

Assessment of Physico-Chemical and Microbial Analyses of Hand Dug Wells in Makeni Town, Sierra Leone

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Abstract

This research assessed the physicochemical and microbial quality of water from four wells in Makeni town Sierra Leone, focusing on parameters such as temperature, pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), and various chemical contaminants

The various water samples were analysed for residual chlorine, ammonia, fluoride, nitrate, sulphite, lead, arsenic, chromium, and bicarbonate levels from January to August 2024. The bacteria contamination was investigated to determine the safety of the water for the consumption of human. The temperatures across the four wells ranged 27.3°C to 30.0°C, with an average values ranging from 27.94°C to 29.15°C. pH values were within the WHO recommended guidelines range of 6.5 to 8.5 for all the wells selected. The turbidity was consistently zero, indicating clear water. EC values were below the WHO limits, range from 24 µS/cm to 148 µS/cm. The TDS values were also below the threshold of 1000 mg/L, with highest values recorded in well in well four. Chemical analyses revealed that no detectable residual chlorine in any of the wells, indicating potential disinfection issues. Ammonia values were below the WHO threshold of 1.5 mg/L. The fluoride levels exceeded WHO limits in well three and well four. The nitrate concentrations were below the WHO limits of 50 mg/L. Sulphite, lead, arsenic levels were all within safe limits, but the chromium concentrations in well one and well four were slightly above the WHO limit for portable water. The microbial testing indicated contamination in all the wells, with the most important issues observed in well three and well four, highlighting concerns for E. coli presence. This suggests that while the chemical parameters are generally within the acceptable ranges, microbial contamination poses a risk to water safety, especially during the rainy season.

Keywords: Physico-chemical, microbial, assessment, wells, microbial testing, TDS

INTRODUCTION

Groundwater is a vital source of fresh water globally, serving a range of needs from domestic use to agriculture and industry. About one-third of the world's population relies on groundwater for drinking purpose (International Association of Hydrogeologists, 2020) [8]. This resource is especially crucial in arid and semi-arid areas where surface water and rainfall are scarce (Li et al., 2017a) [9]. Ensuring a reliable and clean groundwater supply is fundamental to a nation's sustainable development. Nonetheless, groundwater quality faces significant challenges from urbanization, agricultural activities, industrial operations, and climate change. Contaminants including toxic metals, hydrocarbons, trace organic substances, pesticides, nanoparticles, microplastics, and other emerging pollutants pose risks to human health, ecological systems, and long-term

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socioeconomic stability (Li, 2020; Li & Wu, 2019) [10].

Natural factors (e.g., topography, aquifer properties, and meteorological conditions) can affect the groundwater quality through recharge and discharge processes, mineral dissolution, flow paths, and residence time (Van Der Ploeg et al., 2012) [17]. Whereas, anthropogenic factors (e.g., increased population density, industrial activities, and land use) can result in point and non-point pollution, affecting the groundwater quality (Egbi et al., 2021) [3]. Indeed, extensive and intensive human activities can also influence the land-use area, thus affecting indirectly the water environment (Liu et al., 2013; Xu et al. 2022) [11, 21]. Therefore, understanding the impacts of natural and anthropogenic factors on groundwater quality is of great importance in identifying potential groundwater pollution sources (Ceballos et al., 2021) [1].

Groundwater microbial communities play crucial roles in various environmental processes, including nutrient cycling, contaminant degradation, and ecosystem function. Groundwater harbors diverse microbial communities influenced by factors such as hydrogeology, geochemistry, and anthropogenic activities. Studies employing high-throughput sequencing techniques have revealed the presence of diverse bacterial taxa, including Proteobacteria, Actinobacteria, Firmicutes, and Bacteroidetes, with their relative abundances varying across different aquifer systems (Feng et al., 2020; Wu et al., 2021). [20]. They play key roles in processes such as carbon, nitrogen, sulfur, and iron cycling, which are crucial for groundwater quality and ecosystem functioning (Griebler & Lueders, 2009). [2] Groundwater can also harbor pathogenic bacteria, posing risks to human health if ingested or inhaled. However, groundwater can also contain pathogenic bacteria that pose health risks if consumed or inhaled. Pathogens such as *Escherichia coli*, *Salmonella* spp., and *Campylobacter* spp. can infiltrate groundwater sources through fecal contamination from humans or animals (Schoen & Ashbolt, 2010; Islam et al., 2019) [6, 16].

Sierra Leone has vast water resources consisting of both surface and groundwater. Yet, there are serious constraints to meeting the challenge to provide adequate quality water due to its being contaminated by several anthropogenic activities and the negative influence of climate change. In 2012, Sierra Leone experienced a cholera epidemic with 22,815 reported cases and 296 deaths (Nguyen et al., 2014); [14] this is caused by the consumption of contaminated water. In 2017, the impact of climate change caused a devastating landslide and flooding disaster in Sierra Leone and killed more than one thousand people (Lahai & Lahai Jr., 2019) [4, 5].

DESCRIPTION OF THE STUDY AREA

Makeni town is the biggest town in the north part of Sierra Leone. The town serves as the head quarter for Bombali District. This town serves as the center town for business activities for the surrounding neighbor towns. The unique and well-planned settlement is a home to many natives Sierra Leoneans of different religious, political and socio-cultural backgrounds. Geographically, the topography of the land scape consists of hills, valleys, flat lands and swamps. Makeni has a tropical rain season from May to October and dry season from November to April (a period of six months interval each) and an average temperature range of 21° to 30° Celsius throughout the year.

