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Assessment of the Quality of Newly Constructed Hand-Dug Well Usetd for Drinking and Their Treatment System at Kenema Town, Kenema District, Eastern, Sierra Leone

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Abstract: The tremendous increase in the human population increase the stress on both surface and groundwater and it is believed that at the beginning of human civilization itself, groundwater was the most trusted form of drinking water because of the filtering effect of the aquifer however, in the present world drinking water directly from the source without proper treatment is very tough and risky for the health. Kenema District is a district in the Eastern Province of Sierra Leone, its capital and largest city is Kenema City, which is the third most populous city in Sierra Leone, after Freetown and Bo Both the physical and chemical Parameters investigated are within the WHO acceptable limits, except one of bioteriological parameters (non- faecal coliform). Tables 1, 3, and 4 show high statistical mean values for the Non-Faecal Coliform bacteria in the hand dug wells. Diema Hand Dug Well (12.00 cfu/100ml), Ansarul Hand Dug Well (11.67 cfu/100ml) and the combined statistical mean value (10.78cfu/100ml) of the Non-Faecal Coliform bacteria and all the values fell out of World Health Organization (WHO) permissible limit. However, Islamic Hand Dug Well has a statistical mean value of 8.67 cfu/100ml of Non-Faecal Coliform Value which is within the WHO permissible limit (<10cfu/100ml). The combined statistical mean value for Diema, Islamic, and Ansarul hand dug well for the following physiochemical parameters (pH 7.14, Turbidity 2.46NTU, Conductivity 196.56, TDS 100.11mg, Ammonia 0.02mg/l, Nitrite 0.02mg/l, Nitrate 0.06mg/l, Phosphate 6.15mg/l, Cadmium 0.00gm/l, Copper 0.02mg/l, Iron 0.03mg/l and Zinc 2.67mg/l) are all within the World Health Organization permissible limits (Table 4). Non-faecal coliforms were discovered in all of the wells and boreholes examined and analyzed in a similar investigation to identify the bacteriological pollution of groundwater sources.

Keywords: Hand-Dug, Well, Treatment, Physiochemical, Biological Bacteria

1. Introduction

One of the main priorities of people living in developing countries is that obtaining clean and safe drinking water. In Asia and Africa, most people in rural areas depend on ground and surface water for sustenance. Eight hundred and forty-four (844) million people, just 1 in 10 of the global population in 2015 were still living without access even to basic drinking water services [20], and only 71% were using safely managed drinking water service, and sadly 58% of 159 million people who were still collecting drinking water directly from surface water lived in sub-Saharan Africa [23] and the situation is still the same 1 in 3 people do not have access to safe drinking water [24]. Also, it is estimated that 1.2 billion people around the world, or one-fifth of the world's population lack access to safe water either because of unavailability or inadequacy. This could probably be due to an increase in human and animal populations [8]. Water is a vital nutrient, our organs need it for their normal functioning and also to keep the water balance in our body [9]. On average, Water accounts for 60% of the body weight of an adult human being. The average water intake of 2 liters per day for adults is needed as commonly used by the World Health Organization and regulators in computing drinking water guidelines and standards [26].

Sierra Leone Water Company is charged with the responsibility of providing potable water for urban cities within the country since half of the population in the country doesn't have access to safe drinking water. According to Sierra Leone Water Company on average, only 35% of rural residents have access to safe drinking water [19]. In both rural and urban areas of Sierra Leone, access to clean, safe water is still a serious problem. People who live in Sierra Leone's rural villages rely mainly on hand-dug wells. Due to its relatively superior quality to river water, groundwater is preferred as a source of drinking water in rural regions [12].

The country is fortunate to have a six-month rainy season and a six-month dry season. During the wet season (May to October), the majority of people receive their domestic and drinking water from the rains, which lessens the load on people who must find water for these purposes. The availability of potable water throughout the dry season (November to April) can be a significant difficulty for most people [15]. The tremendous increase in the human population increases the stress on both surface and groundwater and it is believed that at the beginning of human civilization itself, groundwater was the most trusted form of drinking water because of the filtering effect of the aquifer however, in the present world drinking the water directly from the source without proper treatment is very tough and risky for the health. The groundwater analysis for physiochemical and bacteriological properties is very important for public health. Quality water is colorless, tasteless, and odourless, as well as free from faecal contamination [13].

