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RESEARCH ARTICLE **OJES0402001-440**

ANALYSIS OF IMPACT OF COMMUNAL ACTIVITIES ON GROUND WATER QUALITY FROM HAND DUG WELLS IN SHERE VILLAGE, ABUJA NIGERIA.

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ABSTRACT

Hand-dug wells are the predominant sources of drinking water in Nigeria, particularly in rural areas. However, hand-dug dug wells are highly vulnerable to contamination bearing a myriad of health consequences. This study evaluated the quality of groundwater from 20 hand-dug wells in Shere rural community of Bwari area council in Abuja, Nigeria; by analysing pertinent physical, chemical, and microbial parameters. The relationship between the monitored water quality parameters and the hand-dug well depth was evaluated using Pearson product correlation coefficient (r) at 1% and 5% levels of significance, and a sanitary risk assessment was conducted for the sampled wells. Parameters occurring in concentrations considered unsafe based on comparison with Nigerian Standard for Drinking Water Quality and World Health Organization Standards revealed percentages of samples above limits as Turbidity (15%); Cadmium (70%); Lead (40%); Manganese (55%); Chromium (55%); Nickel (100%); *Salmonella* sp. (20%); E. coli (80%); *Pseudomonas* sp. (25%) and *Shigella* sp. (30%). r matrix shows that only a few significant correlations exist among the monitored water quality parameters at both 5% and 1% levels of significance, but no significant correlation exists between the monitored parameters and the depth of the wells. The sanitary risk assessment revealed that 16 (80%) of the monitored wells have high contamination risk factors. Our findings revealed that water in Shere should be treated before consumption, and the community should be sensitized on the effects of poor sanitary practices around the wells and its environment to minimize sanitary risk factors.

Keywords: *Hand dug wells, Sanitary Risk Assessment, Turbidity, Chromium, Water Quality Parameters.*

INTRODUCTION

Fresh water is critical to sustaining the ecosystem and a basic human necessity. However, freshwater supplies are distributed unevenly over the world, which is growing scarcer with time (Annapoorna and Janardhana, 2015. The scarcity of fresh water is not far-fetched from the fact that about 97% of the earth's water exists as saline water in ocean and sea; with only about 2.5-2.75% existing as fresh water, of which 1.75-2% exists in frozen forms in glaciers, ice, and snow; 0.01 as surface water in rivers, lakes and swamps and 0.5-0.75 as fresh groundwater (Saha et al, 2018). Thus, surface and groundwater resources are the two most accessible freshwater sources, with the latter being the most abundant in nature, and thus most exploited (Egbinola and Amanambu, 2014).

Individuals obtain water in a variety of ways, which are dependent on their level of civilization, financial constrain, and geographical location (Miner et al, 2015). Hand dug wells (HDWs) however remain the traditional and most prevalent technique of accessing groundwater in rural regions of the developing world (Falola et al, 2021)). In Nigeria, for example, it is still the most prevalent source of drinking water as only a few people have access to and can afford boreholes or other potable water sources (Sawyerr *et al*., 2019). Regrettably, Hand dug wells can easily be contaminated when compared to other groundwater sources, especially if it is left unprotected (Lutterodt *et al*, 2018). The consequences of contaminated drinking water are disastrous, and, could regress from morbidity to mortality. Remarkably, Egbinola and Amanambu (2014), reported that yearly, more people die as a result of unsafe or insufficient water supplies than from all types of violence combined.

This study therefore evaluates the quality of groundwater from hand-dug wells combining physical, chemical, and microbiological assessment in the Shere rural community of Bwari area council, FCT; a region where HDWs is the most predominant source of water supply.

Water quality assessment is crucial to ensure people have access to safe water for drinking and other domestic purposes (Saha *et al,* 2018). It is also important for the prevention of waterborne diseases in the community, thereby, providing an enabling safe environment for the community to thrive. In some African countries such as Ghana, Botswana, and Niger groundwater accounts for 47.56%, 50%, and 71.43% respectively, of their total freshwater sources (Sabrina *et al,* 2013). Similarly, over 70% of the people of Meru City, Tanzania, rely on groundwater as their primary supply of water (Elisante and Muzuka 2016). Akujieze et al, 2003 pointed out that as of 2001, approximately 128 million Nigerians (55 percent of the total population) relied on groundwater, owing to deterioration in the quality and quantity of surface water, insufficient water supply by water authorities, and the effect of communal activities on water sources.

