Case study

Assessment of Bacteriological Quality and Heavy Metals Concentrations of Borehole Water Tanks in Wuse 1 District of Abuja, Nigeria.

Abstract

Borehole water is an alternative source of portable water readily available for domestic and commercial uses in Wuse 1 District of Abuja and Nigeria as a whole. The study evaluates the bacteriological quality and heavy metals concentrations of borehole tank water in Wuse 1 District. Sixty-three (63) water samples (27 Residential and 36 Commercial) were aseptically collected and analyzed following standard microbiological methods while analysis of heavy metals from each water sample was carried out using flame Atomic Absorption Spectrophotometer (Model 220AS Autosampler). Of the total water samples, *E. coli*, *S. typhi*, *S. dysentriae* and *S. aerues* were isolated accounting for 3.2%, 11.3%, 5% and 3.8% respectively in which commercial borehole tank water showed in each case, higher occurrence of individual bacteria isolates The Physiochemical assessment showed no indication of industrial pollution. There was no significant difference in COD (P = 0.04). The elemental composition of borehole water showed that Cadmium and Lead were scarcely detected. The few zones which showed presence of cadmium in Commercial water tanks were, Z5 with 0.007 and Z6 had 0.001ppm, while those of Residential water tanks were, Z1 with 0.001ppm. Overall copper concentration ranged from 0.01ppm to 0.108ppm, iron 0.22ppm to 1.75ppm, and Manganese 0.01ppm to 0.11ppm, while that of Zinc was 0.248ppm and 0.327ppm respectively. The study therefore recommended that borehole water from storage tanks be pre-treated such as boiling before use, and also soil investigation is imperative to ascertain the elemental composition of a choice land before drilling.

Key Words: Storage tanks, Borehole water, Bacteria isolates, Heavy Metals.

Introduction

Water is an essential natural resource that is vital to the existence of all living things. It is used for a wide range of purposes such as drinking, pharmaceuticals, agricultural, industrial, laboratory analysis down to recreational and fire control services. Being one of the most excellent solvents, it's considered as a major constituent in industries during the production of

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different commodities [1]. Given these uses, the importance of water to man cannot be over emphasized, but how many people do have access to clean and safe drinking water even when accessing safe drinking water is of paramount importance [2].

It has been stated that the common water borne diseases in Nigeria include cholera, diarrhea, dracunculiasis, hepatitis, typhoid fever and filariasis [3&4] while [2] report of year 2000, stated that contaminated drinking water is estimated to cause 485,000 diarrheal deaths each year, and by 2025, half of the world's population will be living in water-stressed areas.

Borehole water in most developing countries were provided to serve as major source of water to people especially in the cities. In Wuse District of Abuja, borehole water is considered as one of the most affordable forms of portable water readily available. The study, therefore, was carried out to ascertain the bacteriological content and heavy metal concentration of water tanks in this District.

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Materials and Methods

Study Area

Wuse District is situated in Abuja municipal, Federal Capital Territory of Nigeria with a geographical co-ordinate of $9^0$4'14'' North, and $7^0$28'3''East. Wuse District enjoys a tropical climate with strong seasonal rain fall between April and October and a dry season of between November and March. Wuse 1 is orderly commercialized, and going by the nature of marketing activities and lots of residential and commercial infrastructures; it is one of the biggest cities in Abuja, and a major economic hub for the capital and Nigeria at large. Some parts of the district are vastly vegetative hence giving its beautiful scenery which has encouraged various recreational activities overtime [5] (See Fig 1).