Makeni town has diverse population even though the Temne tribe forms the largest ethnic group. Krio language is used as a general means of communication among the various ethnic groups in the town. The Islamic religion dominates in the town, though with a significant Christianity minority population in the town. Since the town made up of different people of various tribes that have various cultural beliefs and practices with different economic level of different works of life. These people undertake various activities that impact the quality of groundwater. The livelihood of the people in Makeni is mostly based on agriculture, with rice, cassava, and groundnuts being the primary crops. The town is also known for its trading activities, with local markets bustling with vendors selling everything from fresh produce to textiles and crafts. In recent years, there have been an increased in small-scale

industries and businesses, contributing to the town's economic growth Figure 1.

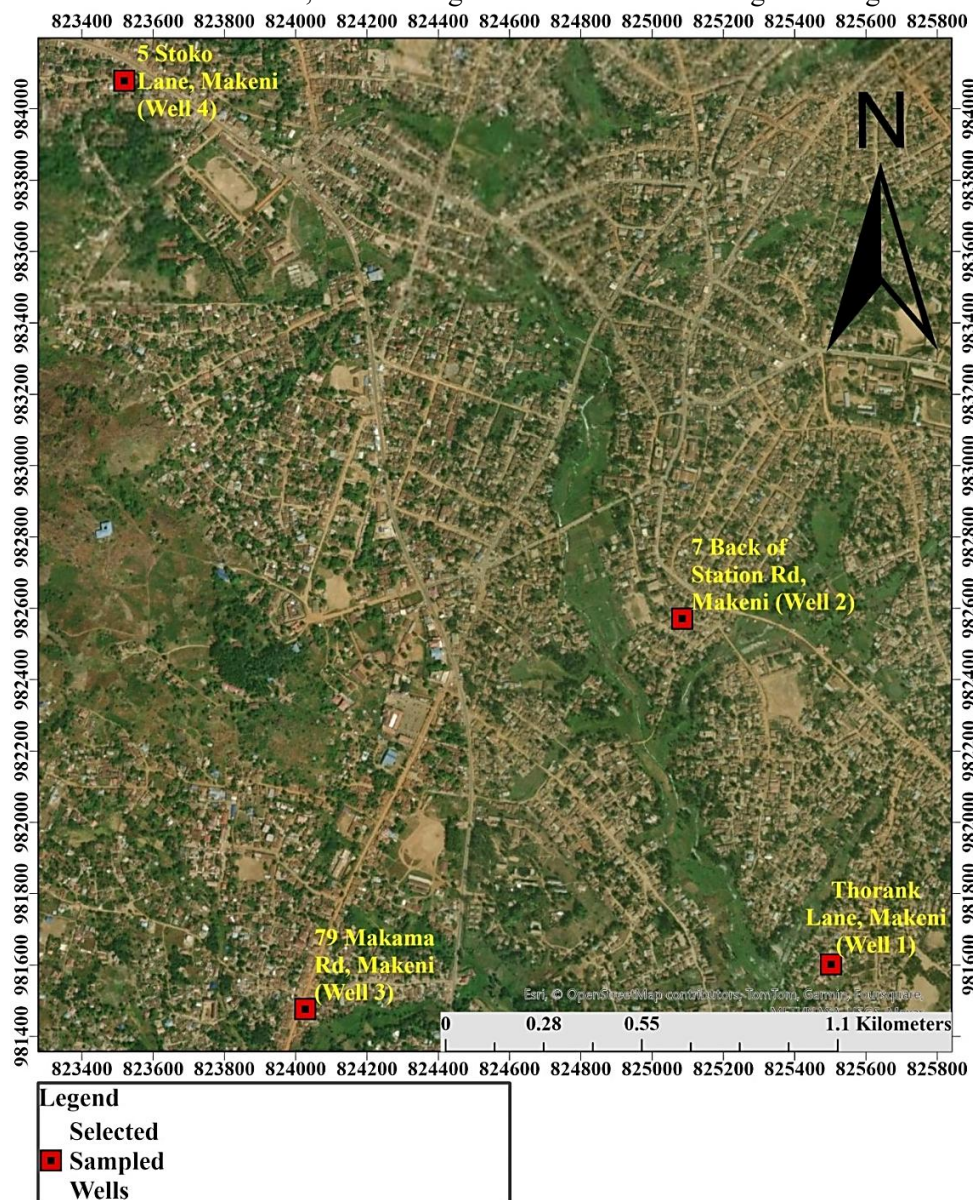


Figure 1. Map of Makeni Town Showing Selected Wells.

MATERIALS AND METHODS

Sampling Procedure

Water samples from four selected hand dug wells in Makeni town were collected for the months of January to August 2024 for each well. Water sample, each of 500 ml volume was collected at each well for physico-chemical analyses and for microbial analyses. Each sample was collected in a new factory-fresh plastic bottle after washed with laboratory detergent and rinsed with chromic acid, tap water and distilled water. After collection, the samples were immediately place in ice cooler for transportation to the laboratory where they were transferred to the refrigerator for each month of collection. The analyses were conducted at the National Water Laboratory at the Ministry of Water Resources at Tower Hill in Freetown throughout the sampling periods.

RESEARCH INSTRUMENT

The research used pH meter, conductivity meter (EC), total dissolved solids (TDS) meter, turbidity meter for physical parameters; Lovibond (MD), nitrate kits, vials, reagents for chemical analyses;

filtration unit, absorbent pads, filter papers, media, surgical spirit, petty dishes for microbial analyses.

METHOD FOR PHYSICO-CHEMICAL ANALYSES

This was done using portable instruments. The SD 70-CON portable conductivity meter (EC) (SD 70-CON) and pH meters were used to test for water conductivity, TDS, pH, and temperature.. These instruments had been calibrated prior to taking measurements. The probes of these instruments were dipped into the water samples according to the instruments manuals and measurement taken. These readings were also saved in the instrument memory. Turbidity testing was done by using the turbidity meter. For the chemical analyses the photometric method was applied throughout the analyses periods with a machine called Lovibond (MD-610). Various chemical water quality parameters namely: Chlorine, Ammonia, Nitrate, Sulfite, Chromium, Fluoride, Led, Arsenic and Bicarbonate were tested. Nitrate was determined by colorimetric procedure using nitrate kit.