Though, groundwater is perceived to be clean, due to little contact with surface pollution; studies have shown that groundwater can be contaminated unknowingly through anthropogenic activities and interaction with geological materials (Hassan et al, 2013) (Francis and Ndububa, 2022). Typical of most rural communities in developing countries, drinking water in the Shere community of the FCT is predominantly sourced from hand-dug wells. However, concerns about the quality of water drawn from hand-dug wells have garnered widespread attention due to its high vulnerability to contamination (Sefa-Ntiri *et al,* 2020), (Isah *et al*, 2015), (Gebresilasie *et al,* 2021) (Braimah et al, 2021), (Tetteh *et al,* 2020) (Adeyemi *et a*l, 2020). For instance, Isah et al, 2015 stated that many Nigerian studies have demonstrated that poor siting of water wells close to soakaway systems and pit latrines, or

close to unlined drainage channels, pollutes water wells; which is typical of rural areas like Shere due to poor planning. Sefa-Ntiri *et al*, 2020 also noted that surface water can easily leach into HDWs, plus the use of bucket and rope to fetch water which is the predominant method of abstracting water from hand-dug wells in rural areas can easily transfer bacteria to the groundwater.

Water pollution is a threat to human health, economic development, and social prosperity; therefore, it is necessary to assess the water quality of HDWs to determine their safety for drinking (Ndububa and Nwafor (2015). However, at the time of this research, no documented study has been conducted to evaluate the quality of domestic water from hand-dug wells in Shere Village, Abuja.

MATERIALS AND METHODS

Study area

Shere is one of the indigenous areas of habitation in Bwari Area Council of the Federal Capital Territory, Abuja Nigeria, and lies on coordinates 9º30' N and 9º14' E. The locals, who are mostly farmers, specialize in farming yam, beans, millets, rice cassava, and guinea corn, as well as making native pots. Their major language is Gbaygi. The area's water supply is mostly provided by manually dug wells and surface water. Due to human activities such as agricultural operations and indiscriminate trash dumping, the quality of these sources of water supply is uncertain.

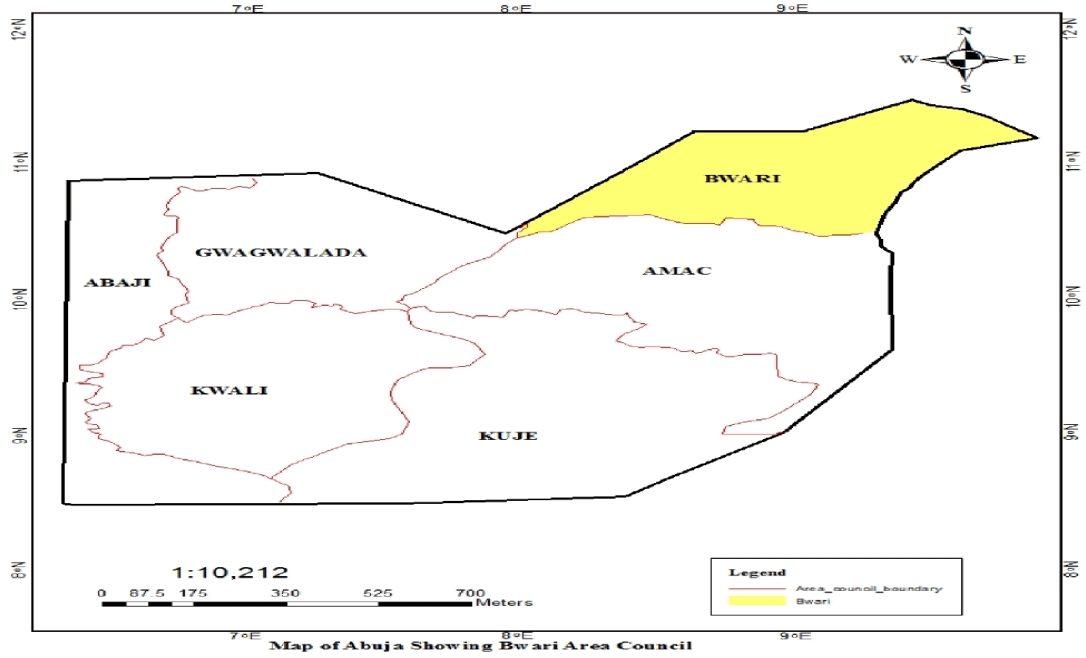

Figure 1: Map of FCT showing Bwari Area Council (Source, FCDA, 2005)