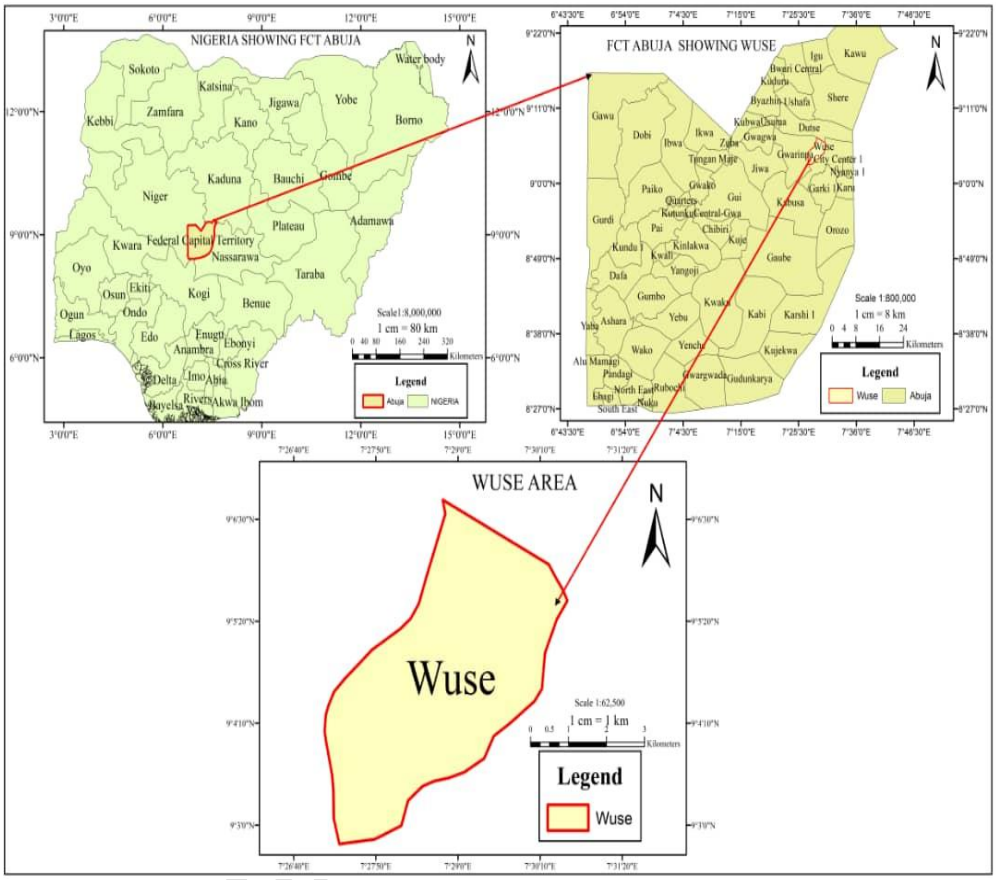

Fig. 1: Map of Nigeria showing the study area. (**Source:** Urban and Regional Planning Department, FCT-Abuja, 2021).

Sample Collection and Analysis

Sixty-three (63) water samples were aseptically collected from residential (27) and commercial (36) water tanks, and were analyzed following standard Microbiological procedures stipulated by [6].

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Preliminary Identification of Isolates and Biochemical Tests

a. Isolation and Identification of selected Bacteria

One milliliter (1ml) of each borehole water collected was mixed with 9.0ml of peptone water as pre-enrichment, and incubated at 37°C for 24 hours. The 24 hours culture was then streaked on to several selective media: MacConkey Agar, *Salmonella-Shigella* Agar, E.M.B Agar and Mannitol Salt Agar [7]. Biochemical tests such as catalase, urease, indole and coagulase, were carried out to identify isolates according to the methods described by [8].

Physiochemical and Heavy Metals

Physicochemical properties of the water samples were determined using standard methods described by American Public Health Association, [6]. Analysis of heavy metals from each water sample was carried out using flame Atomic Absorption Spectrophotometer (Model 220AS Autosampler), [9].

Results

The overall occurrence of bacteria isolated from borehole water tanks in Wuse District were, 1.6%. 6.3%, 3.17% and 4.8% for *Escherichia coli, Salmonella typhi, Shigella dysentriae* and *Staphylococcal aerues* respectively, in which commercial borehole tank water showed in each case, higher occurrence of individual bacteria isolates (Table 1). The Residential borehole water has zero percent occurrence of *Shigella dysentriae* and *Staphylococcal aerues* compared to Commercial borehole tanks water.