Kenema district is the most populous district in the Eastern province with a population of 772,472 and the third most populous city in Sierra Leone. Kenema District has an area of 6,345 km^2 (2,337sqmile) and comprises sixteen chiefdoms [17]. There were pipe-borne water facilities at the main Kenema highways before the outbreak of the civil war in March 1991. But as a result of the 10-year civil war, majority of the public utilities and waterways were destroyed, leaving the ruins as the only physical reminder of the monument as it stands now. A significant problem in Kenema is the lack of access to clean, safe drinking water. Currently, hand-dug wells, rivers, swamps, hand pumps, and streams are the main sources of drinking water in Kenema. The dug well is a conventional technique for removing groundwater from a water table's upper layer by digging a hole with a big diameter that is usually lined with concrete rings and covered with a slab of concrete or metal with ventilation [5, 2].

The most urgent demand for better and clean drinking water, acceptable forms of sanitation, and access to water for other household purposes are among the poor and marginalized people living in rural and periurban areas [4]. Studies from many parts of the world show that the majority of home water sources contain a concerning amount of microbial pollution [8]. According to WHO, 2012, there was a cholera outbreak in Sierra Leone that resulted in 18,919 cases and 273 fatalities [27]. A water-borne illness called cholera is contracted by consuming tainted water. According to epidemiological research, where access to clean water and sanitary facilities is still a major issue, cholera is most common in sub-Saharan Africa [3].

1.1. Aim and Objectives

1.1.1. Aim

The main goal of this study was to assess the quality of the newly constructed hand-dug well used for drinking and their treatment system at Kenema District, eastern province, Sierra Leone, and find a suitable recommendation.

1.1.2. Specific Objectives

1) To assess the quality of the newly constructed water supply (Hand Dug Well) and treatment at the time of start-up.
2) To monitor the ongoing quality of the existing water supply and treatment system.

1.2. Description of Study Area

Kenema District is a district in the Eastern Province of Sierra Leone. Its capital and largest city is Kenema, which is the third most populous city in Sierra Leone, after Freetown and Bo. Tongo is the second most populous city in the district. Other major towns in Kenema District include Blama and Yomboma. The district is the most populous in the Eastern Province with a population of 772,472 and the third most populous city in Sierra Leone. Kenema District has an area of 6,345 km^2 (2,337sqmile) and comprises sixteen chiefdoms [17].

The Economy of Kenema District is largely based on Farming, Diamond Mining, and trade. The Mende is the largest ethnic group in the district, though the district is a home to a significant population of many of Sierra Leone's ethnic groups. The population of Kenema District is majority Muslim, though the district is also a home to a significant Christian minority. Like the rest of Sierra Leone, Muslims, and Christians collaborate and get along very well in the Kenema District [17].

Three newly constructed hand dug well in Nongowa Chiefdom, Kenema District were selected for three months period that is, August, September and October for this research at random. The names and GPS are as follow; Diema: N7.512386, W11.118439, Islamic: N7.515009, W11.117889 and Ansarule: N7.530203, W11.108056. The residents of the community used these three hand-dug wells for drinking water and a few agricultural tasks. The three-month intensive water quality evaluation research began in August 2021 and ran until October 2021.