METHOD OF MICROBIOLOGICAL ANALYSES

Membrane Filtration Method was used in analyzing the bacteriological. The water samples were filtered through the filtration unit by measuring one volume of water sample (100 ml) for each sample and filtered through a membrane filter paper pore size 0.45 μm after sterilizing the filtration unit. The absorbent pads were place in the petty dishes and the laurel broth media was poured on the absorbent pads for each petty dish. The filtered papers were then place on the absorbent pads in each of the petty dish that trapped bacteria. The petty dishes were labeled and place into the incubator with 36°C for 48 hours for the bacteria to grow. Readings were taken from petty dishes that represent each water sample, blue or grey dots or colonies indicates the presence of Escherichia Coli Bacteria, yellow or Brown dots or colonies indicates the presence of fecal Coliform and red dot or colonies indicates the presence of non-fecal Coliform. The colonies are counted methodically and results expressed per 100 ml water sample Figure 2.



Figure 2. Bacteriological Analyses.

RESULTS AND DISCUSSIONS

All the Tables, Figures, were used to portray the physicochemical and bacteriological components of the water samples obtained in this section. Different methods were used to determine the various parameters in the water and the results are compared to the World Health Organization's (WHO) recommendations for drinkable water. This is significant because all these wells selected serves as the only drinking water source for communities around them.

PHYSICAL PARAMETERS

Temperature, pH, turbidity, electrical conductivity, total dissolved solids (TDS), are among the

physical factors studied.

Temperature

The temperature of the four wells collected range 27.3–30.0°C, 27.3–30.0°C, 27.9–29.8°C, 28.4–29.7 for well one, well two, well three and well four respectively. The average values for the water temperature at the four wells collected are $27.94 \pm 0.98^\circ\text{C}$, $29.06 \pm 1.06^\circ\text{C}$, $29.15 \pm 1.9^\circ\text{C}$, and $29.15 \pm 0.62^\circ\text{C}$ corresponding to well one, well two, well three and well four respectively. This parameter if high may affect the groundwater chemistry, which dissolves minerals amongst other reactions. Therefore, it so significant for this parameter to be considers when doing analyses. This value is lower in the study conducted by Massally et al. (2017), [12] but higher than the one reported by Kallon & Margal (2019) despite both studies were carried at the same location [7].

Water pH

Water with a pH of less than 7 that is from 6.4 and below is considered acid and lower numbers on the pH scale indicate that the water is becoming progressively acidic. While pH greater than 7 that is from 8.6 and above is considered as alkaline and higher numbers on the pH scale indicate that the water is becoming progressively alkaline. The wells selected have means of (6.73 ± 0.09) , (7.18 ± 0.33) , (6.9 ± 0.33) , and (6.75 ± 0.09) for well one, well two, well three, and well four respectively. From Figure 3, the pH values are within the acceptable WHO limits for all the four well samples.

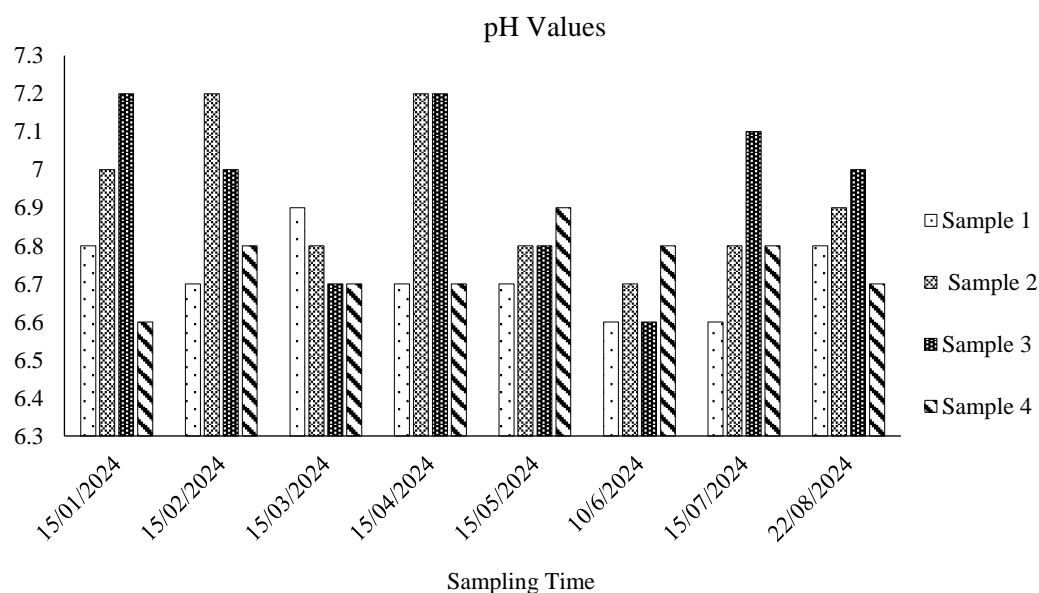


Figure 3. pH values.

Turbidity

According to WHO guidelines, water should be colorless. All the four wells their turbidity Values are zeros for all the sampling periods which are below the WHO standards (5.00 NTU).

