ESCHERICHIA COLI AND COLIFORM BACTERIA AS DRINKING WATER QUALITY INDICATORS AT WARWADE DAM, DUTSE, JIGAWA STATE, NIGERIA

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ABSTRACT

We conducted a systematic examination of water quality, specifically faecal contamination of drinking water, in the Warwade Dam water in our current study. Our goal was to measure physical characteristics (temperature, pH, conductivity, and total dissolved solids) as well as the presence of faecal coliforms (E. coli and total coliforms) in Warwade Dam water, which is used as a source of drinking water for people who live near the dam. This data collection will be used as a baseline for future monitoring and access to drinkable water. The sample locations were chosen based on their principal use as a source of drinking water for the Warwade population. In general, physical parameters have little correlation, but there are weak relationships between total coliform data and increasing temperature and pH. During the dry season, our research clearly shows the existence of bacterial faecal contamination indicators. More E. coli and coliform germs were found in samples from more densely inhabited locations.

Keywords: Faecal coliform, E. coli, Warwade Dam, Drinking water quality, Baseline dataset

INTRODUCTION

The growing amount of farming operations in the Warwade neighbourhood has resulted in widespread anthropogenic concerns related with human waste. The environmental implications of incorrect disposal of non-biodegradable solid trash, such as water bottles, plastic bags, and other littered along the trails, may be seen along the major trekking routes. The combined effects of poorly managed or mismanaged solid waste disposal and open defecation have resulted in significant environmental degradation of Warwade dam water. Despite the pollution, the dam still provides drinking water. Enteropathogenic agents (i.e. salmonella, shigella), enteroviruses, multicellular parasites, and opportunistic pathogens such as Pseudomonas aeruginosa, Klebsiella, Vibrio parahaemolyticus, and Aeromonas hydrophila are among the pathogenic microorganisms that can be transmitted to humans through faeces-contaminated water. Isolating and identifying these species, on the other hand, can be difficult, expensive, and rarely quantifiable. Fortunately, measuring coliform bacteria (total coliform bacteria and/or faecal coliforms (in this case E. coli) is an indirect method of determining faecal contamination, based on the assumption that these normal enteric organisms will indicate the level of faecal contamination in the water supply (WHO 1983; Pathak and Gopal, 2001; Harwood *et al.,* 2001; Vaidya *et al.*, 2001; Kistemann *et al.*, 2002). The presence of bacteria, when paired with other indicators such as physical features of the water, and access to water, can be used to help determine the causes of pollution.

The purpose of this project is to test and monitor drinking water quality in the Warwade dam, using both physical characteristics and coliform bacteria and E. coli as indicators of faecal contamination, in order to help increase access to potable drinking water. The findings of this inquiry can serve as a baseline for future monitoring. The Warwade community requires this research because the growing number of anthropogenic activities is generating considerable, unchecked environmental damage (Carovello *et al.*, 2007).

MATERIALS AND METHODS

Location

The Warwade Dam is located near Dutse in the Nigerian state of Jigawa (Figure 1). The dam, which is located at 11.045'N and 9.013'E, is 1.4 kilometers long, 6.0 meters wide, and 7.0 meters deep, with a total storage capacity of 300.0 million cubic meters (FMWR, 2018). In general, the Warwade Dam suffers an arid environment with distinct seasonality, with hot dry seasons and freezing winters. Between June and September is when the most rain falls.

