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Original Article

Influence of physico-chemical parameters on the intermediate host of *Schistosoma haematobium* and *Schistosoma mansoni* in Makwaye and Kubanni Reservoirs, Zaria, Nigeria

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ABSTRACT

Objective: This research was conducted to determine the influence of physico-chemical characteristics on diversity of the intermediate host of schistosomes in Makwaye and Kubanni reservoirs, Zaria, Nigeria.
Materials and methods: Physico-chemical characteristics and diversity of the intermediate host of schistosomes in Makwaye and Kubanni reservoirs, Zaria, Nigeria, were investigated for a 12-month period (January to December, 2014). Physico-chemical properties were analyzed according to the standard procedures for examination of water and waste waters. The molluscs were collected using an Ekman grab model number 923, measuring 19 cm by 14 cm with an area of 0.0266 m^2. PAST software was used to run Principal Component Analysis, Shanon-Weiner diversity index and Cluster analysis.
Results: A total of 978 *Bulinus globosus* and 3612 *Biomphalaria pfefferi* were recorded in Makwaye reservoir with high abundance in dry season while a total of 163 *B. globosus* and 602 *B. pfefferi* was recorded in Kubanni reservoir with higher abundance in wet season. Shanon-Weiner diversity index of Makwaye reservoir also ranged from 2.01-2.22 and 1.16-1.31 in Kubanni reservoir. Significant variations ($P \leq 0.05$) were observed in physicochemical parameters, schistosomes intermediate host abundance with seasons. Principal Component Analysis (PCA) revealed significant influence ($P \leq 0.05$) of physicochemical properties on schistosome intermediate host composition, with BOD, DO, pH and Calcium significantly influencing the presence of *B. globosus* and *B. pfefferi* in both reservoirs.
Conclusion: It is concluded that the presence of these molluscs in the study areas may constitute a predisposing factor to schistosomiasis and therefore, various management strategies and recommend preventive measures to people coming in contact with these two reservoirs.

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KEYWORDS

Biomphalaria; *Bulinus*; Intermediate host; Reservoirs; Schistosomes

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INTRODUCTION

Schistosomiasis is an infectious disease affecting many people in developing or tropical countries, caused by blood flukes under the genus *Schistosoma* (Rawani et al., 2014). Diversity of intermediate host of schistosomes is determined by many factors that includes pH, water temperature, nutritive content of the water body, dissolved oxygen, physical nature of the substratum, calcium ion and depth (Alhassan et al., 2016).

Intermediate host of schistosomes are distributed in many habitats as they can be adapted in wide range of environments (Sharma et al., 2013). Schistosomiasis is a vector-borne disease caused by parasites of the genus Schistosoma; it is contracted when persons come in contact with infected river water harboring cercariae-shedding snail. The parasite penetrates the skin and migrates via the venous system to the portal vein of the intestine or the bladder where they eventually mature and lay eggs that scar tissues of the organs, which eventually results to disease condition (Angaye, 2016).

Schistosomiasis depends on intensity of infection and the infecting species. The symptoms developed by the disease included fever, headache, abdominal pain, malaise, urticarial and diarrhea (Awobode et al., 2016). Transmission of schistosomiasis depends on the extent and duration human-water contact (Ofulla et al., 2013). The women working frequently in water and domestic chores are at greater risk (Awobode et al., 2016). Morbidity and mortality are mostly associated with teenagers, young adults, women and infections in school-age children (Rollinson et al., 2013).

Reports indicated that around 230 million populations need treatment in each year worldwide. Transmission of schistosomiasis has been occurred in 78 countries with are 52 countries at the highest risk of acquiring the infection. The common schistosome species infecting humans are *Schistosoma mansoni*, *S. japonicum*, *S. haematobium*, *S. mekongi*, and *S. intercalatum*. Other species of Schistosoma which have veterinary importance include *S. mattheei, S. bovis*, *S. sprinadalis* and *S. rodhaini*. These schistosome species may accidentally infect humans (Belete, 2015).

Health education and promotion is one of the major strategies in schistosomiasis control programs. It aims to promote and reinforce healthy behavior with full participation of both the individual and the community. This approach could be developed in all endemic areas, with emphasis on personal/environmental hygiene and community's participation in the controlling programs. Schistosomiasis could largely be prevented by changing human behavior, and health education is of paramount importance to achieve this (Belete, 2015).