Water sampling procedures:

The water samples were collected from 20 hand-dug wells located at various locations in Shere community by random sampling method based on access at the time of sampling. Water samples were taken directly from each well using sterile plastic containers, by approved sampling methods that allowed for the acquisition of representative and viable samples. The collected samples were properly labelled, stored, and transported in an iced cooler at temperatures below 10 ºC to the laboratory where they were analysed.

Data collection

Details of the sampled well depths; coordinates; and sanitary conditions were noted. The depth of the HDWs was measured using wetted steel tape. The coordinates were measured using a Global Positioning System (GPS). Details of the sanitary conditions were obtained by examination of the sampled hand-dug well for sanitary-risk factors. The sanitary inspection adopted the methods employed by Lutterodt, 2018 by designing a sanitary risk assessment form.

Water quality analysis

Physical, Chemical, and Microbiological analyses were carried out to assess the water quality of the sampled hand-dug wells. The physical analysis was conducted by analysing parameters such as pH, conductivity, total dissolved solids (TDS), temperature, turbidity, and colour. Temperature was measured at the point of collection using a digital thermometer. The chemical analysis includes the parameters: Dissolved Oxygen (DO), Cadmium (Cd), Lead (Pb), Sodium (Na), Zinc (Zn), Potassium (K), Iron (Fe), Copper (Cu), Manganese (Mn), Magnesium (Mg), Chromium (Cr) and Nickel (Ni).

The analysed microbial parameters include *Salmonella spp., E. coli, Pseudomonas spp.*, and *Shigella spp.* using the bacteriological techniques. Salmonella Shigella Agar was used as the isolation medium for *Salmonella spp.* and *Shigella spp.;* while MacConkey agar was used for *E. coli* and *Pseudomonas spp.* All of the analytical procedures followed the Standard Methods for Water and Wastewater analysis (American Public Health Association, 2017).

RESULTS AND DISCUSSION

Table 1: Coordinates and depths of the sampled wells at Shere

S/No.	Coordinates		Depth (m)	Water Table (m)	Description
	Latitude	Longitude			
1	9°14'4.81″	7°29'51.40″	19.00	4.00	WELL 1
2	9°14'4.52″	7°29'51.70″	22.20	3.20	WELL 2
3	9°14'4.31″	7°29'50.70″	20.40	5.10	WELL 3
4	9°14'3.67″	7°29'50.68″	18.30	3.00	WELL 4
5	9°14'5.16″	7°29'50.84″	18.30	5.60	WELL 5
6	9°14'4.47″	7°29'50.11″	20.60	6.30	WELL 6
7	9°14'7.34″	7°29'51.05″	23.40	8.70	WELL 7
8	9°14'6.72″	7°29'49.58″	17.00	4.00	WELL 8
9	9°14'5.96″	7°29'47.81″	20.60	8.40	WELL 9
10	9°14'4.92″	7°29'47.66″	18.60	6.60	WELL 10
11	9°14'4.76″	7°29'48.44″	19.20	7.30	WELL 11
12	9°14'5.58″	7°29'48.04″	23.00	5.80	WELL 12
13	9°14'6.84″	7°29'47.25″	17.00	3.80	WELL 13
14	9°14'6.44″	7°29'44.99″	20.00	4.30	WELL 14
15	9°14'2.15″	7°29'47.4″	19.20	5.00	WELL 15
16	9°14'0.79″	7°29'46.89″	21.00	3.30	WELL 16
17	9°14'1.70″	7°29'48.53″	18.60	3.80	WELL 17
18	9°14'4.79″	7°29'48.95″	20.00	4.00	WELL 18
19	9°14'0.93″	7°29'49.21″	16.30	2.80	WELL 19
20	9°14'0.31″	7°29'49.87″	19.40	5.30	WELL 20

The result of physical parameters

The following results were obtained from laboratory analysis of physical parameters which were carried out on collected water samples and are presented in Table 2. Results are compared with World Health Organisation (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) guidelines as shown in the notes at end of the Table 2.