Electrical Conductivity (EC) and Total Dissolved Solids (TDS)

The EC values for all water samples of the four wells are below the WHO standard $450 \mu\text{S}/\text{cm}$. It ranges from $48 \mu\text{S}/\text{cm}$ – $66 \mu\text{S}/\text{cm}$ with an average of 55.63 ± 4.87 for sample one (well one), $24 \mu\text{S}/\text{cm}$ – $58 \mu\text{S}/\text{cm}$ with a mean of 46.25 ± 4.87 , $30 \mu\text{S}/\text{cm}$ – $78 \mu\text{S}/\text{cm}$ with averages of $60.37 \mu\text{S}/\text{cm} \pm 18.28$ and $84 \mu\text{S}/\text{cm}$ – $148 \mu\text{S}/\text{cm}$ with an average of $120.63 \mu\text{S}/\text{cm} \pm 23.97$ for sample two, sample three and sample four respectively.

There is a high degree of correlation between EC and TDS as both signify the amount of dissolved solid. (<https://www.water-research.net/index.php/water-treatment/tools/total-dissolved-solids>). Potable water with a total dissolved solids content of less than $1000 \text{ mg}/\text{l}$ is generally considered safe. The TDS

values are (25–33) mg/L with an average of 24.06 ± 3.83 , (12–29) mg/l with an average of 23.12 ± 5.48 , (15–45) mg/L with an average of 31.44 ± 10.96 and (43–75) mg/L with an average of 60.31 ± 13.06 for sample one, sample two, sample three and sample four respectively. From Figure 4 (a)(b) below, T.D.S is highest in well one, follow by well three, well one and well two.

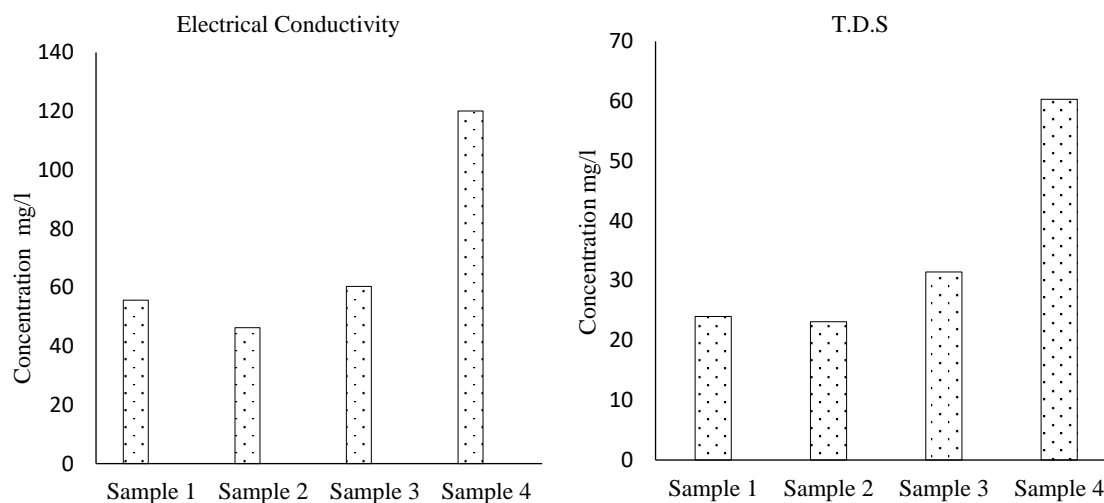


Figure 4. (a) Electrical Conductivity, (b) Total Dissolved Solids.

CHEMICAL PARAMETERS

The chemical parameters include residual chlorine (Cl^-), Ammonia (NH_3), fluoride (F), Nitrate (NO_3), sulfite (SO_3^{2-}), lead (Pb), arsenic (As), chromium (Cr), and bicarbonate (HCO_3).

Residual Chlorine

According to the WHO guidelines residual chlorine levels in drinking water should be between 0.2 to 0.5 mg/L (milligrams per liter) at the point of delivery. The residual chlorine values for all the four wells are zeros throughout the sampling and testing periods. This indicates that there is high tendency for bacteria to present in all the selected wells.

Ammonia

Ammonia is a compound made up of one nitrogen atom and three hydrogen atoms, represented by the formula NH_3 . It is a colorless gas with a characteristic pungent odor. Ammonia is often used in combination with chlorine to form chloramines. This is particularly useful for maintaining a disinfectant residual in the water distribution system over longer distances and time periods (World Health Organization, (2017)). Ammonia can act as a nutrient for nitrifying bacteria, leading to nitrification in the water distribution system. This process can deplete chloramine residuals, reducing the effectiveness of disinfection and potentially resulting in microbial contamination. (Regan, J. M., et al. (2003)) [15]. Ammonia is regarded as an important water quality indicator. It shows the potential for bacterial, sewage, and animal excrement contamination (WHO, 2003). The WHO does not set a health-based guideline value for ammonia in drinking water because it is generally not considered a health concern at levels typically found in drinking water. However, ammonia is monitored for its effects on the aesthetic quality of water and because it can indicate contamination from sewage or agricultural runoff. Ammonia can cause taste and odor issues in drinking water at concentrations above 1.5 mg/L. Therefore, while not a health-based limit, this value is often used as a practical threshold for ensuring water quality.

The values obtained from the analyses ranges 0.04 mg/l–0.08 mg/L with an average of 0.04 ± 0.02 for sample one, 0.02 mg/l–0.05 mg/L with an average of 0.04 ± 0.01 for sample two, 0.02 mg/L–0.06 mg/L with an average of 0.04 ± 0.02 for sample three, and 0.04 mg/L–0.06 mg/L with an average of

0.04 ± 0.009 for sample four. All the values obtained are below the threshold of 1.5 mg/L Figure 5

Fluoride

Fluoride in drinking water occurs naturally and can be emitted from phosphate-containing rocks that contain 4% fluorine (WHO 2004). Dental fluorosis is caused by elevated levels of fluoride in drinking water (up to 10 mg/l). The values range 1.0–1.5 mg/l, 1.4–1.9, 2.0–2.9 mg/l, 0.78–2.1 mg/l for sample one, sample two, sample three and sample four respectively. The estimated fluoride means values for the four wells collected in the study area are 1.2 mg/l ± 0.22, 1.75 mg/l ± 0.18, 2.15 mg/l ± 0.3 and 1.41 mg/l ± 0.42 respectively. These values are above the WHO acceptable limit of 1.50 mg/l, except for well one and well four, which recorded 1.2 mg/l and 1.4 mg/l respectively as shown in Figure 6.