Mollusc communities are known to respond to changes in the quality of water or habitat (Sharma et al., 2013; Alhassan et al., 2016). Diversity, distribution and abundance of intermediate hosts of schistosomiasis depend on the characteristics of their environment such as pollution condition, organic matter content, soil texture and sediment. Because they vary in their adjustment to environmental conditions and their tolerance or sensitivity to contamination, the physicochemical parameters of this intermediate host environment such as pH, calcium hardness, nitrate, phosphate, dissolve oxygen and biological oxygen demand can be utilized to reflect environmental quality and abundance of this species (Alhassan et al., 2016).

MATERIALS AND METHODS

Study Area: Makwaye reservoir is located on 11°11´N and 7°37´E. Makwaye reservoir is one of the important sources of water for the people inhabiting near Ahmadu Bello University (**Figure 1**). Kubanni reservoir is located on 11°08´N and 7°39´E south of Ahmadu Bello University Zaria Samaru campus (**Figure 2**). The reservoir has a seasonal flow whereas Samaru stream that originates from a semi-urban settlement has an all-year round flow due to its sustenance by urban runoffs and seepages (Abolude, 2007).

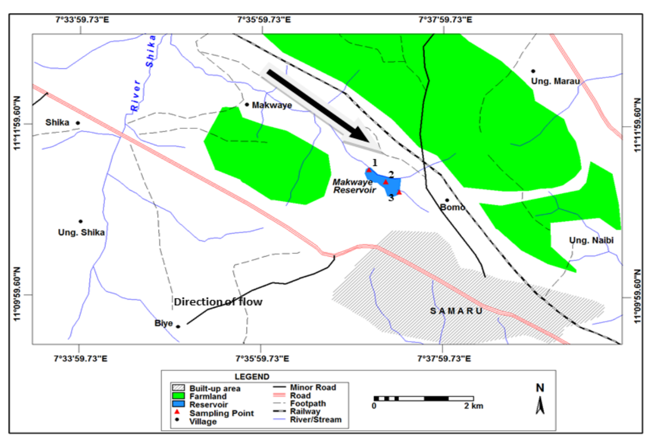

Figure 1: Map of Makwaye reservoir showing three sampling stations

Sample Collection: Samplings were done for twelve months covering rainy and dry season in three ssites each for the two study areas based on the lenthic and lothic nature of the sampling sites.

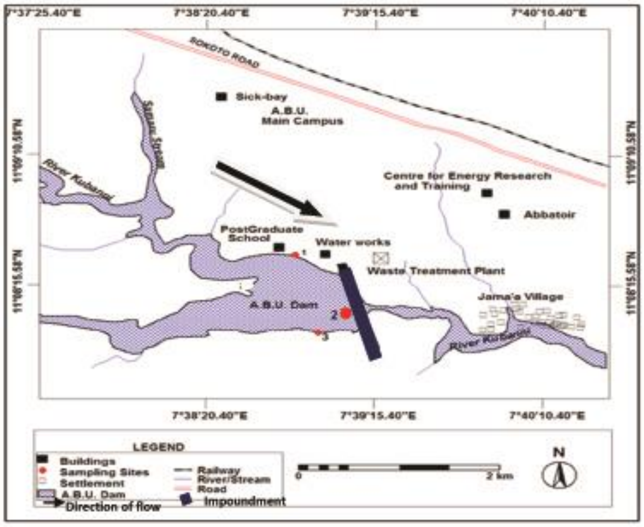

Figure 2: Map of Kubanni reservoir showing three sampling stations

Determination of physicochemical parameters: *In situ* determination of surface water temperature (^oC), pH, Electrical conductivity (EC) and Total dissolved solids (TDS) were carried out using portable HANNA instrument (Model HI 98129). Water samples for the determination of biochemical oxygen demand (BOD) and dissolved oxygen (DO) were collected twice monthly between January and December 2014 in transparent and amber coloured 250 mL reagent bottles. In the laboratory, water samples were analyzed for Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Alkalinity, Nitrate-nitrogen, Phosphate-phosphorus and Calcium hardness according to APHA (2005).