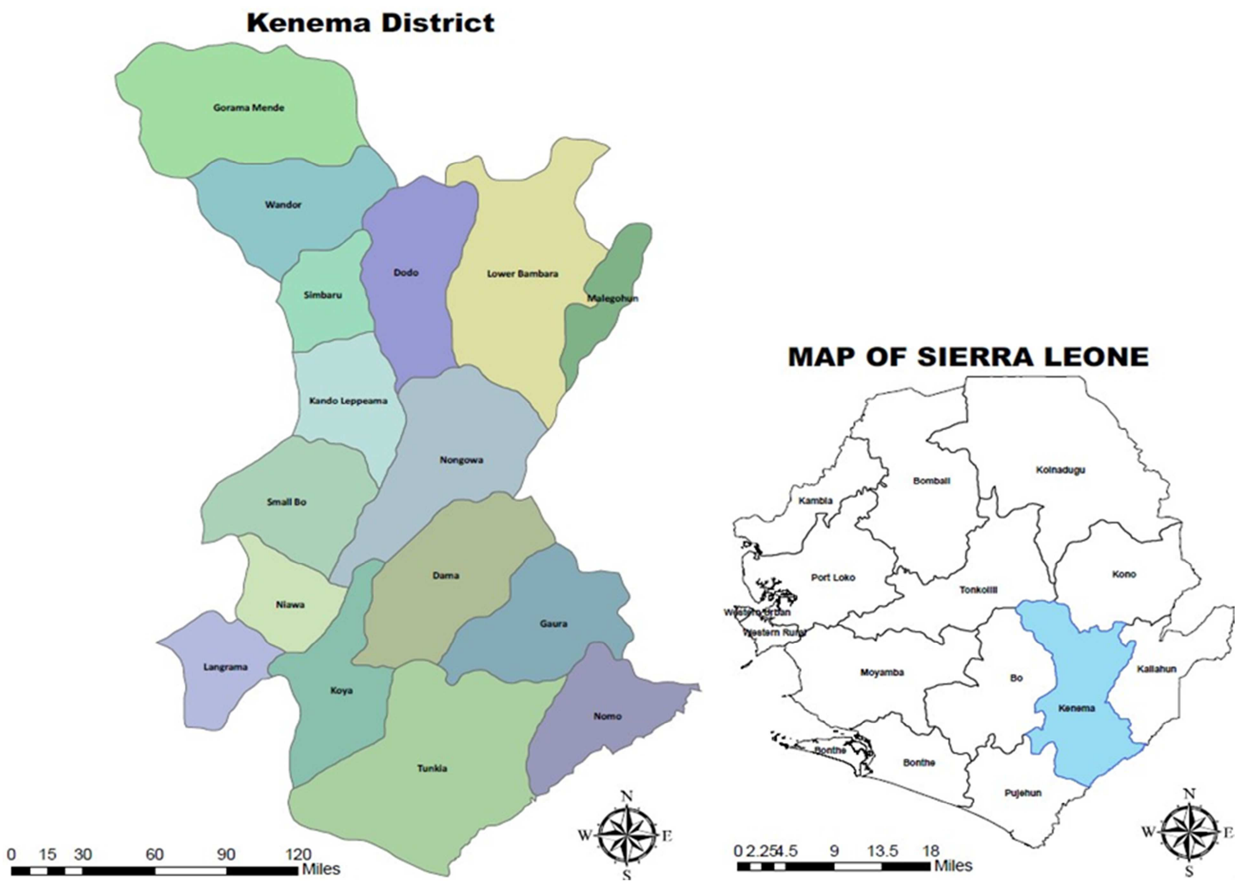

Figure 1. *A Map showing the Area of Study.*

2. Material and Method

Samples were collected in the field by trained researchers using a sterilized sample bottle (500ml), the containers were rinsed three times with the samples to avoid contamination, and these sample bottles were sealed and placed in a dark environment at a constant temperature range of 5-15°C to avoid any contamination and the effects of light and temperature. The water samples were then transported to the lab (Directorate of Water Resources, in the Ministry of water resources). All testing were done by a trained technician in a special room with suitable conditions for analyzing water quality within six hours of the samples being collected.

2.1. Samples Collection and Analysis On-Site Analysis

Inserting a digital thermometer into a sample of water and turning on the electrode, at the location of the sample collection, temperature, pH, conductivity, and turbidity measurements were made on-site using various calibrated standard instruments in accordance with the recommended protocols and methods of the American Public Health Organization [1] and American Society for Testing and Materials (ASTM) [6]. The temperature was checked. Duplicate readings were recorded in degrees Celsius.

A digital pH meter was used to determine the pH of the water samples. The pH meter is first calibrated (verified) to ensure that it was in good working condition. About 10 ml of water sample was poured into a clean glass beaker and the probe was inserted in it. The selector of the pH meter was switched on the pH value was read and recorded instantly. The procedure was repeated twice for all other samples and the probe was rinsed with distilled water after each experiment for all the samples.

The conductivity was determined using the Digital Conductivity Meter in the Laboratory. The meter was first calibrated by setting the temperature knob at 25 ºC, and the function knob was turned to check and adjust the display value to 1.00 by turning the screw at the back of the instrument. The probe was then dipped into a 0.1 M potassium chloride (KCl) solution and the reading was adjusted to 1.408 with the cell constant knob. The function knob was then turned to conduct and the value displayed was recorded. 10 ml of each sample was poured into a clean beaker. The probe was dipped into each sample one after the other. After it was removed from one sample it was rinsed with distilled water and then wiped thoroughly with the tissue before it was dipped into another sample. The fixed or steady value has been displayed on the screen is been recorded as the conductivity value. The process was repeated three times for each sample to ensure accuracy and consistency.