The Physiochemical quality of water in Wuse District revealed that the mean total temperature, pH, Dissolved Oxygen, and salinity for Commercial borehole tank water were 27.87^{o}C, 6.7, 5.11 and 0.08 respectively while that of the Residential borehole tank water were 28.32^{o}C, 6.5, 5.44,

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and 0.06 respectively. (Table 2). Though the pH of both Commercial and Residential borehole water were below the FME standard (6-9), Commercial borehole water from Zone 4 had the highest pH value of 7.1 while zone 3 had 7.0 pH as the highest among the Residential borehole water. Our analysis further revealed that Commercial borehole water in Wuse 1 had its highest TDS (182.2mg/l) from zone 5 while zone 3 had the highest (150.25mg/l) among the Residential borehole water. With respect to salinity of borehole water in Wuse 1, zone 3 had 0.1 as the highest among the Commercial borehole water while 0.05 was recorded in zone 3 as the highest for Residential borehole water. The total mean salinity of borehole water tanks in each zone, from Wuse 1 is represented in Fig. 2 in which zone 1 of both Commercial and Residential borehole water had the highest value of 0.4 and 0.3 respectively.

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Table 1: Distribution of isolates in the district borehole water tanks

Total No. of Samples	Bacteria Isolates			
	E. coli (%)	*S. typhi* (%)	*S. dysentriae* (%)	*S. aureus* (%)
Residential 27	--	1(3.7)	--	--
Commercial 36	1(3.2)	3(8.3)	2(5.6)	3(8.3)
Total sample 63	1(1.6)	4(6.3)	2(3.17)	3(4.8)

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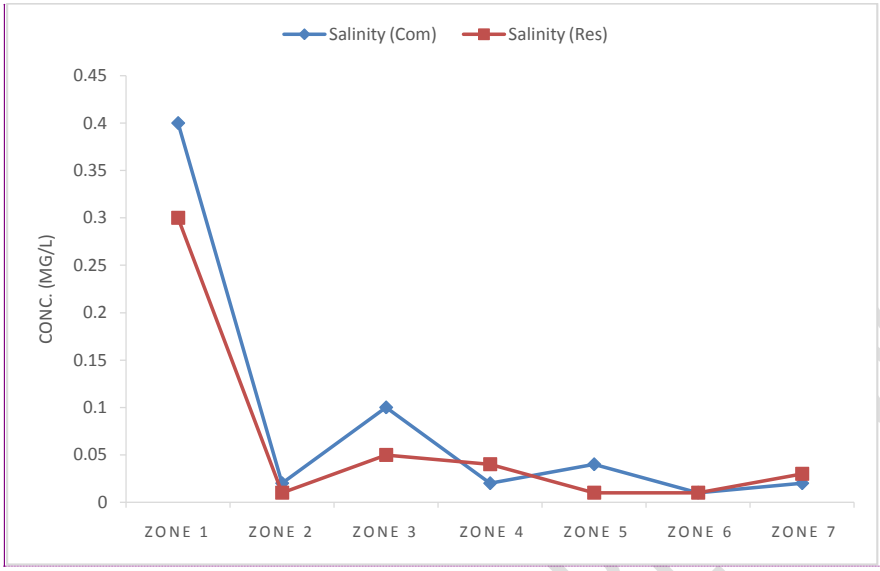

Fig. 2: Average salinity of the residential and commercial water tanks

Electrical conductance Total mean values of borehole water in Wuse 1 showed that zones 3, 4 and zone 7 residential borehole water tanks had 254µS/cm, 270.3 µS/cm and 396 µS/cm in this manner, as against that of Commercial water tanks which were highest in zones 3, and 5 with 294.2 µS/cm and 294.6 µS/cm respectively (see Table 2). The overall total suspended solid in Wuse 1 borehole water were 0.415mg/L in residential and 0.351mg/L in commercial water tanks. The analysis of DO, BOD and COD of borehole water in Wuse 1 is shown in Table 2 and Table 3. Our study revealed that the DO values ranged between 4mg/L and 6mg/L. In Residential borehole water tanks, Zone 5 had an average DO value of 6.15mg/L, while the Commercial water tank had 6.2mg/l. There was coherence in DO mean values. BOD values were also observed to be within the recommended limit in both residential and commercial water tanks, the highest value was recorded as 4.16mg/L in Zone 5 Commercial water tanks.