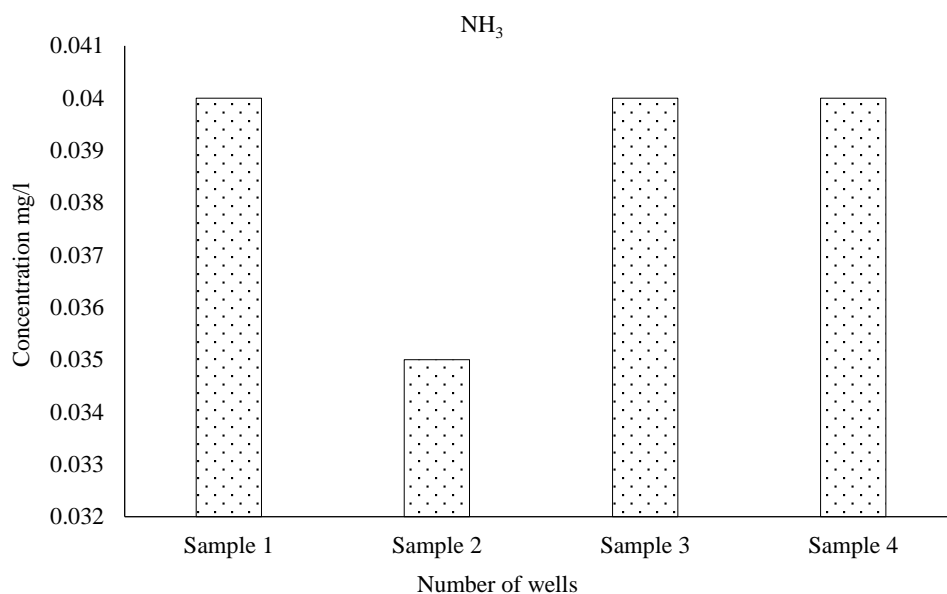


Figure 5. Average ammonia measurement for the four wells.

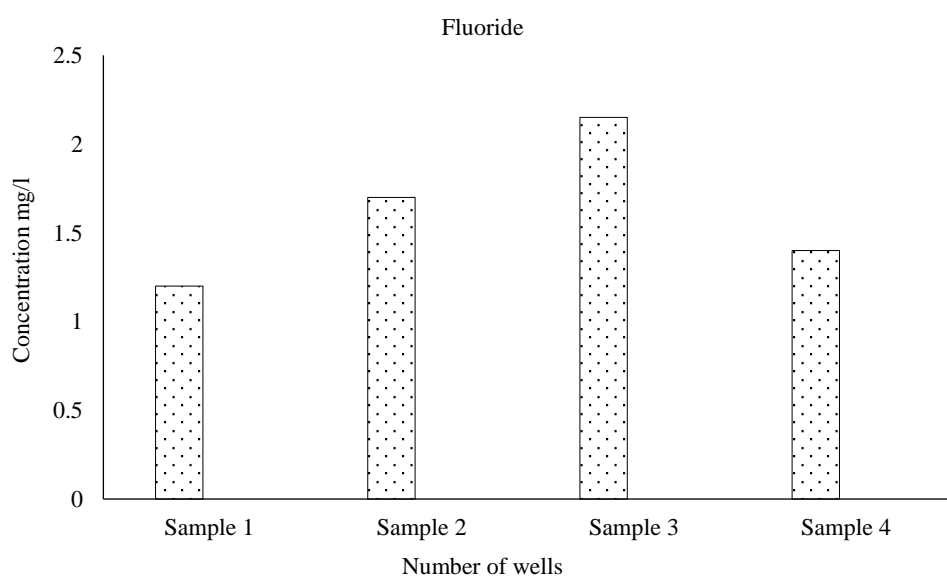


Figure 6. Average concentration of fluoride.

Nitrate

Nitrate has a low toxicity except at massive doses and is generally of no concern with respect to human health. Nitrogen cycle, industrial waste, nitrogenous fertilizers, and other sources are among them. The highest permitted limit of nitrate in drinking water, according to the WHO, is 50 mg/l (Meride

and Ayenew, 2016) [13]. According to the Food and Agriculture Organization (FAO), nitrate concentrations in irrigation water should generally be below 50 mg/L to avoid negative effects on most crops. Farmers used these wells also for irrigation at their backyards and swamps during dry season.

Analysis of water samples from the four wells ranges (4–8 mg/L) for well one (sample one), (4–8 mg/L) for well two (sample two), (4–9 mg/L) for well three (sample three), and (10–15 mg/L) for well four (sample four). The mean values were estimated at 5.87 ± 1.05 mg/L, 5.75 ± 1.85 , 6.12 ± 1.65 and 11.62 ± 1.65 for the four wells mentioned respectively. From Figure 7, sample four has the highest nitrate value which is 11.62 mg/L, follow by sample three 6.12 mg/L, sample one 5.87 mg/L and sample two 5.75 mg/L. All these values are below the WHO standard for nitrate Figure 7.