Sampling

For eligible sample sites, the entire Warwade dam was surveyed. Sampling began in late March 2020 and ended in early February 2021. The sites were chosen based on the availability of water for both local and drinking purposes. Ten distinct places were used to collect representative samples (APHA, 2005).
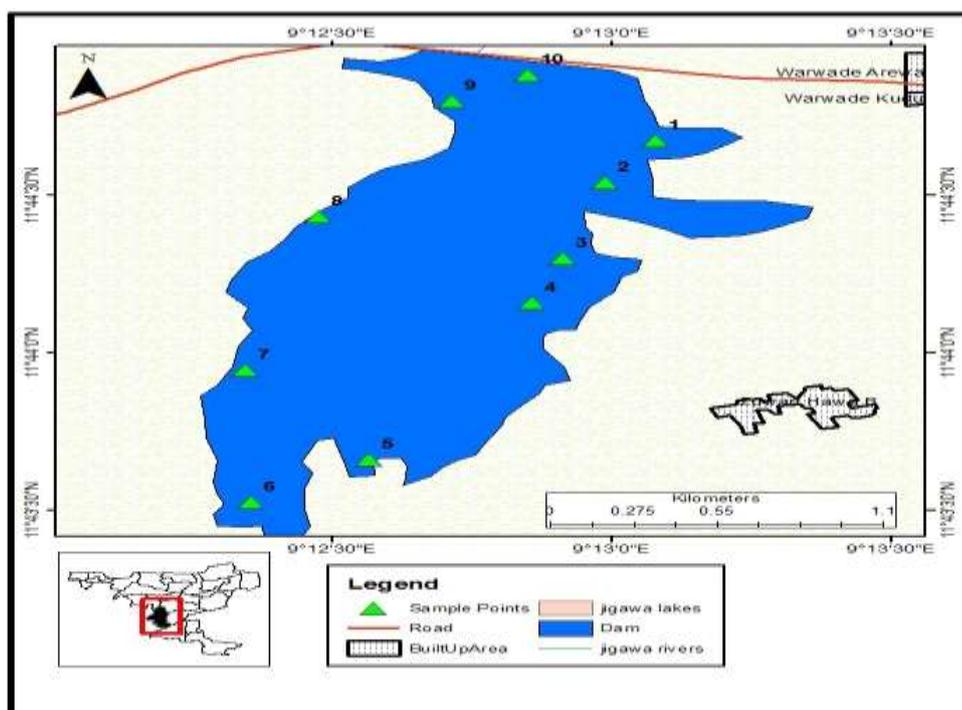
Figure 1: Map of the Study Area Showing Warwade Dam (Source: GIS Lab Geography Dept. BUK, 2019)

Warwade Dam Sampling Sites
Coordinates at these sampling locations were all determined with GPS 12 model (GARMIN USA). Depth measurements were carried out using graduated lines (Welcomme, 1985). Ten sampling points selected for this research were based on differences in their anthropogenic conditions.

Table 1: Warwade Dam Sampling Locations

Location	Depth	Latitude	Longitude
1	6.5m	11.74454N	9.21796E
2	6.7m	11.74234N	9.21647E
3	1.4m	11.74343N	9.21507E
4	5.4m	11.74459N	9.214225E
5	6.4m	11.74588N	9.21336E
6	1.6m	11.74706N	9.21280E
7	1.9m	11.74825N	9.21446E
8	6.6m	11.74827N	9.21546E
9	1.7m	11.74770N	9.21655E
10	2.0m	11.74721N	9.21712E

Bacterial Analyses and Physical Parameters
Standard E. coli collection methods were modified due to the remote location of the study area, which had no road access, no power, and was subjected to severe weather (Gruver *et al.*, 2017). Bacterial samples were obtained in sterile 60 ml syringes and analysed accordingly in the laboratory. 100ml of sample was put through a push filter with a sterile 0.45 micron filter. Because it was not possible to filter the samples on the spot, they were collected in sterile containers. 100 mL Whirl-pak bags containing a non-nutritive pill, but containing 10 mg sodium thiosulfate and kept below 20°C prior to filtration. Within two hours after collection, all samples were filtered. After filtration, the filter paper was placed on a sterile test card (Micrology Laboratories LLC's Easy Card TM) that included a growing medium that included color-producing bacteria. Enzyme substrates that are particular to the target organisms (E. coli and other coliforms), in order to ensure that these organisms form distinct colored colonies that are easy to distinguish was introduced.

After that, samples were placed in a portable field incubator and incubated between 20°C and 35°C for a period of time, 24 to 48 hours. E. coli colonies were counted using a hand lens at a magnification of 10x. *E. coli* colonies were royal blue/purple and coliform bacteria colonies appeared to be light green. To confirm the quality of the analyses, triplicate samples were conducted in each location. Colony forming units (cfu) per unit sample volume were used to calculate the results (100 ml). A Fisher Sci. Ap85 pH/conductivity meter was used to monitor temperature, pH, conductivity, and TDS in the field. In samples collected in Whirl-pak bags, no physical parameters were measured.

RESULTS
Physical Parameters
According to the 2011 WHO (World Health Organization) criteria for drinking water, total dissolved solids in potable water should be less than 600 mg/l (approximately equivalent to 600 ppm) (TDS). According to the 2011 WHO standards for pH in drinking water, pH should not exceed 8, and that values less than

4 may be linked to health issues and infrastructure deterioration. The average temperature of drinking water was between 31.66 ± 4.33 to 30.15 ± 4.32. The mean and standard deviation of pH of the drinking water was between 7.9 ± 0.47 to 8.7 ± 0.31. (Figure 2). The TDS and conductivity (Figure 2) ranges in the samples were quite narrow.

The TDS average ranged from 66.8 ± 7.3 to 83.4 ± 26.4 ppm, whereas conductivity was 102.8 ± 11.2 to 130.29 ± 41.74 µS/cm (Figure 2). Table 3 shows a weak negative association between TDS and temperature, as well as a very faint positive link between temperature and pH.