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Table 2: Physical Tests Mean values of the district water tanks

Parameters	FME STD	Commercial Borehole								Residential Borehole							
		Z1	Z2	Z3	Z4	Z5	Z6	Z7	TOTAL MEAN	Z1	Z2	Z3	Z4	Z5	Z6	Z7	TOTAL MEAN
Temp (^{0}C)	<40	27.8	28.1	26.92	28.02	27.5	27.96	28.8	27.87	28.74	28.3	29.5	28.63	26.9	27.83	28.4	28.32
pH	6 to 9	6.6	6.6	6.8	7.1	6.6	6.8	6.6	6.7	6.4	6.3	7	6.6	6.4	6.9	6.5	6.5
Cond. (µS/cm)	1000	237.75	202.2	294.6	228.8	294.2	161.2	242.8	237.3	115.6	222	396	270.3	128.2	135	254	217.3
D.O (mg/l)	7	4.58	4.83	4.93	5.48	5.4	6.2	4.39	5.11	4.65	5.57	5.66	5.78	6.15	4.2	6.1	5.44
TDS (mg/l)	500	117	101.8	182.2	108.5	146.6	80.6	121.1	122.5	75.9	110.5	150.25	125.6	63.2	66	127	102.6
TSS (mg/l)	<10	0.03	0.02	0.57	0.88	0.03	0.12	0.81	0.351	0.02	0.01	0.04	1.35	0.02	0.03	1.44	0.415
Salinity	0	0.4	0.02	0.1	0.02	0.04	0.01	0.02	0.08	0.3	0.01	0.05	0.04	0.01	0.01	0.03	0.06

FME STD = Federal Ministry of Environment; Z = Zones

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The COD on the other hand showed similar trend as the Zones had values ≤12mg/l. The highest Total mean value of COD was 11.12mg/L in Zone 2 Commercial water tanks (see Table 3). The COD values were generally much as twice the values of DO and BOD in these Zones. DO, BOD and COD values showed similarity in their trend and were generally within the acceptable limits.

Of the residential and commercial borehole water tanks investigated from the seven zones of the District, Z1, Z4 and Z6 Commercial water tanks showed Total mean values of 180.0mg/l, 151.23mg/l and 157.5mg/l respectively, the calcium and magnesium concentration were 124.1mg/l, 111.28mg/l and 119.8mg/l, as well as 42.2mg/l, 39.95mg/l and 37.66mg/l in that order; whereas the average values obtained in residential water tanks which were, 175.48mg/l (Z2) and 182.61mg/l (Z4), as seen in Table 4. More so, it revealed that individual calcium and magnesium concentrations were, 126.6mg/l and 142.71mg/l, as well as 47.08mg/l and 39.91mg/l respectively (Table 3). The overall mean values for Commercial and Residential water tanks total hardness were 142.70mg/l and 139.87mg/l respectively. Those were maximally within the limits as all other zones had values which were substantially below the permissible limit.

The Phosphate, Potassium, Nitrate, Nitrite and Sulphate levels in residential and commercial water tanks were generally below the limit (Table 3). The result showed that sulphate, phosphate, nitrate, nitrite, and potassium overall mean concentration for commercial and residential tanks were as follows, 18.86mg/L, 1.37mg/L, 0.73mg/L, 0.13mg/L and 7.96mg/L as against 19.73mg/L, 0.59mg/L, 2.3mg/L, 0.41mg/L and 9.72mg/L respectively, indicating less exposure of borehole water in this District to nitrate pollution, fertilizers waste water discharges, and excessive chlorine treatment.

The elemental composition of borehole water from Wuse District of Abuja showed that Cadmium and Lead were scarcely detected. The few zones which showed presence of cadmium

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in Commercial water tanks were, Z5 with 0.007 and Z6 had 0.001ppm, while those of Residential water tanks were, Z1 with 0.001ppm (Table 4). The average lead concentration in Commercial water tanks were as follows, Z3 with 0.001ppm, Z5 with 0.008ppm and Z6 had 0.001ppm, while those of Residential water were 0.001ppm (Z1), 0.001ppm (Z2) and 0.001ppm (Z7).