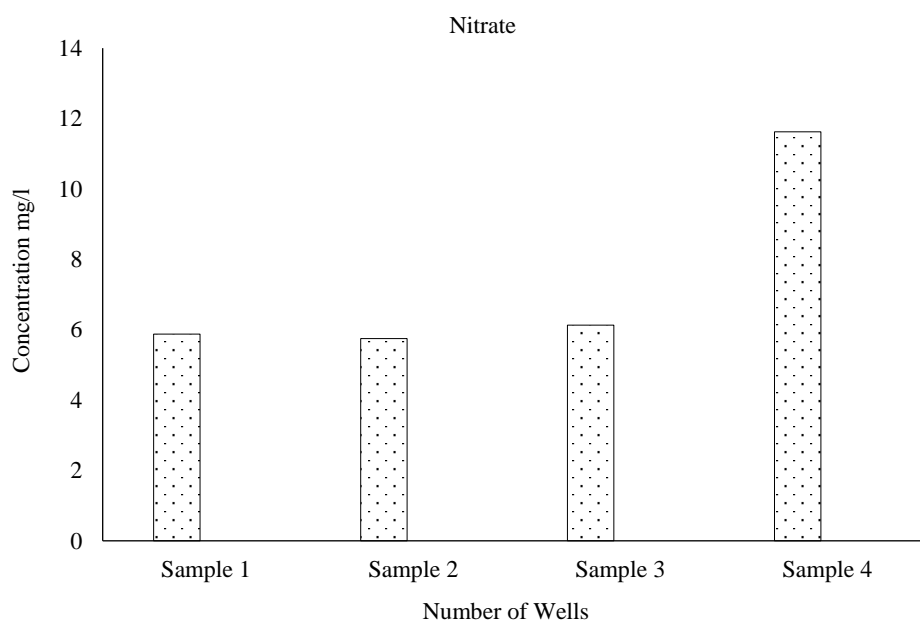


Figure 7. Mean concentration of nitrate.

Sulfite

Sulfites can affect the taste and odor of drinking water, making it unpalatable. Sulfites can contribute to the corrosion of pipes and water infrastructure, leading to increased maintenance costs and potential contamination from corroded materials. There is no specific guideline or limit value for sulfite in portable water. This is because sulfite is not commonly found in drinking water at levels that would pose a health risk. Instead, sulfite levels are typically managed through regulations on industrial discharges and water treatment processes to ensure that concentrations remain low. The values obtained from the analyses ranged from (0.02–0.03 mg/l) for well one, (0.02 mg/l) for well two, (0.01–0.04 mg/l) for well three (sample three), and (0.03–0.06 mg/l) for well four (sample four). The mean values were estimated at 0.02 ± 0.003 mg/l, 0.02 ± 0 , 0.02 ± 0.01 and 0.04 ± 0.008 for the four wells respectively Figure 8.

Lead

Lead in water is a critical public health issue. Ensuring safe drinking water involves stringent regulations, proactive testing, and remediation measures to protect populations from the harmful effects of lead exposure. Lead can leach into water from lead pipes, faucets, and fixtures, especially in older homes and buildings where lead-containing materials were commonly used (United States Environmental Protection Agency (EPA), 2022). Lead can also be found in natural deposits in the environment, leading to groundwater contamination (World Health Organization (WHO), 2019). *World Health Organization (WHO) (2017)* guideline for lead in drinking water is 10 micrograms per liter (10 µg/L), or 0.01 milligrams per liter (0.01 mg/L) [18, 19]. The values obtained for lead for all the wells

selected in the study area during the monitoring periods are zeros.

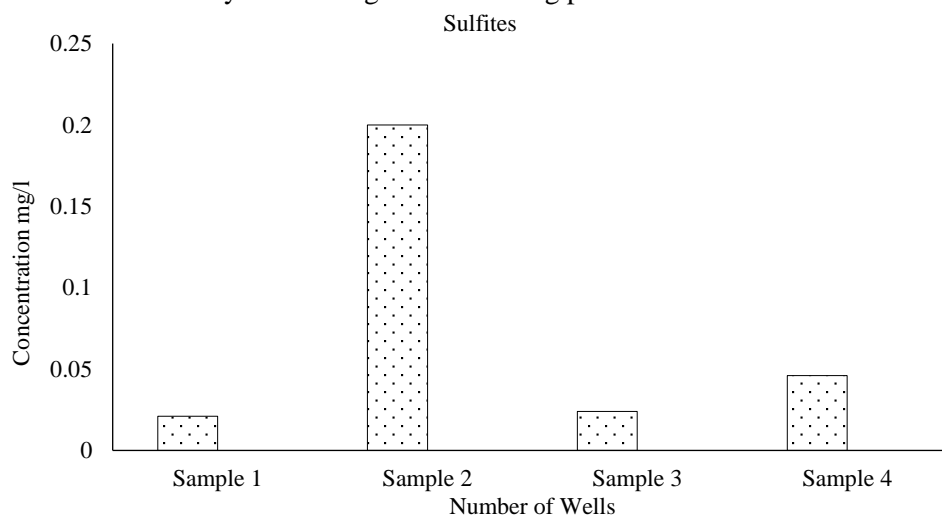


Figure 8. Mean concentration of sulfites.

Arsenic

Arsenic (atomic number 33; relative atomic mass 74.91) is a metalloid widely distributed in the earth's crust. The World Health Organization (WHO) has set a guideline limit for arsenic in drinking water is 10 micrograms per liter (10 $\mu\text{g/L}$), also expressed as 0.01 milligrams per liter (0.01 mg/l). This guideline is based on the toxicological and epidemiological evidence that long-term exposure to arsenic in drinking water can lead to adverse health effects, including skin lesions, cancer, cardiovascular disease, and diabetes (World Health Organization (2017)). All the values obtained for the four wells within the periods of monitoring are zeros.