Collection and identification of Schistosome species intermediate host: Sediments were collected from the reservoirs between the hours of 8.00 am and 9.00 am using an Ekman grab (Model No. 923) measuring 19cm by 14 cm with an area of 0.0266 m^2. Three grab hauls were taken from each station, emptied into pre-labeled polythene bags and taken to the laboratory for sorting and identification. The collected materials were washed through a 0.5 mm mesh sieve. The residue in the sieve for each station was then preserved in 10% formalin solution for further analysis. Small portions of the sediment samples were washed in a 0.5 mm sieve to remove debris. Snail species were identified with the aid of dissecting microscope according to Odum (1971) and Pennak (1978). Thereafter, the snails were grouped into either *B. globosus* or *Biomphalaria pfefferi*.

Data analysis: Variarion in physicochemical characteristics was determined using Analysis of Variance (ANOVA) at $P \leq 0.05$ while the influence of physico-chemical characteristics on schistosome intermediate hosts were determine using Principal Component Analysis (PCA). Diversity of schistosome intermediate host in each reservoir was also determined using Shannon - Wiener diversity index (H´). Statistics Analysis System (SAS) version 9.1 and Paleontological Statistics Software Package (PAST) V.2.17c were used for the analyses.

RESULTS

Influence of physico-chemical characteristics on schistosome intermediate hosts

Principal Component Analysis (PCA) biplot of physico-chemical characteristics and schistosome intermediate hosts of Makwaye reservoir (**Figure 3**) and Principal Component Analysis (PCA) loadings for correlation between physico-chemical characteristics and intermediate host of schistome (**Figure 4**) shows the influence of physico-chemical characteristics on the intermediate hosts of *Schistosome*. The same apply to Kubanni reservoir as shown in **Figure 5** and **Figure 6**.

In Makwaye reservoir, PCA showed that the first two components accounted for 80.9% of the total variation observed in the PCA. The two intermediate hosts of schistosome *i.e.*, *B. globosus* and *B. pfefferi* were positively correlated with pH, Ca, BOD, DO and NO_3^- N but negatively correlated with EC, TDS, Temperature, Alkalinity and PO_4^- P. However, strong positive correlation exist more between *B. globosus* (r =0.7793) and pH (r=0.5999), Ca (0.8206), DO (0.881), BOD (0.9617) and NO_3^- N than between *B. pfefferi* (r = 0.163) with the physico-chemical parameters.

In Kubanni reservoir, PCA showed that the first two components accounted for 76.2% of the total variation observed. *B. globosus* and *B. pfefferi* were positively correlated with pH, Ca, BOD, DO, TDS, EC and PO_4-P but negatively correlated with Alkalinity and NO_3^- N. However, there exist more strong positive correlation between *B. pfefferi* (r=0.9323) and BOD (r=0.789), Ca (r=0.8439), DO (r=0.726), EC (r=0.9784) and pH (r=0.714) than between *B. globosus* (r=0.306) and the physicochemical parameters.

Cluster analysis shows the relationship in the physico-chemical parameter and schistosome intermediate host diversity between the three sampling stations in Makwaye reservoir (**Figure 7**) and Kubanni reservoir (**Figure 8**). With station 1 and 3 more closely related than with station 2 in terms of physico-chemical characteristics and schistosome intermediate host diversity in Makwaye and Kubanni reservoirs.

Table 1: Seasonal Variation and Shannon-Weiner Diversity Index of intermediate host of schistosomes in Makwaye and Kubanni Reservoirs

	Makwaye			Abundance	Kubanni			Abundance
	Wet	Dry	Total	%	Wet	Dry	Total	%
Biomphalaria pfefferi	522	3090	3612	78.69	440	162	602	78.69
Bulinus globusus	228	750	978	21.31	102	61	163	21.31
TOTAL	**750**	**3840**	**4590**		**542**	**223**	**765**	
H´	2.01	2.22			1.31	1.16		