Turbidity was determined in the Laboratory using the HACH 2100Q turbidimeter measured in a Nephlometer turbidity unit (NTU). The instrument was calibrated first using standards such as 20, 60, 80, 100, and 10 (verification standards) respectively. After calibration, a portion of each sample is poured into its specific labelled clean oiled turbidity vial after the sample had been shaken several times. The turbidity vial was filled to the white line, gently inverted several times, and then placed into the turbidimeter. The final readings were obtained after 60 seconds and the average reading was obtained. This process was repeated three times to ensure accuracy and consistency.

2.2. Laboratory Analysis

2.2.1. Physical and Chemical Analysis

TDS in water samples were measured using the filter method in accordance with APHA's [1] and Sawyer [16], recommended standards. The accuracy and precision of the procedures below are so well acknowledged and referenced in the scientific literature. Before beginning the vacuum filtration procedure, a pre-weighed glass fiber filter with a predetermined pore size was filled with a defined volume of the water sample. By using the gravimetric method, the TDS of the water samples was measured, and the filtrate of the TDS was cooked in an oven at a temperature over 100^0 C until all the water had evaporated. The amount of TDS in a sample is represented by the residue's residual mass.

The WAGTECH PHOTOMETER, 7100, was used to analyze chemicals and heavy metals such as NO_2, NO_3, PO_4, NH_3, Cu, Zn, Fe, and Cd to look into the chemical properties. References from the operational handbook were used before the analysis. To calibrate the photometer, a blank solution (reference, 0.00 mg/L) was initially prepared. One chemical tablet was inserted in a test tube with a 10 ml sample of water, and it was crushed and mixed to create a uniform mixture before being let to stand for 10 minutes to fully colored. The cell holder was then inserted, and the lid was shut. After setting the photometer to the proper wavelength and turning on the power, the concentration of each sample was recorded in milligrams per liter.

2.2.2. Microbiological Analysis

The Membrane filter technique was used to investigate the bacteriological status of the samples collected. Growth absorbent pads were dispensed with pad dispenser into twelve (12) sterile petri-dishes and labelled 'FC' (from 1–5) for faecal Coliforms testing and TC (from 1–5) for Total Coliforms test. Two sterile petri-dishes were set as blanks for both faecal and total Coliforms.

The pads were saturated or soaked with Membrane Lauryl Sulphate Broth (MLSB). Forceps were sterilized using a flame and allowed to cool, after which, methanol was smeared on them. Using these forceps, sterile membrane filters were placed onto the bronze membrane support and covered with the filtration funnel. 10 ml of water sample was poured into the filter funnel and a hand vacuum pump connected to the filtration unit base was pumped to suck the water sample through the membrane. Sterile forceps were used to remove the membrane filter from the bronze membrane support after the water has been filtered. The membrane filter was then placed on the pad in the petri-dish which had been saturated or soaked with the MLSB media.

This was repeated for the various water samples. The lids for the petri-dish were replaced immediately. The membrane filter was placed on top of the soaked pads and the petri-dishes were placed in a petri-dish rack. When the last sample had been processed, a resuscitation period of about 30 minutes was observed before incubating. For the incubation of faecal Coliforms, a temperature of 44°C was selected on the incubator, and 37°C for that of total Coliforms. The racks were placed into the incubator for 24 hours for observation and counting of colonies. Yellow colonies indicated that faecal Coliforms were present and pink colonies indicated total Coliforms. Counting was done with the aid of a hand lens and the estimated bacteria present per 100 ml of water and calculated was done as shown below:

The bacterial colonies were then counted using magnifying lens or colony counter when necessary and expressed as numbers per 100mls of water.

$$TCC = \frac{NC \times VW}{100}$$

where TCC is total coliform count; VC is the number of colonies; and VW is the volume of water

The non-faecal Coliforms growth was calculated by using the formula below

$$NFC = TCG - FCG$$

where NFC is non-faecal coliform; TCG total coliform growth; and FCG is faecal coliform growth.

3. Results

Tables 1 to 4 illustrates the results of physicochemical and biological parameters from three different hand dug wells at Diema, Islamic and Ansarul in the Nongowa Chiefdom, Kenema District. The results are presented in statistical methods (Mean, Variance and Standard Deviation).