E. coli and Coliform Bacteria

E. coli in drinking water has a tolerance range according to the 2011 WHO drinking water standards. Although it is ideal for drinking water to be free of E. coli, samples with less than 10 E. coli colonies per 100 ml are deemed low risk. In this study the highest count were limited to 28 T.coliform.

Table 2: WHO (2011) classification and color-codes scheme for E. coli colonies per 100 mL water sample

Colour	Blue	Green	Yellow	Orange	Red
Risk level	In Conformity	Low Risk	Intermediate Risk	High Risk	Very High Risk
Number of Colonies	0	1-10	10-100	100-1000	>1000

In summary, there appears to be little relationship between bacterial counts (E. coli and total coliforms) and both physical parameters.
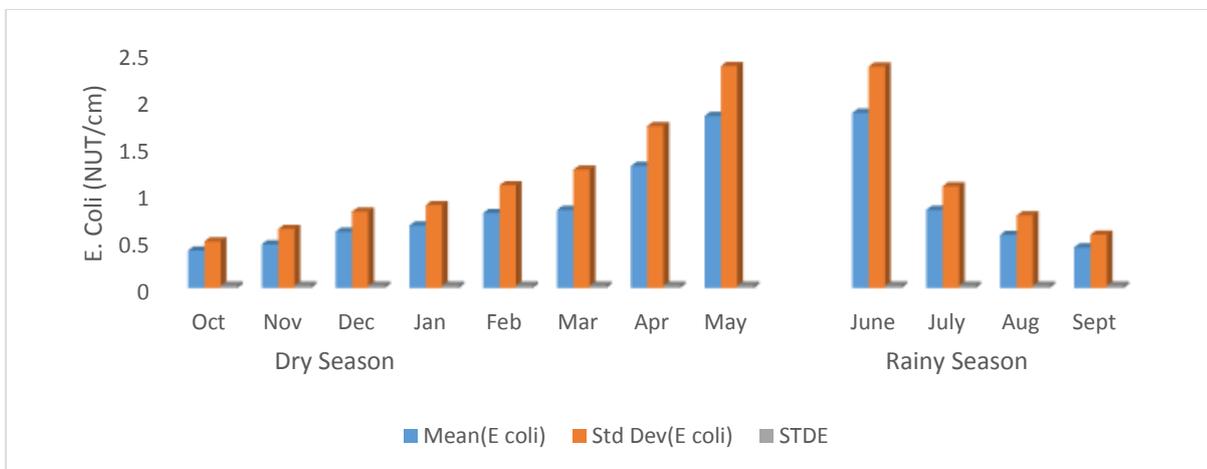

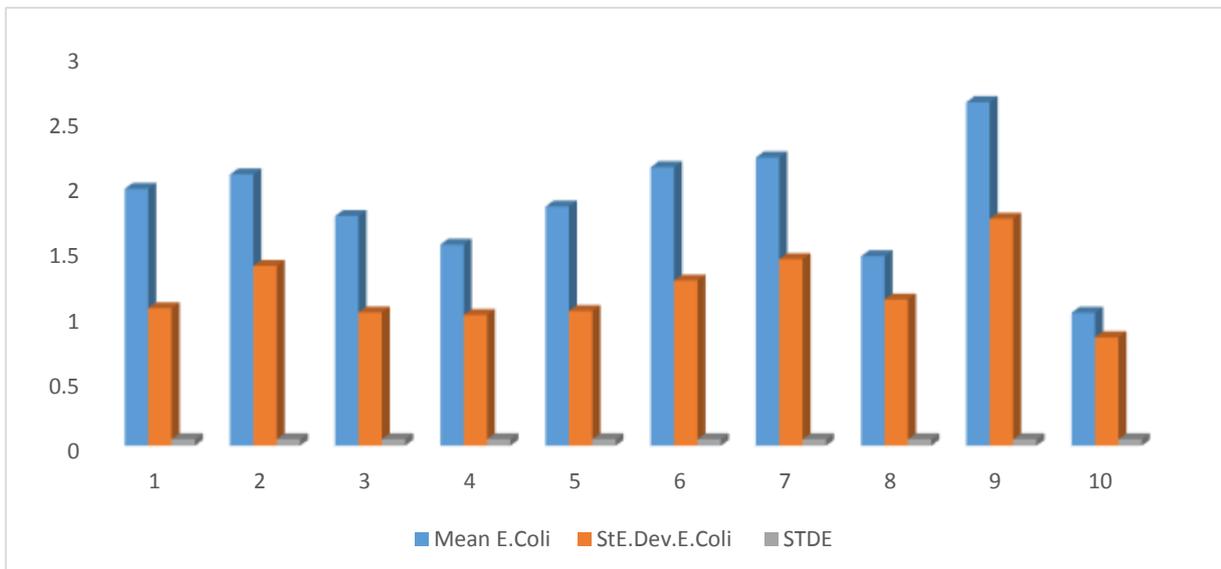Fig. 2: Seasonal E. Coli Variation (NTU/cm)