H´=Shannon-Weiner diversity index, WS = Wet season, DS = Dry season

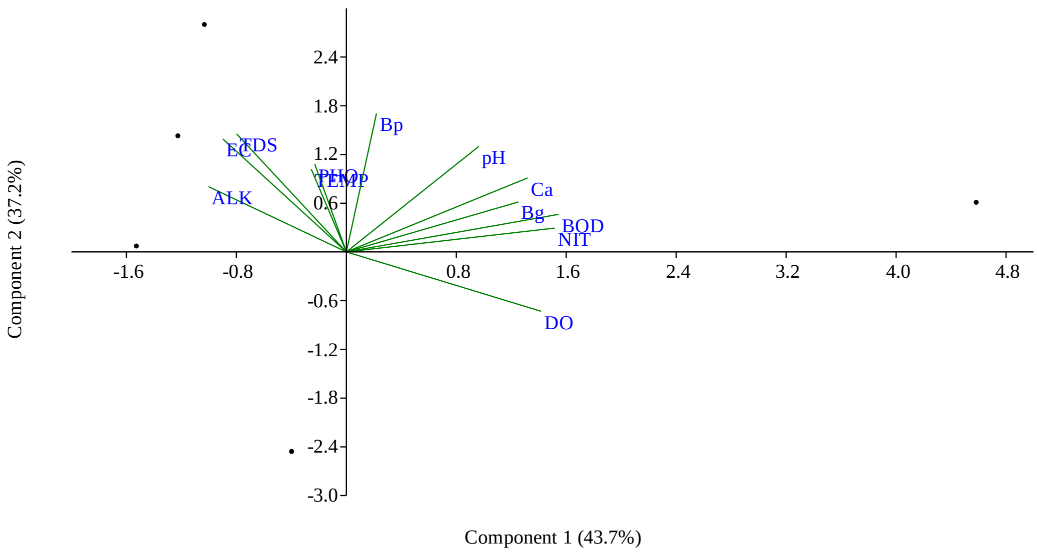

Figure 3: Principal Component Analysis Biplot for physicochemical parameters and intermediate host of *Schistosoma haematobium* and *Schistosoma mansoni* in Makwaye reservoir

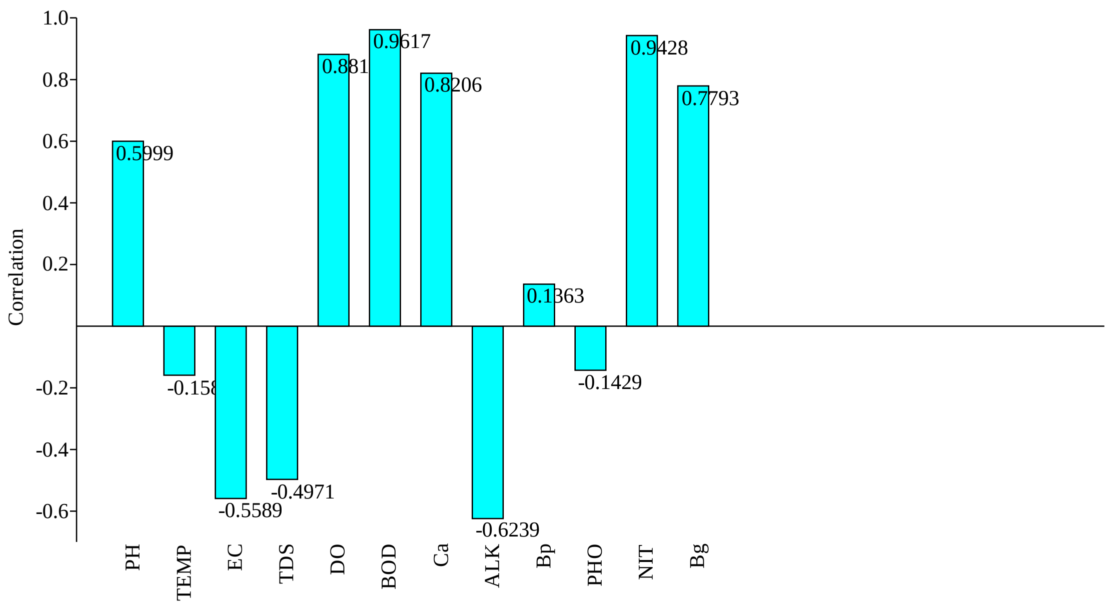

Figure 4: Principal component analysis biplot correlation loadings for physicochemical parameters and intermediate host of *Schistosoma haematobium* and *Schistosoma mansoni* in Makwaye Reservoir