Table 2: Result of Physical Parameters from Sampled Water in Shere

S/No.	Sample	Parameters					
		pH	Conductivity (µS/cm)	TDS (mg/l)	Temperature (ºC)	Turbidity (NTU)	Colour (HU)
1	C	7.384	127.70	62.59	28.70	0.27	0.00
2	**Well 1**	5.900	970.70	476.50	28.70	1.28	0.00
3	**Well 2**	5.784	88.07	43.01	28.70	2.82	0.00
4	**Well 3**	5.798	70.34	34.54	28.70	0.71	0.00
5	**Well 4**	6.754	530.30	259.90	28.70	3.27	0.00
6	**Well 5**	6.075	11.08	5.42	28.70	1.95	0.00
7	**Well 6**	5.970	82.15	40.25	28.70	2.04	0.00
8	**Well 7**	6.064	130.50	64.00	28.70	10.50	0.00
9	**Well 8**	5.751	446.60	218.80	28.80	1.46	0.00
10	**Well 9**	5.761	471.90	231.30	28.80	1.16	0.00
11	**Well 10**	6.759	886.20	434.40	28.80	2.12	0.00
12	**Well 11**	5.734	802.10	393.00	28.90	3.57	0.00
13	**Well 12**	6.377	828.80	49.70	29.00	3.82	0.00
14	**Well 13**	5.608	181.30	88.83	29.10	2.19	0.00
15	**Well 14**	5.392	557.60	273.20	29.30	0.72	0.00
16	**Well 15**	5.578	562.30	275.90	29.10	10.72	0.00
17	**Well 16**	6.191	281.60	138.00	29.70	11.90	0.00
18	**Well 17**	5.704	83.86	41.29	29.60	2.84	0.00
19	**Well 18**	6.038	404.10	198.20	29.70	2.84	0.00
20	**Well 19**	4.357	298.70	138.60	29.70	1.06	0.00
21	**Well 20**	6.844	924.30	452.70	29.80	1.08	0.00
	Mean Values	5.92	430.63	192.88	29.06	3.40	
	Standard Deviation	±0.497	±311.628	±149.864	±0.404	±3.339	
	WHO	NS	NS	NS	NS	5.00	NS
	NSDWQ	6.50-8.50	1000	500	Ambient	5.00	15

C: Control sample (Borehole water), WHO: World Health Organization Guidelines for Drinking-water Quality (Fourth Edition). NSDWQ: Nigerian Standard for Drinking Water Quality (NSDWQ)
NS: Not specified

The Nigerian Standard for Drinking Water Quality (NSDWQ) specifies a pH range of 6.5 to 8.5, only the control well and wells 4,10, and 20 are within the specified range. pH values ranged from 4.36 – 6.84 with a mean of 5.92 and SD ±0.497. Conductivity values ranged from 11.08 – 970.7 µS/cm with a mean of 430.63 µS/cm and SD of ±311.628. Total Dissolved Solids (TDS) ranged from 5.42 – 476.5 mg/l with a mean of 192.88 and SD of ±149.864; Temperature ranged from 28.7 – 29.8 ℃ with a mean of 29.06 ℃ and SD of ±0.404. Turbidity ranged from 0.71 – 11.90 NTU with a mean of 3.40 NTU and SD of ±3.339. 15% of the monitored wells have turbidity values non-compliant with WHO and NSDWQ. The colour for all 20 monitored wells is in total compliance with WHO and NSDWQ.