Copper and Manganese Total mean values were below the limits, in Residential water tanks the average value obtained from all zones was 0.072ppm for Cu and 0.055ppm for Mn, while that of Commercial had 0.04ppm for Cu and 0.061ppm for Mn.

The Iron concentration in borehole water tanks from the zones were within the acceptable limits except Z2 that indicated a mean concentration of 1.756ppm (Table 4). The overall mean concentration for Zinc in Z2 among the Residential water was slightly above the recommended limits, with a concentration of 1.187ppm and 0.248ppm for commercial borehole water (Table 4).

Discussion

The bacteriological results obtained from this study clearly showed occurrence of bacteria isolates (coliform) in which members of Enterobacteriaceae constituted 19.5% and *Staphylococci* 3.8%. These may probably be from the users especially in Commercial boreholes as also observed in a similar work carried out in Kaduna, Nigeria by [10], who reported 62.44% of Enterobacteriaceae and 19.11% of *Staphylococcus* in his findings. The relatively moderate coliform counts in the borehole tanks suggest contamination from biotic activities. The lower coliform counts in most residential tanks were expected due to the level of adequate hygiene practices by private users. The coliform levels obtained in this study are also similar to the work

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of [11] on bacteriological analyses of drinking water from wash boreholes in Maiduguri Metropolis, Borno State, Nigeria.

Table 3: Chemical tests Mean values of the district water tanks

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Parameters	FME	Commercial Borehole								Residential Borehole							
	STD	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Total mean	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Total mean
Alkalinity	100	20	42.1	38	37	-	25	25	31.18	22.5	50	24.5	40	--	22.5	27.5	26.71
Total Hard (mg/l)	200	184.04	89.02	140.38	151.23	136.96	157.5	139.81	142.70	140.3	175.48	124.12	182.61	132.6	115.56	108.42	139.87
Mg. Hard (mg/l)	50	42.2	30.81	51.35	39.95	34.24	37.66	34.42	38.7	37.66	47.08	29.95	39.91	29.96	25.68	28.53	34.11
Ca. Hard (mg/l)	150	124.12	58.23	89.02	111.28	106.14	119.8	102.72	101.62	111.8	126.6	76.74	142.71	102.7	72.47	79.89	101.84
PO_4^- (mg/l)	5	1.19	0.59	0.54	0.52	0.87	0.68	0.72	0.7	0.23	0.42	0.81	0.61	1.26	0.37	0.43	0.6
k (mg/l)	100	9.45	4.15	8.07	0.65	21.23	4.65	7.53	7.96	9.35	5	6.23	9.01	21.96	6.49	10.05	9.73
NO_3^- (mg/l)	10	1.12	1.85	0.14	0.85	2.3	1.6	1.74	1.37	7.2	1.01	2.01	0.15	1.27	2.5	1.89	2.3
NO_2 (mg/l)	1	0.05	0.02	0.76	0.01	0.05	0.05	0.03	0.13	1.76	0.03	_	0.02	0.2	_	0.04	0.41
Cl^- (mg/l)	600	50	21.06	7.37	6.9	56.6	11.5	21.5	24.99	47.5	38.75	7.44	9.5	38.25	25	25	27.3
BOD (mg/l)	7.5	3.32	3.9	3.28	3	4.16	2.54	2.77	3.28	2.84	2.4	2.05	2.02	3.3	3.8	1.93	2.62
COD (mg/l)	30	10.65	11.12	7.88	10.47	10.84	9.8	9.93	10.09	9.6	5.8	8.22	7.82	8.75	11.3	6.53	8.3
SO_4^{2-} (mg/l)	500	20.5	18.35	16.64	5	25.62	20.6	23.9	18.66	17.87	20.6	17.25	13.77	28.2	16.3	24.16	19.73

FME STD = Federal Ministry of Environment Standard; Z = Zones

Table 4: Total Mean Concentrations of Heavy metals of Wuse District water Tanks.