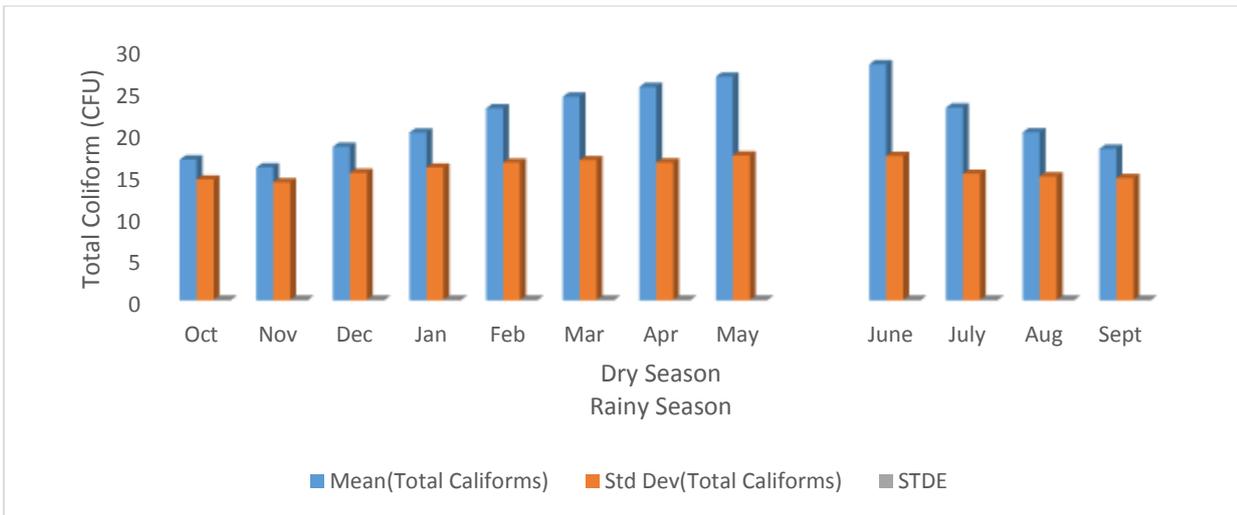Fig. 3: E. Coli Variation at Different Locations

Fig. 4: Seasonal Total Coliform (CFU/100cm) Variation
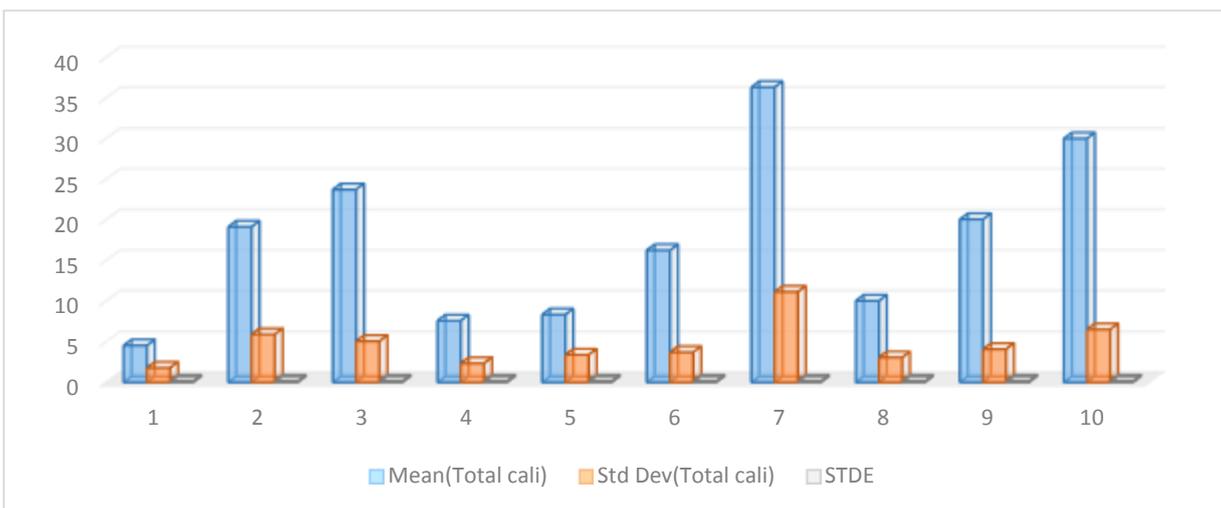