Table 1. *Hand Dug Well at Diema, Kenema.*

Parameters	Month			Mean	Variance	Standard Deviation	WHO Const.
	August.	Sept.	Oct.				
Temperature (°C)	28.00	30.80	31.00	29.93	2.81	1.68	No Value
pH	7.10	7.00	7.00	7.03	0.00	0.06	6.5 – 8.5
Turbidity (NTU)	1.35	4.15	4.42	3.31	2.88	1.70	<5.0
Conductivity	160.00	166	175.00	167.00	57.00	7.55	<450
TDS (mg/l)/ppm	87.50	83.00	84.00	84.83	5.59	2.36	<240

Parameters	Month			Mean	Variance	Standard Deviation	WHO Const.
	August.	Sept.	Oct.				
Ammonia (mg)	0.05	0.03	0.02	0.03	0.00	0.01	No Value
Nitrite (mg/l)	0.03	0.02	0.02	0.02	0.00	0.01	<3.0
Nitrate (mg/l)	0.04	0.05	0.05	0.05	0.00	0.01	<50
Phosphate (mg/l)	2.6	2.88	2.89	2.79	0.03	0.17	<20
Cadmium (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	<0.003
Copper (mg/l)	0.24	0.18	0.19	0.20	0.00	0.03	<1.0
Iron (mg/l)	0.04	0.03	0.05	0.04	0.00	0.01	<0.3
Zinc (mg/l)	4.00	3.52	3.50	3.67	0.08	0.28	<5
E. Coli	0.00	0.00	0.00	0.00	0.00	0.00	0 cfu/100ml
Faecal Coliform	0.00	0.00	0.00	0.00	0.00	0.00	0 cfu/100ml
Non-Faecal Coliform	13.00	11.00	12.00	12.00	1.00	1.00	<10cfu/100ml

Table 2. *Hand Dug Well at Islamic, Kenema.*

Parameters	Month			Mean	Variance	Standard Deviation	WHO Const.
	August.	Sept.	Oct.				
Temperature (°C)	27.90	29.30	31.30	29.50	2.92	1.71	No Value
pH	7.00	7.30	7.20	7.17	0.10	0.32	6.5 – 8.5
Turbidity (NTU)	0.77	1.05	1.07	0.96	0.03	0.17	<5.0
Conductivity	164.00	204.00	210.00	192.67	625.33	25.01	<450
TDS (mg/l)/ppm	82.00	102.00	115.00	99.67	276.33	16.62	<240
Ammonia (mg)	0.02	0.02	0.02	0.02	0.00	0.00	No Value
Nitrite (mg/l)	0.01	0.01	0.02	0.01	0.00	0.00	<3.0
Nitrate (mg/l)	0.09	0.08	0.09	0.06	0.00	0.04	<50
Phosphate (mg/l)	6.00	6.19	6.24	6.14	0.02	0.13	<20
Cadmium (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	<0.003
Copper (mg/l)	0.08	0.09	0.09	0.09	0.00	0.03	<1.0
Iron (mg/l)	0.02	0.01	0.02	0.02	0.00	0.01	<0.3
Zinc (mg/l)	2.00	2.15	2.17	2.11	0.01	0.09	<5
E. Coli	0.00	0.00	0.00	0.00	0.00	0.00	0 cfu/100ml
Faecal Coliform	0.00	0.00	0.00	0.00	0.00	0.00	0 cfu/100ml
Non-Faecal Coliform	9.00	8.00	9.00	8.67	0.33	0.58	<10cfu/100ml