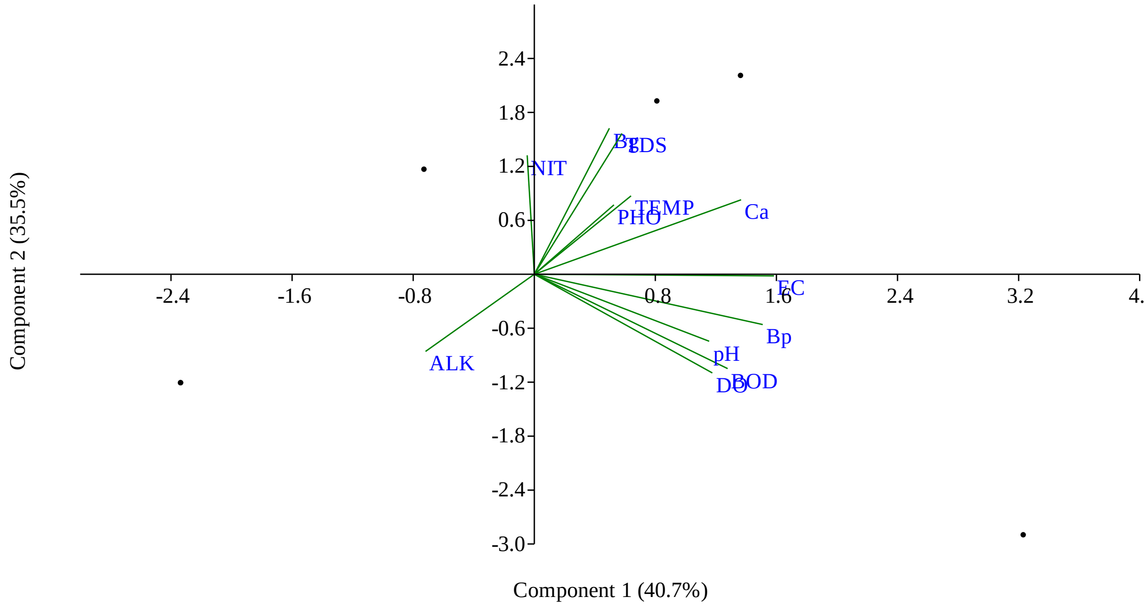

Figure 5: Principal component analysis biplot for physico-chemical parameters and intermediate host of *Schistosoma haematobium* and *Schistosoma mansoni* in Kubanni Reservoir. pH = Potential of hydrogen, TEMP = Surface water temperature, ALK = Total alkalinity, EC = Electrical conductivity, TDS = Total dissolve solids, DO = Dissolve oxygen, BOD = Biological oxygen demand, Ca = Calcium, PHO = Phosphate, NIT = Nitrate, Bg = *Bulinus globosus*, Bp = *Biomphalaria pfefferi*

