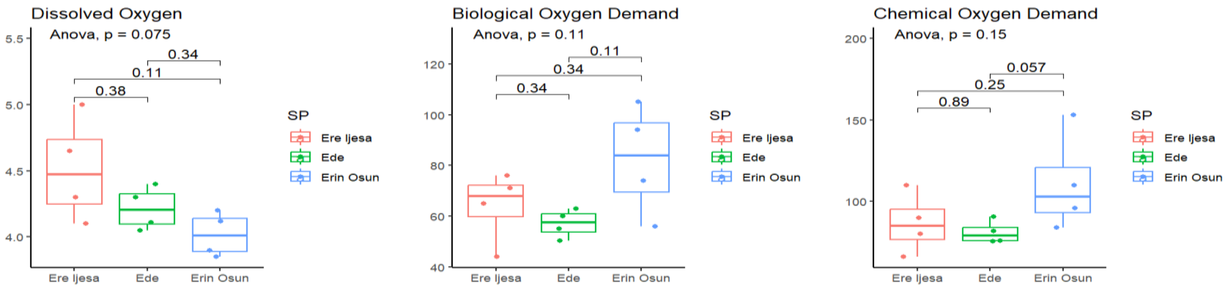

Fig 3: Chemical parameters of water samples across Sampling points in Ere Ijesa, Ede and Erin Osun

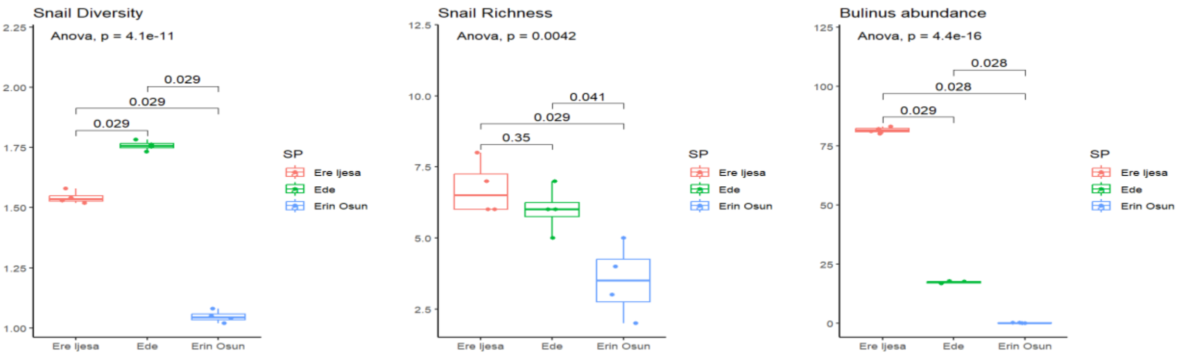

Fig 4: Diversity, Snail Richness and Bulinus Abundance across Sampling Points in Ere Ijesa, Ede and Erin Osun

Physicochemical parameters of water across seasons

While considering the variations in the physical and chemical parameters of the sampled water across seasons, the results in table 4 show that only turbidity varies significantly across seasons (P< 0.05) while other parameters do not differ significantly across seasons (P>0.05).

Table 4: Physicochemical parameters of water samples across seasons using Student T-Test

Parameters	Dry Season (Mean ± SD)	Rainy Season (Mean ± SD)	P-Value
Turbidity	134.01 ± 15.05	110.08 ± 30.38	**0.043***
Salinity	93.05 ± 57.88	80.78 ± 37.97	0.341
Conductivity	221.45 ± 108.59	165.35 ± 82.40	0.645
TDS	143.85 ± 76.84	108.10 ± 62.51	0.702
Total hardness	186.67 ± 128.22	144.02 ± 61.02	0.271
Chloride	25.39 ± 10.51	21.64 ± 8.10	0.121
Nitrate	0.85 ± 0.63	0.90 ± 0.32	0.457
DO	4.21 ± 0.27	4.29 ± 0.39	0.552
BOD	63.88 ± 21.61	71.68 ± 13.67	0.548
COD	93.18 ± 30.77	92.33 ± 15.25	0.464
pH	6.89 ± 0.32	6.98 ± 0.44	0.746

*DO= Dissolved oxygen; BOD= Biochemical oxygen demand, TDS= Total dissolved solids

Relationship between physicochemical parameters against Biodiversity indices

Table 5 shows the result of association between physicochemical parameters and snail richness, diversity and *Bulinus* Abundance. A significant positive correlation exists between pH and diversity (rho= 0.64, P< 0.05), pH and *Bulinus* abundance (rho = 0.68, P< 0.05), chloride and snail richness (rho = -0.65, P< 0.05), chloride and diversity (rho = -0.88, P< 0.01), BOD and snail richness (rho = -0.78, P< 0.05), BOD and diversity (rho = -0.64, P< 0.05) and COD and snail richness (rho = -0.61, P< 0.05).