Table 3. *Hand Dug Well at Ansarul, Kenema.*

Parameters	Month			Mean	Variance	Standard Deviation	WHO Const.
	August.	Sept.	Oct.				
Temperature (°C)	27.9	31.30	31.4	30.20	3.97	1.99	No Value
pH	7.20	7.20	7.30	7.23	0.00	0.06	6.5 – 8.5
Turbidity (NTU)	0.59	3.88	3.89	2.79	3.62	1.90	<5.0
Conductivity	184.00	191.00	315.00	230.00	5431.00	73.70	<450
TDS (mg/l)/ppm	157.50	92.00	98.00	115.83	1311.08	36.21	<240
Ammonia (mg)	0.01	0.03	0.03	0.023	0.00	0.01	No Value
Nitrite (mg/l)	0.00	0.01	0.03	0.01	0.00	0.01	<3.0
Nitrate (mg/l)	0.02	0.05	0.06	0.04	0.00	0.02	<50
Phosphate (mg/l)	9.70	9.25	9.61	9.52	0.06	0.23	<20
Cadmium (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	<0.003
Copper (mg/l)	0.22	0.02	0.02	0.09	0.00	0.03	<1.0
Iron (mg/l)	0.03	0.02	0.03	0.03	0.00	0.01	<0.3
Zinc (mg/l)	2.00	2.32	2.34	2.22	0.04	0.19	<5
E. Coli	0.00	0.00	0.00	0.00	0.00	0.00	0 cfu/100ml
Faecal Coliform	0.00	0.00	0.00	0.00	0.00	0.00	0 cfu/100ml
Non-Faecal Coliform	15.00	10.00	10.00	11.67	8.33	2.89	<10cfu/100ml

Table 4. *The Three Hand Dug Well Locations in Nongowa Chiefdom, Kenema.*

Parameters	Months									$\bar{x}$	σ^2	σ	WHO
	Diema			Islamic			Ansarul						
	Aug.	Sept.	Oct.	Aug.	Sept.	Oct.	Aug.	Sept.	Oct.				
Temperature (°C)	28.00	30.80	31.00	27.90	29.30	31..30	27.90	31.30	31.40	29.88	2.49	1.58	No Value
pH	7.10	7.00	7.00	7.00	7.30	7.20	7.20	7.20	7.30	7.14	0.02	0.12	6.5-8.5
Turbidity (NTU)	1.35	4.15	4.42	0.77	1.05	1.07	0.59	3.88	3.89	2.46	2.44	1.56	<5.0
Conductivity	160.00	166.00	175.00	164.00	204.00	210.00	184.00	191.00	315.00	196.56	2281.03	47.76	<450
TDS (mg/l)/ppm	87.50	83.00	84.00	82.00	102.00	115.00	157.50	92.00	98.00	100.11	578.56	24.05	<240
Ammonia (mg)	0.05	0.03	0.02	0.02	0.02	0.02	0.01	0.03	0.03	0.02	0.00	0.01	No Value
Nitrite (mg/l)	0.03	0.02	0.02	0.01	0.01	0.02	0.00	0.01	0.03	0.02	0.00	0.01	<3.0

Parameters	Months									$\bar{x}$	σ^2	σ	WHO
	Diema			Islamic			Ansarul						
	Aug.	Sept.	Oct.	Aug.	Sept.	Oct.	Aug.	Sept.	Oct.				
Nitrate (mg/l)	0.04	0.05	0.05	0.09	0.08	0.09	0.02	0.05	0.06	0.06	0.00	0.02	<50
Phosphate (mg/l)	2.60	2.88	2.89	6.00	6.19	6.24	9.70	9.25	9.61	6.15	8.08	2.84	<20
Cadmium (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.003
Copper (mg/l)	0.24	0.18	0.19	0.08	0.09	0.09	0.22	0.02	0.02	0.13	0.01	0.08	<1.0
Iron (mg/l)	0.04	0.03	0.05	0.02	0.01	0.02	0.03	0.02	0.03	0.03	0.00	0.01	<0.3
Zinc (mg/l)	4.00	3.52	3.50	2.00	2.15	2.17	2.00	2.32	2.34	2.67	0.60	0.78	<5
E. Coli	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 cfu/100ml
Faecal Coliform	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0 cfu/100ml
Non-Faecal Coliform	13.00	11.00	12.00	9.00	8.00	9.00	15.00	10.00	10.00	10.78	4.94	2.22	<10cfu/100ml

3.1. Discussion

From the result in table 1 above, the mean value for the Temperature of the hand dug well at Diema is (29.93°C, Islamic is 29.50°C and Ansarul is 30.20°C. all the values of the temperature are above the World Health Organization (WHO) permissible limits and the standard deviation for Diema hand dug well is 1.68, Islamic is 1.71 and Ansarul is 1.99, from the statical point of view the deviation is very minimal. Furthermore, the statistical mean value for the three-hand dug well at different locations is also above the WHO permissible value (Table 4) and deviation is also negligible (Table 4). WHO does not have a specific temperature requirement for safe water, but suggests that it should be 25°C and have a pH of 7. Drinking water temperature can be affected by environmental factors such as soil type, water depth, and other anthropogenic causes. Temperature has a significant impact on the absorption of chemicals and the growth of microbiological organisms when examining the quality of water. And also, directly influences the availability of the amount of dissolved oxygen in water, The optical health of aquatic organisms from microbes to fish depends on temperature [14]. Pankow, J. F. reported that the temperature of the water also affects the following: the volume of dissolved oxygen it can hold (water's ability to contain dissolved oxygen decreases as the water temperature rises), the rate of photosynthesis by aquatic plants, metabolic rates of aquatic organisms and the sensitivity of organisms to pollution [14].