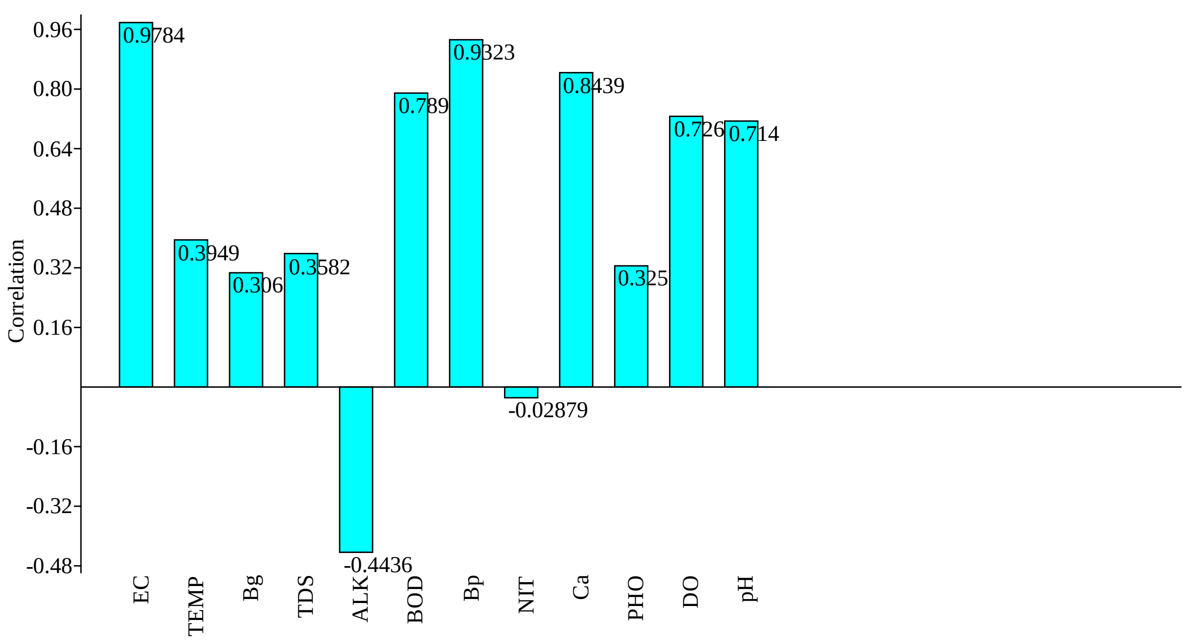

Figure 6: Principal Component Analysis Biplot Correlation Loadings for Physico-chemical Parameters and Intermediate Host of *Schistosoma haematobium* and *Schistosoma mansoni* in Kubanni Reservoir. pH = Potential of hydrogen, TEMP = Surface water temperature, ALK = Total alkalinity, EC = Electrical conductivity, TDS = Total dissolve solids, DO = Dissolve oxygen, BOD = Biological oxygen demand, Ca = Calcium, PHO = Phosphate, NIT = Nitrate, Bg = *Bulinus globosus*, Bp = *Biomphalaria pfefferi*

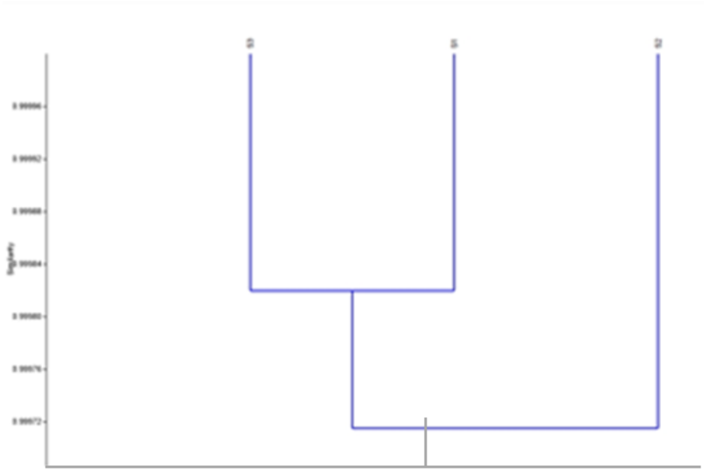

Figure 7: Cluster analysis dendogram of relationship between the sampling stations relative to physicochemical parameters and Intermediate hosts of *Schistosoma haematobium* and *Schistosoma mansoni* in Makwaye reservoir. S1 = Station 1, S2 = Station 2, S3 = Station 3

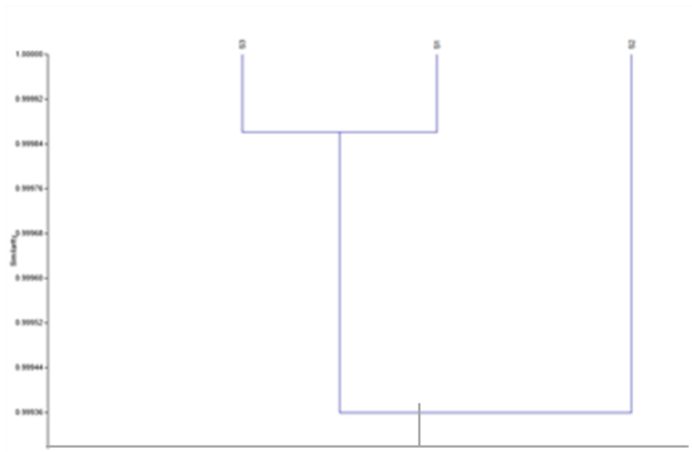

Figure 8: Cluster analysis dendogram of relationship between the sampling stations relative to physicochemical parameters and Intermediate hosts of *Schistosoma haematobium* and *Schistosoma mansoni* in Kubanni reservoir. S1 = Station 1, S2 = Station 2, S3 = Station 3

Schistosome intermediate hosts abundance and diversity

In this study, seasonal collection of *B. globosus*, and *B. pfefferi* and Shannon–Weiner diversity index is presented in **Table 1**. A total of 4500 snails comprising 3612(78.69%) *B. pfefferi* and 978(21.31%) *B. globosus* were recorded in Makwaye reservoir with higher abundance of the snails recorded in dry season. Shannon – Weiner diversity index of snails in Makwaye reservoir was 2.01 in wet season and 2.22 in dry season. In Kubanni reservoir, a total of 766 snails comprising 602(78.59%) *B. pfefferi* and 164(21.41%) *B. globosus* were recorded with high abundance of snails in wet season. Shannon – Weiner diversity index of snails in Kubanni reservoir was 1.31 in wet season and 1.16 in the dry season.