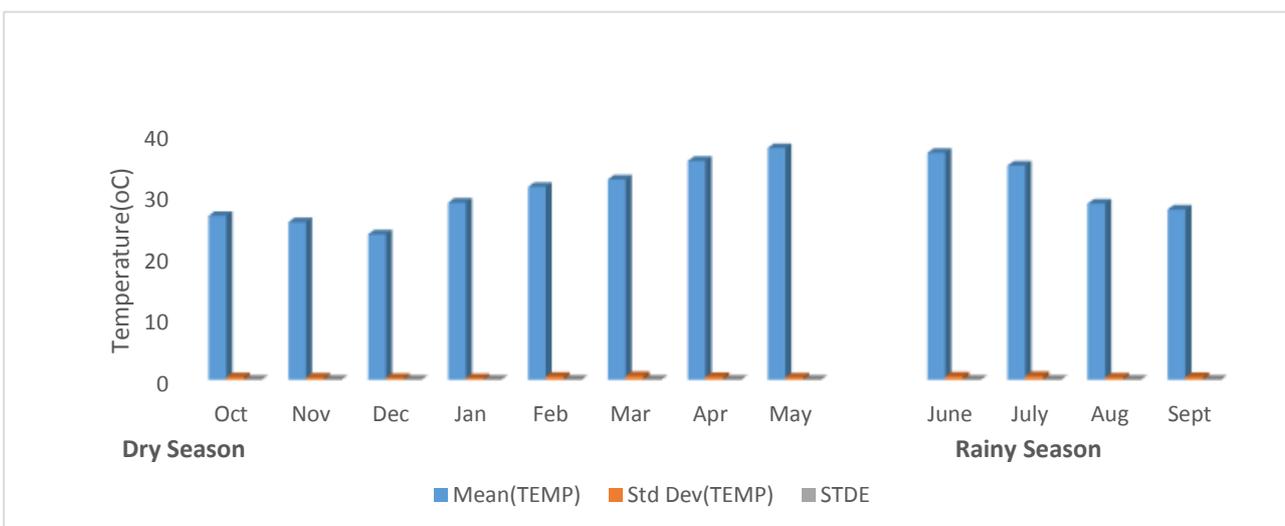Fig. 5: Total Coliform Variation at Different Locations
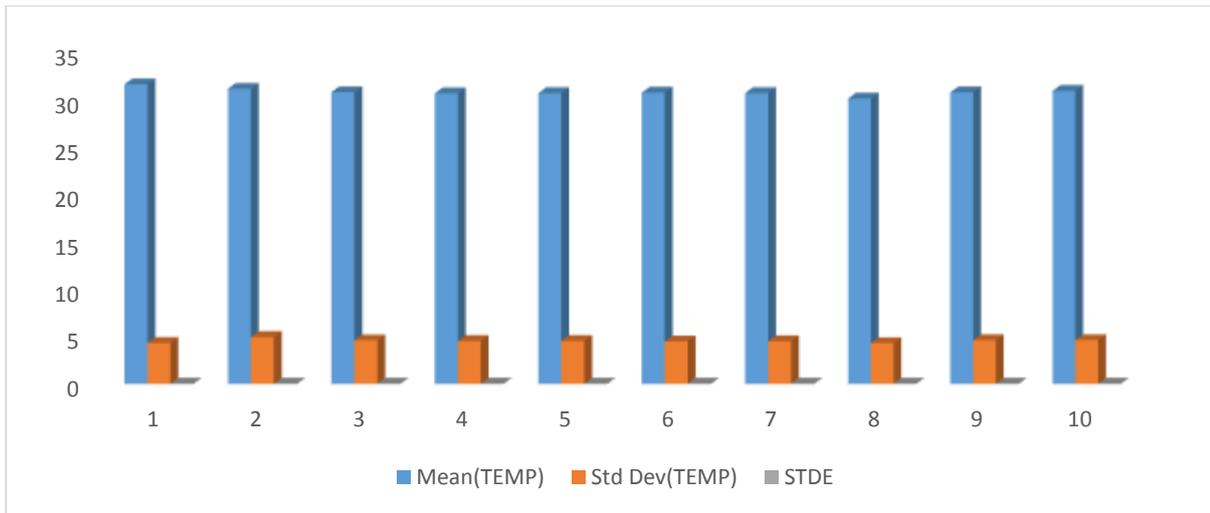