Chromium

From the analysis of water samples, the chromium values range from 0.21–0.28 mg/l for well one, 0.00–0.09 mg/l for well two, 0.02–0.04 for well three, and 0.20–0.30 for well four. In terms of the mean concentration, the well one, well two, well three and well four record 0.23 ± 0.02 mg/l, 0.04 ± 0.02 mg/l, 0.03 ± 0.09 mg/l, and 0.25 ± 0.03 mg/l respectively. The chromium concentration recorded for well one (0.23 mg/l) and four (0.25 mg/l) exceeds the WHO limit requirement for drinking water (0.05 mg/l) Figure 9.

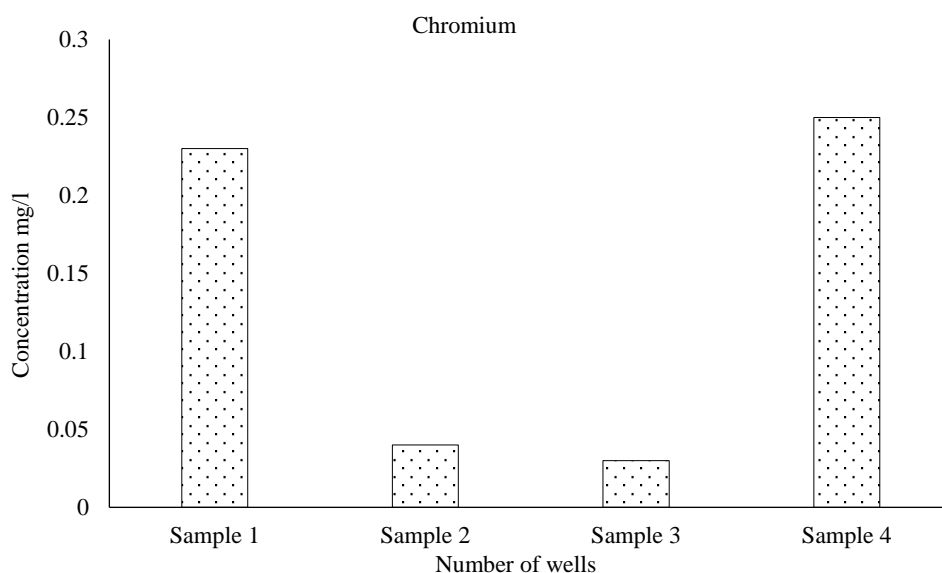


Figure 9. Mean concentration of chromium.**Bicarbonate**

Bicarbonate (HCO_3^-) is an anion that plays a crucial role in the buffering systems of natural waters and biological fluids. It forms when carbon dioxide (CO_2) dissolves in water, resulting in carbonic acid (H_2CO_3), which then dissociates into bicarbonate and hydrogen ions (H^+). Regarding drinking water, the World Health Organization (WHO) does not specify a health-based guideline limit for bicarbonate concentrations. Bicarbonate contributes to the alkalinity and pH balance of water, which can influence taste and corrosivity but generally does not pose a direct health risk. (World Health Organization (2017)). The results obtained from the periods of analyses range (2.5 mg/l–3.4 mg/l) with a mean of 3.1 ± 0.3 for well one, (2.6 mg/l–5.4 mg/l) with a mean of 3.84 ± 0.95 for well two, (2.6 mg/l–5.5 mg/l) with a mean of 4.16 ± 1.05 for well three and (2.7 mg/l–4.3 mg/l) with a mean of 3.55 ± 0.51 .

All other parameters were measured in mg/l except Temperature, pH, Turbidity, Electrical Conductivity and Total Dissolved Solids that measures in °C, pH Units, NTU, $\mu\text{S}/\text{cm}$, and ppm respectively Table 1.

Table 1. Summary statistics of the physicochemical parameters for sample one (well one).

Parameters	Min	Max	Mean	Std. Deviation (\pm)
Temperature	27.3	30.0	27.94	0.98
pH	6.6	6.9	6.7	0.09
Turbidity	0.00	0.00	0.00	0.00
Conductivity	48	66	55.63	4.87
Total Suspended Solids	25	33	24.06	3.83
Residual Chlorine	0.00	0.00	0.00	0.00
Ammonia	0.04	0.08	0.04	0.02
Nitrate	4.00	8.00	5.87	1.05
Sulfite	0.02	0.03	0.02	0.003
Fluoride	1.00	1.5	1.2	0.22
Lead	0.00	0.00	0.00	0.00
Arsenic	0.00	0.00	0.00	0.00
Chromium	0.21	0.28	0.23	0.04
Bicarbonate	2.5	3.4	3.1	0.3

All other parameters were measured in mg/l except Temperature, pH, Turbidity, Electrical Conductivity and Total Dissolved Solids that measures in °C, pH Units, NTU, $\mu\text{S}/\text{cm}$, and ppm respectively. Table 2

Table 2. Summary statistics of the physicochemical parameters for sample three (well two).

Parameters	Min	Max	Mean	Std. Deviation (\pm)
Temperature	27.3	30.0	29.06	1.06
pH	6.7	7.2	6.98	0.33
Turbidity	0.00	0.00	0.00	0.00
Conductivity	24	58	46.25	4.87
Total Suspended Solids	12	29	23.12	5.48
Residual Chlorine	0.00	0.00	0.00	0.00
Ammonia	0.02	0.05	0.04	0.01
Nitrate	4.00	8.00	5.75	1.85
Sulfite	0.02	0.02	0.02	0.00
Fluoride	1.4	1.90	1.75	0.18
Lead	0.00	0.00	0.00	0.00
Arsenic	0.00	0.00	0.00	0.00
Chromium	0.02	0.09	0.04	0.02

Bicarbonate	2.6	5.4	3.84	0.95
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All other parameters were measured in mg/l except Temperature, pH, Turbidity, Electrical Conductivity and Total Dissolved Solids that measures in °C, pH Units, NTU, µS/cm, and ppm respectively Table 3.