Table 3: Result of Chemical parameters of well water in Shere

S/No.	Sample	DO (mg/L)	Cd (mg/L)	Pb (mg/L)	Na (mg/L)	K (mg/L)	Zn (mg/L)	Cu (mg/L)	Fe (mg/L)	Mn (mg/L)	Mg (mg/L)	Cr (mg/L)	Ni (mg/L)
1	C	7.38	0.000	0.000	9.478	4.246	0.111	0.674	0.000	0.000	2.637	0.000	0.011
2	Well 1	5.58	0.000	0.014	27.690	73.089	0.128	0.068	0.000	1.338	17.226	0.262	0.512
3	Well 2	5.27	0.308	0.000	6.897	7.343	0.069	0.671	0.000	0.000	2.390	0.000	0.689
4	Well 3	5.03	0.000	0.000	10.883	1.951	0.052	0.628	0.000	0.255	0.332	0.146	0.521
5	Well 4	6.88	0.041	0.959	26.626	15.896	0.045	0.646	0.000	0.000	1.295	0.000	0.651
6	Well 5	5.09	0.079	0.000	0.446	1.362	0.034	0.616	0.000	0.000	0.000	0.000	0.570
7	Well 6	5.77	0.000	1.249	4.142	1.825	0.054	0.635	0.000	0.022	1.158	0.014	0.566
8	Well 7	9.21	0.154	0.000	12.921	5.569	0.034	0.616	0.000	0.326	3.0467	0.058	0.662
9	Well 8	9.76	0.072	0.000	26.020	37.913	0.054	0.668	0.000	0.656	12.816	0.000	0.510
10	Well 9	6.46	0.078	0.718	26.468	33.776	0.037	0.616	0.000	0.887	15.799	0.365	0.733
11	Well 10	5.35	0.000	0.000	28.779	68.221	0.096	0.593	0.000	0.862	14.337	0.000	0.494
12	Well 11	5.35	0.247	0.985	25.227	81.228	0.262	0.614	0.000	0.815	16.664	0.033	0.714
13	Well 12	6.83	0.139	0.000	25.511	78.821	0.077	0.672	0.000	0.132	15.985	0.000	0.633
14	Well 13	11.09	0.000	0.000	15.809	14.225	0.221	0.661	0.000	0.710	3.715	0.052	0.468
15	Well 14	9.38	0.267	0.136	24.896	59.132	0.097	0.703	0.000	0.445	16.492	0.266	0.728
16	Well 15	5.11	0.215	0.000	22.350	47.784	0.094	0.717	0.000	0.070	16.306	0.077	0.530
17	Well 16	5.87	0.095	1.460	11.989	37.077	0.105	0.634	0.000	0.000	10.036	0.079	0.778
18	Well 17	6.27	0.000	0.000	3.837	3.159	0.104	0.708	0.000	0.223	4.375	0.055	0.546
19	Well 18	5.61	0.137	0.489	26.368	30.849	0.092	0.664	0.000	0.235	7.555	0.078	0.645
20	Well 19	5.46	0.049	0.000	23.628	16.738	0.086	0.755	0.000	0.021	4.589	0.392	0.697
21	Well 20	5.10	0.091	0.000	29.011	72.303	0.090	0.755	0.000	0.021	13.201	0.091	0.496
	WHO	NS	0.003	0.010	NS	NS	NS	2.000	NS	NS	NS	0.050	0.070
	NSDWQ	NS	0.003	0.010	200.000	NS	3.000	1.000	0.300	0.200	20.000	0.050	0.020

Only 6 wells and the control sample have values of Cadmium within the range specified by Standards, showing that 70% of samples did not meet the required standards. 13 wells have values of lead within range of specified values by standards, 40% of samples did not meet the required values in standards., all values of Nickel are above specified values of standards except the control sample. Values for Sodium, Potassium, Zinc, Copper, Iron and Magnesium are all within the specified range of values of the standards. 55% of samples did not meet the drinking water standards for Manganese and Chromium, while Wells with chemical parameters above standard limits must be treated.

Results obtained from the analysis of microbiological parameters of water samples from Shere are presented in Table 4. Explanatory notes are also presented at the end of the table.

Table 4: Result of Microbial parameters of well water in Shere

S/No.	Samples	*Salmonella* spp. (cfu/100mL)	*E. Coli* spp. (cfu/100mL)	*Shigella* spp. (cfu/100mL)
1	**C**	**0.00**	**0.00**	0.00
2	**Well 1**	**0.00**	**10.00**	0.00
3	**Well 2**	**0.00**	**18.00**	**0.00**
4	**Well 3**	**0.00**	**2.00**	**0.00**
5	**Well 4**	**0.00**	**0.00**	**0.00**
6	**Well 5**	**0.00**	**12.00**	**0.00**
7	**Well 6**	**0.00**	**47.00**	**0.00**
8	**Well 7**	0.00	**22.00**	0.00
9	**Well 8**	0.00	**15.00**	0.00
10	**Well 9**	0.00	**102.00**	**2.00**
11	**Well 10**	0.00	**11.00**	**8.00**
12	**Well 11**	0.00	0.00	0.00
13	**Well 12**	0.00	**10.00**	0.00
14	**Well 13**	**10.00**	**100.00**	**5.00**
15	**Well 14**	**5.00**	**92.00**	**25.00**
16	**Well 15**	0.00	**90.00**	0.00
17	**Well 16**	0.00	**4.00**	0.00
18	**Well 17**	0.00	**17.00**	**3.00**
19	**Well 18**	0.00	0.00	0.00
20	**Well 19**	0.00	0.00	0.00
21	**Well 20**	0.00	**110.00**	**49.00**
	WHO	**0.00**	**0.00**	**0.00**
	NSDWQ	**0.00**	**0.00**	**0.00**