Fig. 6: Seasonal Temperature Variation

Fig.7: Temperature Variation at Different Locations
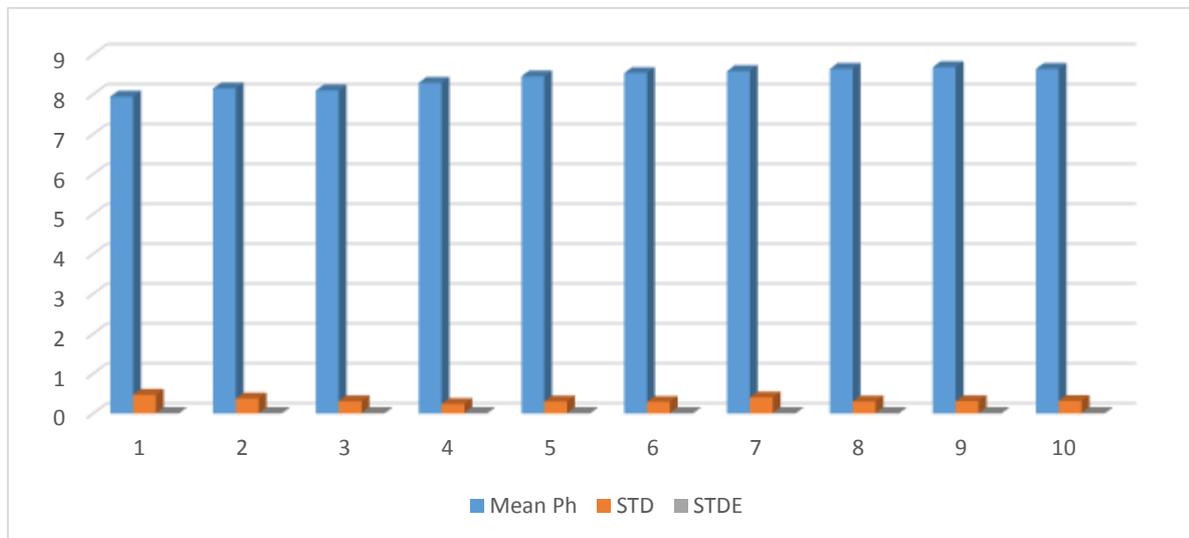