Table 3. Summary statistics of the physicochemical parameters for sample two (well three).

Parameters	Min	Max	Mean	Std. Deviation (±)
Temperature	27.9	29.8	29.15	1.90
pH	6.6	7.2	6.9	0.33
Turbidity	0.00	0.00	0.00	0.00
Conductivity	30	78	60.37	18.28
Total Suspended Solids	15	45	31.44	10.96
Residual Chlorine	0.00	0.00	0.00	0.00
Ammonia	0.02	0.06	0.04	0.02
Nitrate	4.00	9.00	6.12	1.65
Sulfite	0.01	0.04	0.02	0.01
Fluoride	2.00	2.90	2.15	0.30
Lead	0.00	0.00	0.00	0.00
Arsenic	0.00	0.00	0.00	0.00
Chromium	0.02	0.04	0.03	0.09
Bicarbonate	2.6	5.5	4.16	1.05

All other parameters were measured in mg/l except Temperature, pH, Turbidity, Electrical Conductivity and Total Dissolved Solids that measures in °C, pH Units, NTU, µS/cm, and ppm respectively Table 4.

Table 4. Summary statistics of the physicochemical parameters for sample two (well four).

Parameters	Min	Max	Mean	Std. Deviation (±)
Temperature	28.4	29.7	29.15	0.62
pH	6.6	6.9	6.75	0.09
Turbidity	0.00	0.00	0.00	0.00
Conductivity	84.0	148	120.6	23.97
Total Suspended Solids	43.0	75.0	60.31	13.06
Residual Chlorine	0.00	0.00	0.00	0.00
Ammonia	0.04	0.06	0.04	0.009
Nitrate	10.0	15.0	11.62	1.65
Sulfite	0.03	0.06	0.04	0.008
Fluoride	0.78	2.1	1.41	0.42
Lead	0.00	0.00	0.00	0.00
Arsenic	0.00	0.00	0.00	0.00
Chromium	0.20	0.30	0.25	0.03
Bicarbonate	2.7	4.3	3.55	0.51

MICROBIAL ASSESSMENT FOR PORTABLE USE

Figure 10 shows that all the wells selected for this research are contaminated with bacteria. These wells serve as source of drinking water and other domestic activities for the people that live around the wells selected. The months of May and June show high contaminated of E-coli, fecal coliform and non-fecal coliform. This might be as a result of the beginning of raining season. In Sierra Leone rainy season start May and gradually frequent in June. This shows the level of contamination our environment exposed to because the first two months of rainy season washed the waste materials that have been laid

on the ground during the dry season and deposited the waste elsewhere. Some of the waste materials mixed with human excretal and dead bodies of animals and other items, and these wells did not have proper covers to seal the mouth of the wells that will prevent surface runoff water from infiltrating into the wells. Overall, well three (sample three) and well four (sample four) are particularly concerning due to the presence of *E. coli*. These results suggest that the water may be unsafe for consumption or use without treatment. Well one and well two have lower levels of concern but still show elevated fecal coliforms, indicating that further treatment may be needed. *E. coli* indicates some level of fecal contamination. This is a concern, especially if the sample is from drinking water. Fecal coliform are bacteria found in the intestines of warm-blooded animals, and their presence suggests possible fecal contamination.

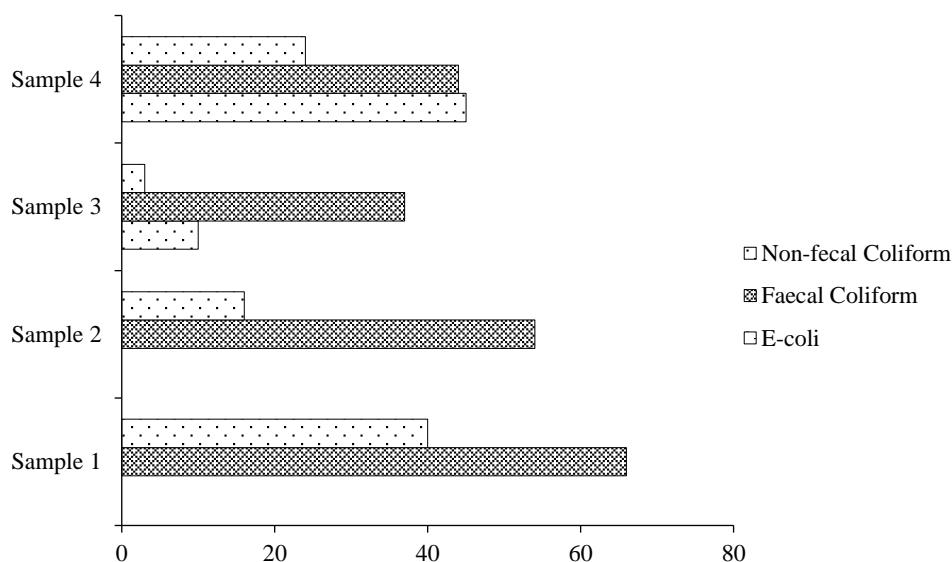


Figure 10. Microbial contaminant within the wells.

CONCLUSIONS

The analysis of the selected four wells reveals that the parameters such as temperature, pH, turbidity, and TDS are within the acceptable WHO limits for drinking water. Fluoride concentrations in well three and well four exceed the WHO recommended guidelines. Chromium levels in well one and well four are also slightly elevated, indicating potential environmental issues. There are notable concerns of bacterial contamination. The absence of residual chlorine across all the wells suggests inadequate disinfection, which combined with the observed bacteria contamination which poses a significant health risk.

To ensure safe drinking water, it is crucial or important to address the microbial contamination and enhance disinfection practices. The results obtained underscore the need for regular monitoring and to improved water treatment infrastructure to minimize health risks associated with both microbial and contaminants.

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