C: Control sample (Borehole water); WHO: World Health Organization Guidelines for Drinking-water Quality (Fourth Edition). NSDWQ: Nigerian Standard for Drinking Water Quality (NSDWQ). NS: Not specified.

Salmonella spp. ranged from 0.00 – 10.00 CFU/100ml with a mean of 0.75 CFU/100ml and SD of ±2.440; 20% of the sampled HDWs were considered unsafe because of *Salmonella spp.* contamination. *E. coli* ranged between

0.00 – 110.00 CFU/100mL with a mean of 33.1 CFU/100mL and SD of ±40.138; 80% of the monitored wells are considered unsafe in terms of *E. coli* contamination levels indicating the need to critically monitor contaminants in domestic water (Ndububa and Ardo, 2017). *Pseudomonas spp. ranged from* 0.00 – 82.00 CFU/100mL with a mean of 7.65 CFU/100mL and SD of ±19.621; 25% of sampled HDWs were considered unsafe because of *Pseudomonas spp. Shigella spp. ranged from* 0.00 – 49.00 CFU/100ml.

Table 5: Correlation matrix of monitored parameters and depth of HDWs in Shere

		pH	Conductivity	TDS	Temperature	Turbidity	DO	Cd	Pb	Na	K	Zn	Cu	Mn	Mg	Cr	Ni	*Salmonella*	*E. Coli*	*Pseudomonas*	*Shigella*	Depth
1	pH	1																				
2	Conductivity	0.355	1																			
3	TDS	0.268	0.896	1																		
4	Temperature	-0.184	0.078	0.093	1																	
5	Turbidity	0.112	-0.119	-0.135	0.110	1																
6	DO	-0.142	-0.141	-0.163	-0.097	0.013	1															
7	Cd	-0.147	0.009	0.043	0.031	0.291	0.000	1														
8	Pb	-0.183	-0.050	0.025	0.035	0.266	0.166	-0.013	1													
9	Na	0.130	0.852	0.783	0.156	-0.164	0.087	0.087	-0.060	1												
10	K	0.260	0.945	0.777	0.147	-0.032	-0.102	0.255	-0.025	0.755	1											
11	Zn	-0.175	0.313	0.349	0.207	-0.011	0.130	0.128	0.108	0.206	0.425	1										
12	Cu	-0.114	-0.332	-0.376	0.411	0.098	0.108	0.271	0.006	-0.137	-0.260	-0.129	1									
13	Mn	-0.038	0.473	0.553	-0.330	-0.285	0.252	-0.188	-0.122	0.450	0.455	0.422	-0.671	1								
14	Mg	0.063	0.831	0.716	0.138	0.046	-0.001	0.269	-0.033	0.724	0.910	0.326	-0.240	0.542	1							
15	Cr	-0.602	0.113	0.207	0.251	-0.263	-0.041	-0.067	-0.075	0.315	0.086	-0.048	-0.189	0.290	0.264	1						
16	Ni	-0.241	-0.104	-0.141	0.169	0.280	-0.058	0.544	0.524	0.022	0.003	-0.053	0.185	-0.204	0.076	0.317	1					
17	*Salmonella*	-0.227	-0.125	-0.089	0.083	-0.160	0.705	-0.032	-0.168	-0.005	-0.058	0.488	0.099	0.222	-0.044	0.065	-0.176	1				
18	*E. Coli*	-0.003	0.123	0.197	0.153	-0.065	0.307	0.125	-0.129	0.162	0.143	0.082	0.235	0.083	0.299	0.260	-0.172	0.512	1			
19	*Pseudomonas*	0.024	0.119	0.170	0.054	-0.228	0.129	-0.075	0.102	0.252	0.088	-0.055	0.080	0.284	0.270	0.477	0.136	0.202	0.683	1		
20	*Shigella*	0.291	0.397	0.453	0.441	-0.262	0.034	0.101	-0.206	0.310	0.389	0.051	0.246	-0.081	0.283	0.114	-0.181	0.191	0.598	0.325	1	
21	Depth	0.319	-0.062	-0.278	-0.197	0.408	-0.095	0.432	0.147	-0.196	0.034	-0.297	-0.023	-0.199	0.032	-0.168	0.398	-0.273	-0.036	0.025	-0.052	1