Fig, 8: Seasonal pH Variations

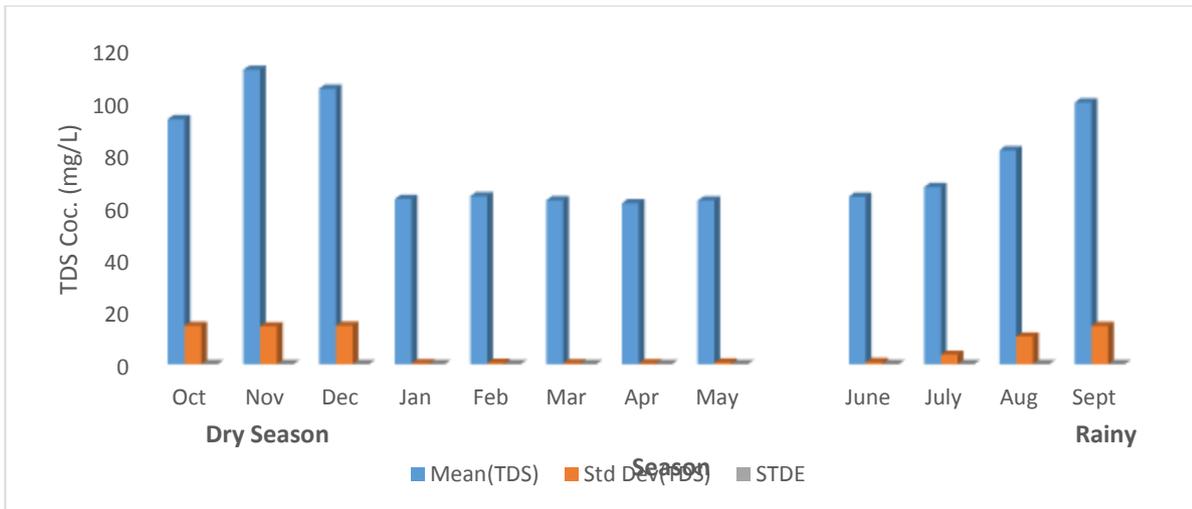Fig. 9: pH Variation at Different Locations 2020/2021
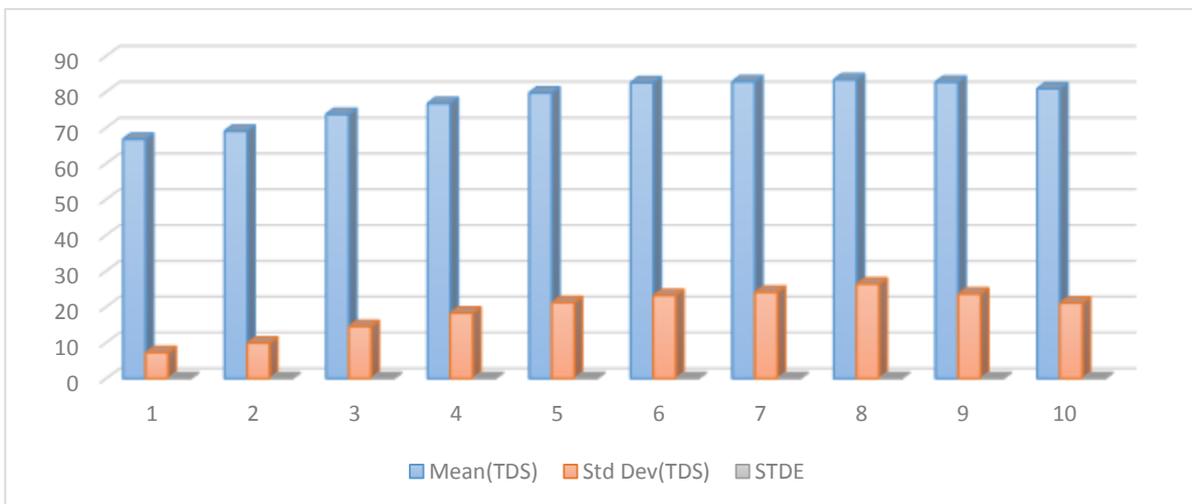
Fig. 10: Seasonal TDS Variation (mg/L)
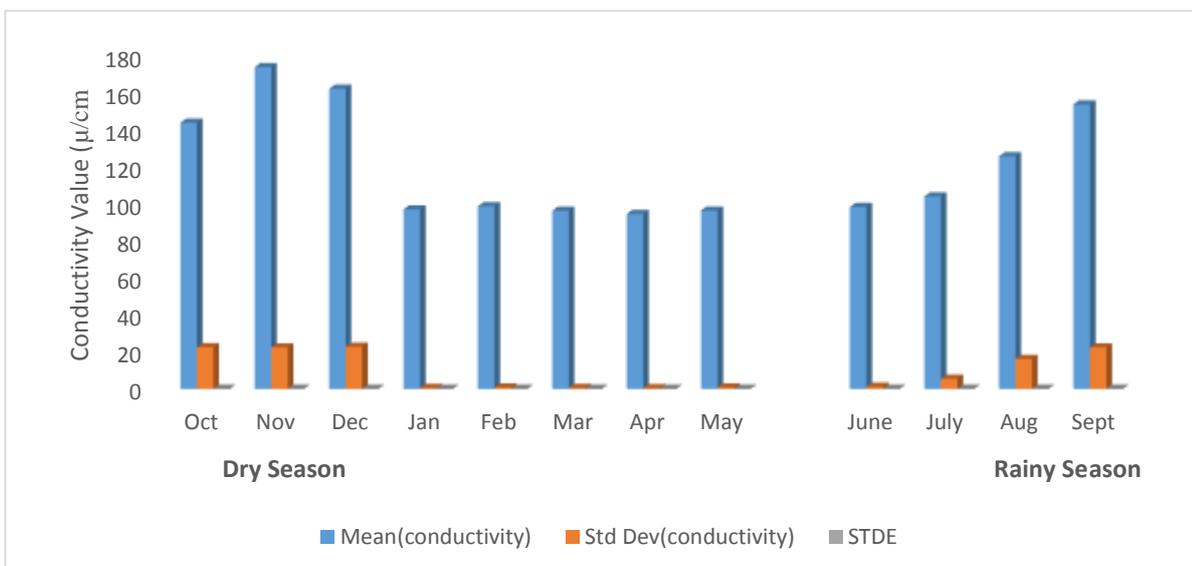