Parameters	FME	COMMERCIAL BOREHOLE								RESIDENTIAL BOREHOLE							
	STD	Z1	Z2	Z3	Z4	Z5	Z6	Z7	TOTAL MEAN	Z1	Z2	Z3	Z4	Z5	Z6	Z7	TOTAL MEAN
Mn (ppm)	0.2	0.04	0.06	0.02	0.1	0.01	0.03	0.13	0.056	0.06	0.03	0.07	0.1	0.05	0.01	0.11	0.061
Fe Total (ppml)	1.5	0.589	0.389	0.489	0.43	0.691	0.614	0.63	0.547	0.534	1.756	0.22	0.926	0.358	0.46	0.47	0.674
Cu (ppm)	0.1	0.027	0.015	0.037	0.06	0.329	0.028	0.01	0.072	0.024	0.108	0.026	0.01	0.002	0.03	0.08	0.04
Cd (ppml)	0.05	-	-	-	-	0.007	0.001	-	0.004	0.001	-	-	-	-	-	-	0.001
Zn (ppm)	0.1	0.287	0.179	0.262	0.25	0.459	0.141	0.16	0.248	0.153	1.187	0.115	0.28	0.227	0.15	0.18	0.327
Pb (ppm)	0.05	-	-	0.001	-	0.008	0.001	-	0.003	0.001	0.001	-	-	-	-	0.001	0.001

FME STD = Federal Ministry of Environment; Z = Zone

The American Public Health Association, [6] stated that FC/HC ratio greater than 4.0 implies contamination arising mostly from human activity, while values less than 1.5 indicate contamination from non-human driven sources. The coliform count obtained between 1.1cfu/100ml and 4.4cfc/100ml, an indication of human and non-human pollution. On the spot observation of these borehole water tanks revealed that some of these borehole tanks were without covers while others were not properly covered especially around commercial areas. The handling of tanks outlets particularly at commercial points may be the substantial reason for additional contamination.

The measure of mineralization and salt content is usually reflected in the electrical conductivity of water. Presence of ions, their concentrations, mobility, and valence determine the electrical conductivity of a water [12]. Conductance values were within the limit and do not indicate physical contamination. Our study shares similarity with those of [13] & [14], on water quality assessment of selected Boreholes in in Yola metropolis, Nigeria and Biu Local Government Area of Borno State, Nigeria respectively where they reported that phosphate, potassium, nitrate, nitrite and sulphate levels were generally below the recommended limit, indicating less exposure of the water tanks to nitrate pollution, fertilizers and waste water discharges which are a contributing factor.

The overall elemental composition of all borehole water sampled in Wuse District were generally within or below the acceptable limit [6] which clearly showed that the borehole water elemental concentration falls within the prescribed limit. However, Zinc concentration in some water tanks is not within the limit. These higher values may be a result of additional human-driven activities following unlawful dumping and discarding of zincous materials around some of the borehole sites as observed by [15] and [16].

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As the human populace increases, there is an increase in clean water demand. Hence, water pollution as observed by [17] is a major global problem that requires consistent evaluation and revision of water resource policies.

Conclusion

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The bacteriological assessment of borehole water tanks in Wuse District of Abuja clearly showed moderate coliform counts with members of Enterobacteriaceae constituted 19.5% and *Staphylococci* 3.8%, This suggests contamination from biotic activities. The lower coliform counts in most residential tanks were expected to be due to the level of adequate hygiene practices by these private users.

The Chemical nature of water tanks suggest no industrial pollution. However, the concentration of Fe, Mn, Zn, and Cu in some water tanks were not within the allowable limit and indicated possible natural sources of contamination, hence, soil laboratory investigation is strongly recommended to determine the elemental composition of a choice land before drilling of a borehole.

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Based on the outcome of bacteriological assessment, adequate hygiene practices by the users and proper washing of containers, regular monitoring of tanks and outlets for openings/leakages should be considered by all users to ensure maximum protection of borehole water from preventable sources of contamination, Furthermore, adequate and routine cleaning of water tanks should be initiated and sustained.

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