Values of correlation between the ranges of 0.45 to 0.55 shows that correlation is significant at the 0.05 level (2-tailed)
Values of correlation above 0.6 show correlation is significant at the 0.01 level (2-tailed)

Table 6: Sanitary risk categorization for monitored wells

S/No.		Well No.																			
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	Lack of/inadequate well lining	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2*	Is the concrete floor less than 1 m wide around the well	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1
3	Is there a latrine/septic tank within 10 m of the well	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1
4	Is the nearest latrine on the higher ground than the well	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 m of the well	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	Is there poor drainage, causing stagnant water within 2 m of the well	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	1
7	Are there any cracks in the concrete floor around the well which could permit water to enter the well	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	Absence of well cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	Is the headwall (parapet) around the well inadequate, allowing surface water to enter the well?	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1
10	Are the rope bucket exposed to contamination	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1
	Total Score of risk	7	8	7	5	7	7	7	7	8	7	3	6	8	8	7	6	8	5	5	8
	Risk category	High	High	High	Moderate	High	High	High	High	High	High	Moderate	High	High	High	High	High	High	Moderate	Moderate	High

Sanitary risk assessment for the monitored hand-dug wells; it is noted that 16 of the investigated wells have high contamination risk factors, that is; 80% of the monitored wells fall in the high-risk category while 4 (20%) fall in the moderate risk factor category. The 4 wells within the moderate risk factor category are well 4, well 11, well 18, and 19. These wells with moderate risk factors happen to be the 4 wells noted with the absence of *E. coli* contamination. This is an indication that the prevalent sanitary conditions have a consequent impact on the microbial quality of water (Lutterodt et al, 2018) (Abdulsalam and Zubairu, 2013) showing that the sanitary conditions around a hand-dug well water source can impact the water quality.

CONCLUSION

This study evaluated the quality of groundwater from HDWs in Shere rural community of Bwari area council, FCT; and the outcome of this study indicated the following:

The water quality analysis showed various percentages of water quality parameters that did not meet standards as follows: turbidity (15%); Cadmium (70%); Lead (40%); Manganese (55%); Chromium (55%); Nickel (100%); *Salmonella spp.* (20%); *E. coli* (80%); *Pseudomonas spp.* (25%) and *Shigella spp*. (30%) existed in concentrations considered unsafe based on non-compliance with NSDWQ and WHO for the sampled wells.

Pearson product correlation coefficient showed significant correlations exist among the monitored water quality parameters at both 5% and 1% level of significance, but no significant correlation exists between the monitored water quality parameters and the depth of the HDWs.

The sanitary risk assessment revealed that 16 (80%) of the monitored wells have high contamination risk factors; arising from proximity to pit latrines, other sources of pollution such as dumpsites, animal excreta, gutters (wastewater channels), inadequate well lining, inadequate headwall, and exposure to contamination by the rope and bucket being used to draw water from the wells among others.

The high levels of microbial contamination are linked to the poor sanitary conditions noted in the study area.

Based on the extent of non-compliance with the World Health Organisation and Nigerian Standard for Drinking Water Quality guidelines, the quality of water from HDWs in Shere is not suitable for drinking without treatment.

RECOMMENDATIONS

From the study, the following recommendations are made for safe and healthy delivery of potable water. The well users should be sensitized to the effects of poor sanitary conditions around the wells and its environment; and consequently, the need to improve and minimize sanitary risk factors.

Given the extent of non-compliance to the WHO and NSDWQ noted in some monitored parameters; water from HDWs in Shere should be treated before consumption.

Further studies investigating the cause of high concentrations of some chemical parameters such as Ni, Cr, Cd, Pb, and Mn should also be pursued.

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