Fig. 11: TDS Variation at Different Locations 2020/2021
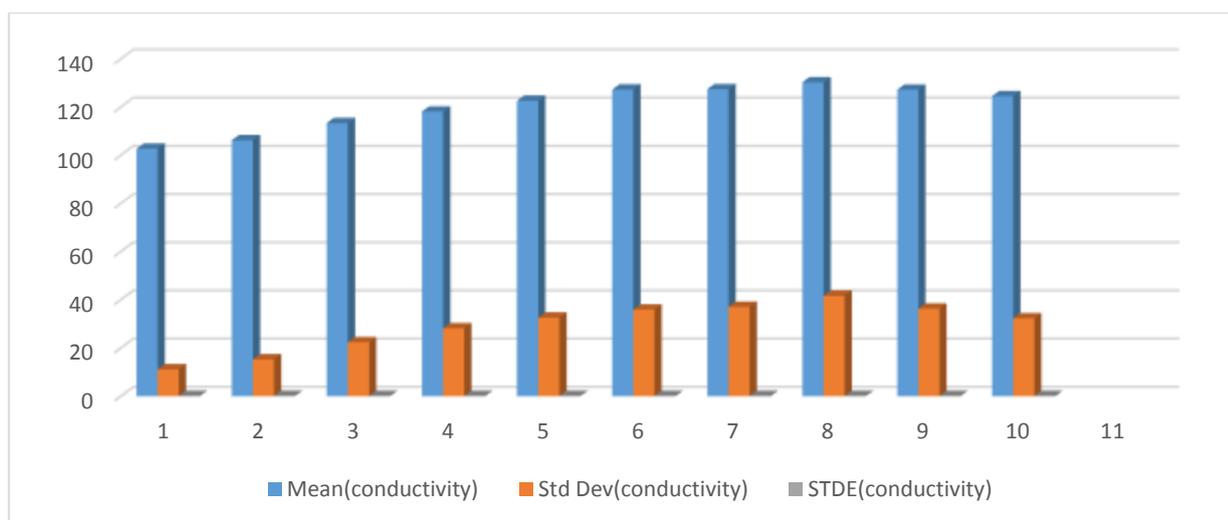

Fig. 12: Seasonal Conductivity Variation (µs/cm)

Fig. 13: Conductivity Variation at Different Locations

Table 3: Correlation Coefficient of Warwade Dam Water Parameters

	Temp.	pH	EC	TDS	T.Coli	E.Coli
Temp	1.00					
pH	-0.41	1.00				
EC	0.76	0.54	1.00			
TDS	-0.76	054	0.8	1.00		
T.Coli	0.25	0.06	-0.13	-0.13	1.00	
E.Coli	0.24	-0.23	-0.24	-0.24	-0.89	1.00

DISCUSSION

The research area's physical factors all match WHO (2011) criteria. The pH rises with depth in all of the samples. This could be due to a variety of variables, the most likely of which is a shift in geology; more carbonates and carbonate-bearing minerals are found at higher elevations, greater altitudes. The time of day and/or the amount of sunlight on a given day are likely to influence the temperature.

The study's major focus was on faecal contamination of drinking water utilizing E. coli as an indirect way to detect faecal contamination, which poses serious health implications (WHO 1983; Kistemann *et al.,* 2002; Pathak and Gopal, 2001; Harwood *et al.,* 2001; Vaidya et al., 2001). The results of the bacterial tests revealed that the dam water was contaminated with E. coli and coliform germs. Total coliforms ranged from 13 to 27 colonies per 100 ml sample, (WHO permissible value for total coliform is 10) while E. coli levels ranged from 1 to 2 cfu/100 ml sample (WHO allowable limit for E. coli is zero). Sharma *et al.,* (2010) and Ghimire *et al.* (2013) are two studies that are related to this one. Nepal's surface water (rivers and lakes).

They found E. coli and coliform bacteria in all of the surface water samples they analyzed, with contamination increasing dramatically at lower altitudes. Baghel *et al., (*2005) discovered that bacterial contamination increased as time went on. According to Sharma *et al.,* (2010) and Ghimire *et al.,* (2013a), increased development in anthropogenic and socio-cultural activity at their study areas' and lower altitudes were responsible for increasing bacterial contamination.

Baghel *et al.,* (2005) also discovered that overall coliform and thermotolerant coliforms were at their highest levels during the summer (followed by monsoon and winter), which the researchers attributed to a higher number of pilgrims and warmer temperatures. During the summer, hikers flock to the area. Nicholson *et al.,* preliminary's work (2016) supports the premise that drinking water pollution is higher at lower elevations and residential population that is possibly related.

We detect a link between bacterial counts and altitude in community drinking water sources, similar to Baghel *et al.*, (2005), Sharma *et al.*, (2010), Ghimirie et al., (2013a,b), and Nicholson *et al.,* (2016).According to the findings of this study, the drinking water sources of the Warwade community are reasonably uncontaminated by faecal matter and are classified as Low Risk by WHO (2011) guidelines.

CONCLUSION

The physical parameters of pH, temperature, conductivity, and TDS in drinking water from the dam community generally meet current WHO (2011) drinking water guidelines. This research establishes a baseline for future monitoring and enables for comparisons in the quest for better water sources. Physical factors and bacteria content appear to have little or no correlation. These findings clearly demonstrate the necessity for improved water protection methods. Future research should concentrate on collaborating with communities to establish better water management techniques and promote community-

driven sanitation education efforts. Improved water testing, education, and management, when combined, have the potential to solve the problem of contaminated drinking water in Warwade community.

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