Table 5: Correlation of physicochemical parameters of water samples against Biodiversity indices in Ere Ijesa, Ede and Erin Osun

Physicochemical parameters	Richness Rho (P-value)	Diversity Rho (P-value)	*Bulinus* Abundance Rho (P-value)
pH	-0.53 (0.78)	**-0.61 (0.04)** *	**0.64 (0.03)** *
Turbidity	0.14 (0.66)	0.08 (0.82)	0.13 (0.7)
Salinity	-0.45 (0.15)	-0.45 (0.14)	-0.28 (0.38)
Conductivity	-0.45 (0.15)	**-0.61 (0.03)** *	-0.40 (0.19)
TDS	-0.45 (0.12)	-0.62 (0.03)	-0.48 (0.11)
Total hardness	-0.48 (0.11)	-0.46 (0.13)	-0.33 (0.3)
Chloride	**-0.65(0.02)** *	**-0.88 (0.00)** *	-0.45 (0.12)
Nitrate	-0.31 (0.32)	-0.27 (0.41)	-0.24 (0.46)
DO	0.37 (0.24	0.36 (0.25)	**0.66 (0.02)** *
BOD	**-0.78 (0.03)** *	**-0.64 (0.03)** *	-0.39 (0.22)
COD	**-0.61 (0.03)** *	-0.57 (0.06)	-0.40 (0.20)

**TDS= Total dissolved solids; DO= Dissolved oxygen; BOD= Biological oxygen demand; COD= Chemical oxygen demand*

Discussion

This study sought to identify the role of physicochemical parameters on biodiversity indices of fresh water snails in selected rivers in Osun State. We found out that physicochemical parameters had significant role to play in snail richness, snail diversity and *Bulinus* richness. First is the pH, which shows a negative correlation with snail diversity and *Bulinus* richness. This implies that increase in pH will significantly reduce the snail diversity and *Bulinus* richness. Similarly, increase in chloride concentration and BOD were also found to significantly reduce snail richness and snail diversity while COD is negatively correlated with snail richness. Noting from the result of this study, the significant variation in snail richness, snail diversity and *Bulinus* richness observed across sampling points may not be unconnected with the significant variation in pH and Chloride contents across the sampling points. Emphasis has been laid on the role of pH in survival of fresh water snail with reports that water snails are well adapted to habitat with pH levels ranging from 6.5 – 8.5. Lower values of pH have been reported to increase the solubility potential of other toxic elements especially heavy metals which make them available for absorption by aquatic organisms (Onyekachi *et al*., 2022).

In a study carried out by Nwoko *et al*. (Onyekachi *et al*., 2022) to determine the species diversity, distribution, and abundance of freshwater snails in KwaZulu-Natal, South Africa, snails were found in sites with pH levels ranging from 6.42–7.98, which is similar to what was obtained in the current work where maximum pH across sampling sites recorded was 7.28 ± 0.15 and minimum value of 6.71 ± 0.36. The role of pH on the life cycle of trematodes and their vector host such as freshwater snail cannot be overemphasized. At low pH values (acidic conditions), the snails may be killed thereby reducing their abundance and subsequently leading to low infection rate since most snails may not be able to reach the miracidia before their death (Candia *et al*., 2015; De Francesco & Isla, 2003).

Chloride concentration in this study ranged between 14.77 to 33.65mg/l and was observed to be negatively correlated with snail richness and diversity. This is in agreement with the study carried out in the Ethiopian Rift Valley region to determine the environmental and biotic factors affecting freshwater snail intermediate hosts. In the study, (Olkeba *et al*., 2020) abundance of *B. Globosus* was negatively correlated with chloride concentration. A major problem of elevated chloride in aquatic ecosystem is chronic toxicity which is harmful to aquatic lives as it interferes with their balance of body fluids and also increases water corrosivity (Wei *et al*., 2017). BOD which is the measure of organic material contamination in water or measure of amount of dissolved oxygen required for the biochemical decomposition of organic compounds, was found to be negatively correlated with snail richness and diversity. This is not unprecedented as increased level of BOD leads to reduced dissolved oxygen (DO) and subsequently causing oxygen deprivation for the aquatic organisms including the fresh water snails. Highest BOD value of 82.25 mg/l was recorded at Erin Osun against 5 mg/l which is the EPA standard limit for river water (Patil *et al*., 2015). This may be connected with both organic and inorganic matter pollution evident at the site during sampling period. Study has shown that high level of organic pollution of river waters can result in higher demand for oxygen (BOD), COD and total dissolved solids (Patil *et al*., 2015). The highest BOD and COD recorded in Erin Ijesa might be the cause of the site returning lowest number of snails and this is evident from analysis of variance result which shows that all other sites differed significantly from Erin Osun in terms of snail richness, diversity and bulinus abundance.

Also, this work is similar to the work of Sunday *et al* (Sunday *et al*., 2023), who found a positive correlation between dissolved oxygen and bulinid species. Such relationship may be explained by poor aeration which usually occurs in an oxygen deficient medium due to decomposition of organic matters from aquatic lives such as algae and other aquatic plants. This view, that dissolved oxygen is positively correlated with bulinus abundance is widely supported by other researchers (Hussein *et al*., 2011; Idowu *et al*., 2004; Onyekachi *et al*., 2022; Seid *et al*., 2019).

This study also revealed that Ede is the most diverse ecosystem considering its Shanon index value followed by Ere-Ijesha while the least diverse is Erin-Osun. The few species inhabiting a less diverse ecosystem are able to thrive better than in a more diverse ecosystem since they are less influenced by competitive activities of other species in terms of food, space and other requirements as competition reduces in a less diverse ecosystem according to study (Ryan, 2022). This may explain why *Bulinus* species are more abundant at Ere- Ijesha than Ede.

Conclusion

Physicochemical parameters such as pH, chloride content, BOD and COD play significant role in biodiversity indices of fresh water snails. Environmental modification of these parameters can go a long way in snail bound infection control.

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