The pH values were also analyzed for the hand-dug wells, the statistical mean values are as followed; Diema is 7.03, Islamic is 7.17 and Ansarul is 7.23 and all the values are within the World Health Organization permissible limit (6.5-8.5). Moreover, the values of the standard deviation of all the hand dug wells (Diema 0.06, Islamic 0.32, and Ansarul 0.06) are very negligible and the statistical mean value of all the three-hand dug well also falls within the WHO permissible limit (6.5-8.5) as well as the standard deviation value which is also minimal (Table 4).

The following physiochemical parameters statistical mean values for Diema hand dug well falls within the World Health Organization (WHO) (Table 1); (Turbidity 3.31NTU, Conductivity 167.00, TDS 84.83mg/l/ppm, Nitrite 0.02mg/l, Nitrate 0.5mg/l, Ammonia 0.03mg, Phosphate 2.79mg/l, Cadmium 0.00 mg/l, Copper 0.20mg/l Iron 0.04mg/l and Zinc 3.67mg/l), also for Islamic hand dug well the following physiochemical fall within the WHO permissible limit (Table 2) (Turbidity 0.96NTU, Conductivity 192.67, TDS 99.67mg/l/ppm, Ammonia 0.02mg, Nitrite 0.01mg/l, Nitrate 0.06mg/l, Phosphate 6.14mg/l, Cadmium 0.00mg/l, Copper 0.09mg/l, Iron 0.02mg/l and Zinc 2.11mg/l and Ansarul hand dug well (Table 3); (Turbidity 2.79NTU, Conductivity 230.00, TDS 115.83mg/l/ppm, Ammonia 0.02mg/l, Nitrite 0.01mg/l, Nitrate 0.04mg/l, Phosphate 9.52mg/l, Cadmium 0.00mg/l, Copper 0.09mg/l, Iron 0.03mg/l and Zinc 2.22mg/l.).

Moreover, the deviation for the following physiochemical parameters are very negligible (Turbidity, Conductivity, TDS, Ammonia, Nitrite, Nitrate, Phosphate, Cadmium, Copper, Iron and Zinc) are they all fall within the World Health Organization (WHO) permissible limits (Tables 1, 2 and 3).

Furthermore, the combined statistical mean value for Diema, Islamic, and Ansarul hand dug well for the following physiochemical parameters (pH 7.14, Turbidity 2.46NTU, Conductivity 196.56, TDS 100.11mg, Ammonia 0.02mg/l, Nitrite 0.02mg/l, Nitrate 0.06mg/l, Phosphate 6.15mg/l, Cadmium 0.00gm/l, Copper 0.02mg/l, Iron 0.03mg/l and Zinc 2.67mg/l) are all within the World Health Organization permissible limits (Table 4). Notwithstanding, the statistical mean value of the temperature is above the WHO permissible limit (29.88°C) with a minimal deviation value of (1.58) which is due to some environmental factors such as the temperature of drinking water which can be affected by the kind of soil, the depth of the water, and other anthropogenic factors. (Table 4).

3.2. Bacteriological Parameters

3.2.1. E. Coli and Faecal Coliform

There is no E. coli and Faecal Coliform presence from Tables 1 to 4 for all three hand dug wells, the statistical mean value for the hand dug wells are as follows; Diema Hand dug well (E. Coli 0.00cfu/100ml and Faecal Coliform 0.00cfu/100ml) Islamic Hand Dug Well (E. Coli 0.00cfu/100ml and Faecal Coliform 0.00cfu/100ml) and Ansarul Hand Dug Well (E. Coli 0.00cfu/100ml and Faecal Coliform 0.00cfu/100ml). Moreover, the standard deviation is also 0.00cfu/100ml for both E. Coli and Faecal Coliform in all the hand dug wells. This is evident that all the values are within the specification limits of World Health Organization (WHO) standards for both E. Coli and Faecal Coliform.