DISCUSSION

Physico-chemical characteristics of Makwaye and Kubanni reservoirs with its influence on abundance and diversity of intermediate hosts of *Schistosoma haematobium* and *S. mansoni* has been established in this study and the positive correlation that exists between the intermediate hosts and some physico-chemical parameters in both reservoirs can be as a result of their importance in body physiology and survival of these organisms. However, the abundance of intermediate hosts was recorded to be higher in the dry season in Makwaye reservoir but lower in Kubanni reservoir. This can be due to dredging activity that was going on at the reservoir in the dry season during the study. Dredging of reservoir can lead to physical disturbance of aquatic environment leading to decrease in abundance and diversity (George et al., 2009).

The abundance and diversity of living organisms in aquatic environment usually varies with the variation of physico-chemical parameters and this can be the sole reason for the variation in abundance of this intermediate host both in season and between the two reservoirs. So also can be due to the effect of domestic and industrial wastes in the reservoir (Adeyemo et al., 2008).

In the two reservoirs, positive correlation between the intermediate hosts and pH, Ca, BOD and DO values recorded in the present study may have favour the presence of these species which are used as indicator species for pollution in an aquatic environment. The ability of these species to be found in polluted environment can be a characteristic of species in water showing some degree of change due to anthropogenic activities. Their high presence is a common feature of organically polluted water bodies (Atobatele et al., 2005; Chindah et al., 1999). Studies on diversity of intermediate hosts were higher in Makwaye reservoir as the Shanon-Weiner diversity index was higher in both dry and wet season at Makwaye reservoir. A value of this index above three indicates clean water, whereas values fewer than this would indicate pollution (Maiti, 2004) and the higher the value, the greater the diversity. Although the range of this index in Makwaye and Kubanni reservoir indicate that the reservoir is mildly polluted and this can be the reason for the various relationship between the organisms and the physico-chemical parameters. The lowest value in wet season can be due to increase in flow of water and methods of sampling and also the high value in dry season can also be due to decrease in water flow and the methods of sampling (Nkwoji and Edokpayi, 2013).

One major difference between the two reservoirs was in abundance and Shanon-Weiner diversity index where the Shanon-Weiner diversity index in dry season was the lowest while the highest value was recorded in wet season at Kubanni reservoir which is not same with Makwaye reservoir and this can be due to the different activities in the catchment of the reservoir and in the reservoir (Robinson et al., 2005).

Close relationship in the stations were samples were collected can be as a result of similarities interms of organism abundance and physical and chemical characteristics of the stations which is determined by the type of anthropogenic activities, lenthic and lothic nature, and depth (Robinson et al., 2005).

CONCLUSION

There is influence of physical and chemical properties of Makwaye and Kubanni reservoir on the abundance and diversity of intermediate hosts of *S. mansoni* and *S. haematobium*. There exist Positive correlation between the intermediate hosts and some physicochemical parameters in both reservoirs. Physico-chemical properties such as BOD, DO, pH and Ca have significant influence on the presence of intermediate hosts of *S. mansoni* and *S. haematobium* in Makwaye and Kubanni reservoirs. Seasonal difference in abundance and diversity, and relationship between the sampling stations are as a result of physical and chemical characteristics of the reservoirs. The presence of the two species of molluscs which are intermediate hosts of *S. mansoni* and *S. haematobium* in the study areas may constitute a predisposing factor to schistosomiasis and therefore, various management strategies such as limnological measurements should be carried out on the reservoirs to monitor and track the trend of changes in the physico-chemical characteristics and composition of intermediate host of schistosomes, and recommend preventive measures to people coming in contact with these two reservoirs.

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CONFLICT OF INTEREST

The authors declared no conflicts of interest regarding the research, authorship, and/or publication of this article.

AUTHORS' CONTRIBUTION

ABA initiated the work, the initial draft, literature review and data analysis; MLB and IMKG made the necessary corrections over the entire manuscript. SRI overhauled the overall manuscript to give it the present outlook. YAW design the research to determine the importance of physicochemical parameters on the two intermediate hosts of *S. haematobium* and *S. mansoni* and AY was involve in the field collection of the two intermediate hosts of *S. haematobium* and *S. mansoni*.

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