3.2.2. Non-Faecal Coliform

Tables 1, 3, and 4 show high statistical mean values for the

Non-Faecal Coliform bacteria in the hand dug wells. Diema Hand Dug Well (12.00 cfu/100ml), Ansarul Hand Dug Well (11.67 cfu/100ml) and the combined statistical mean value (10.78cfu/100ml) and all the values fell out of World Health Organization (WHO) permissible limit. Notwithstanding, Islamic Hand Dug Well has a statistical mean value of 8.67 cfu/100ml of Non-Faecal Coliform Value which is within the WHO permissible limit (<10cfu/100ml). The high levels of non-faecal coliform in the water samples may be related to environmental factors such as the composition of the soil, the decomposition of organic materials, and septic tank leaks. Non-faecal coliforms were discovered in all of the wells and boreholes examined and analyzed in a similar investigation to identify the bacteriological pollution of groundwater sources [7, 15] Total coliform bacteria have historically been used to indicate the presence of faecal contamination, although this parameter has been shown to exist and thrive in soil and water habitats and is therefore regarded as a poor indicator for evaluating the presence of pathogens [18]. Total coliform bacteria are not appropriate measures of the sanitary quality of rural water supplies, especially in tropical regions where nearly all untreated supplies include a high concentration of bacteria of no sanitary relevance [21].

The thermotolerant coliform E. coli is an exception. It is the most prevalent of the entire coliform group found in animal or human faeces, rarely grows in the environment, and is thought to be the most accurate predictor of faecal contamination in drinking water [25]. Strong evidence of recent faecal contamination is provided by the presence of E. coli [25, 18].

When fecal coliform and E. coli bacteria are found in water, they may be contaminated with faeces from people or animals. Diarrhoea, cramps, nausea, headaches, and other symptoms can be brought on by disease-causing bacteria (pathogens) in these wastes. The health of babies, young children, and those with extremely weakened immune systems may be particularly in danger from these viruses [11]. Study in Nigeria found that certain bacteria isolated from drinking water were even resistant to eight popular antibiotics, which provides a hint as to the potential public health problems associated with bacterial contamination of drinking water. It is possible to tell whether drinking water has been exposed to a source of faecal contamination and may therefore include harmful organisms by looking for the indicator organism E. coli. According to the WHO's drinking water recommendations, there should be no detectable E. coli in every 100 milliliters of water that is intended for consumption [22].

4. Conclusion

The combined statistical mean values for Diema, Islamic, and Ansarul hand dug wells for the following physiochemical parameters (pH 7.14, Turbidity 2.46NTU, Conductivity 196.56, TDS 100.11mg, Ammonia 0.02mg/l, Nitrite 0.02mg/l, Nitrate 0.06mg/l, Phosphate 6.15mg/l, Cadmium 0.00gm/l, Copper 0.02mg/l, Iron 0.03mg/l and Zinc 2.67mg/l) are all within the World Health Organization permissible limits (Table 4), except for Temperature (°C), the statistical mean value is above the WHO permissible limit (29.88°C) with a minimal deviation value of (1.58) and Non-Faecal Coliform (cfu/100ml) (Table 4) whose statistical mean values in the hand dug wells: Diema Hand Dug Well (12.00 cfu/100ml), Ansarul Hand Dug Well (11.67 cfu/100ml) and the combined statistical mean value (10.78cfu/100ml) fell out of World Health Organization (WHO) permissible limit. Islamic Hand Dug Well has a statistical mean value of 8.67 cfu/100ml of Non-Faecal Coliform Value which is within the WHO permissible limit (<10cfu/100ml). Although, WHO does not have a specific temperature requirement for safe water, but suggests that it should be 25°C and have a pH of 7. Drinking water temperature can be affected by environmental factors such as soil type, water depth, and other anthropogenic causes. Additionally, the presence of coliform bacteria has been used to suggest faecal contamination; however, this metric has been proven to exist and develop in soil and water settings and is therefore regarded as a poor indicator for evaluating the presence of pathogens [18]. The authors, therefore, conclude that all the water samples collected and examined are safe and fit for drinking purposes since they are within the WHO permissible limit and also recommend that there should be regular monitoring and treatment (for instance; chlorinating) of the hand dug wells and other researchers to undertake further studies in different seasons and consider other water quality parameters.

Conflict of Interest

There is no conflict of interest regarding the publication of the paper, declared the author.

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