

SUITABILITY OF HAND-DUG WELLS FOR DRINKING WATER AND AGRICULTURE IN BLAMA, EASTERN SIERRA LEONE: A DETAILED ANALYSIS

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Abstract

Access to safe and reliably managed drinking water remains a critical global challenge, impacting the lives of 2.2 billion people worldwide who lack this basic necessity within their homes (WHO/UNICEF, 2019). The World Health Organization (WHO) defines safe drinking water as water possessing microbial, chemical, and physical attributes that align with established guidelines or national standards for drinking water quality (WHO/UNICEF, 2019). To qualify as "safely managed," drinking water must fulfill specific criteria: it should be accessible on the premises, available for a minimum of 12 hours per day, and free from contaminants such as *Escherichia coli*, arsenic, or fluoride, as outlined by WHO standards.

The WHO/UNICEF (2017) report underscores the persistent global disparities in drinking water access. Out of an estimated 5.3 billion people with access to safely-managed drinking water, 1.4 billion relied on basic services, 206 million on limited services, 435 million on unimproved sources, and 144 million depended on untreated surface water. The report highlights the diverse range of water sources and services that communities worldwide rely on for their daily water needs, emphasizing the need for comprehensive strategies to bridge existing gaps in water access and quality.

This abstract encapsulates the global magnitude of the drinking water challenge, underscoring the multifaceted nature of the issue and the varying levels of service that communities receive. It sets the stage for an in-depth exploration into the dynamics of drinking water access, quality, and management, with a focus on meeting the stringent criteria outlined by WHO for "safely managed" drinking water. Through a critical analysis of the WHO/UNICEF data, this study aims to contribute to the discourse on effective strategies for enhancing drinking water accessibility, availability, and safety, ultimately working towards the overarching goal of ensuring safe drinking water for all.

Keywords: Drinking Water Access, Water Quality Standards, Safely Managed Water, Global Water Disparities, WHO Guidelines

INTRODUCTION

Globally, 2.2 billion people lack access to safely managed drinking water at home (WHO/UNICEF, 2019). Safe drinking water is defined as "water with microbial, chemical and physical characteristics that meets WHO guidelines or national standards on drinking water quality (WHO/UNICEF, 2019). According to WHO, for water to be qualified as being —safely managed, drinking water must meet three criteria: be accessible on the premises, be available for at least 12 h/day, and be free from *Escherichia coli*, arsenic, or fluoride contamination. WHO/UNICEF (2017) report stated that an estimated 5.3 billion people had access to safely-managed drinking water, of that number, 1.4 billion used basic services, 206 million used limited services, 435 million used unimproved sources, and the remaining 144 million relied on untreated surface water.

According to world Water Development Report (2019) on the disparities between the rich and the poor, on a global scale, half of the people who drink water from unsafe sources live in Africa. In sub-Saharan Africa, only 24% of the populations have access to safe drinking water, and 28% have basic sanitation facilities that are not shared with other households (UNICEF/WHO, 2017). Access to clean and safe water continue to be a major challenge for citizens of Sierra Leone.

The Water Aid (2017) report stated that more than six out of 10 people in Sierra Leone do not have safe water and eight out of 10 people do not have access to a decent toilet. As a result, over 1,200 children under five die each year from waterborne disease in Sierra Leone. A recent publication by World Bank (2020) stated that access to safe water in Sierra Leone was reported at 1 in 2020, according to collection of development indicators. Access to an improved water source is currently defined as the percentage of the population that can obtain at least 20 L/person/day from an —improved source that is within 1 km of the user's dwelling.

Access to clean and safe water remains an eyesore for rural and urban settlements across Sierra Leone. A lot of people inhabiting in rural communities of Sierra Leone heavily depend on hand-dug well. The preference of groundwater as a source of drinking water in rural areas is because of its relatively better quality than river water (Obiri-Danso et al., 2009).

The country is blessed with six months of wet season and six months of dry season, during wet season (May to October) most people get their drinking and domestic water from the rains which reduced the burden on people in search of water for drinking and domestic purposes. In the dry season (November to April), the availability of potable water sometimes poses a major challenge for most families. The urban settlements such as Bo, Kenema, and Makeni seldomly received potable water from the Sierra Leone Water Company (SALWACO) and Guma Valley Water Company for the capital Freetown.

Water is an essential part of human nutrition and is required for maintenance of personal hygiene, food production and prevention of diseases (Thliza et al., 2015). It is absolutely necessary for most life driven processes (Aroh et al., 2013). Quality water is colorless, tasteless, odourless, as well as free from faecal contamination (Opara and Nnodim, 2014).

Blama is the chieftdom headquarter of Small-Bo, with an estimated population of 8,146, according to Statistics Sierra Leone (SSL, 2021 Population Census of

Cities/Towns). Before the start of the civil war in March, 1991, there were pipe borne water facilities at principal roads of Blama. But as a result of the 10-year civil war, most of the government infrastructures and water channels were destroyed, leaving the wreckages as existential evidence of today's monument. The availability of clean and safe drinking water has become a major issue at Blama. At present, the major sources of available drinking water at Blama are hand-dug well, river water, swamp water, hand pump wells and streams. The dug well is a traditional method of withdrawing groundwater from the upper layer of a water table by constructing a well of large diameter,

typically lined by concrete rings and enclosed by a concrete slab or metal sheet with ventilation (Howard et al., 2006; Bain et al., 2014).

In rural areas of developing countries, the great majority of health-related water quality problems are the result of bacteriological or other biological contamination (WHO, 1997).

A similar report published by Statistics Sierra Leone (Stats SSL, 2017), with the technical support of UNICEF, conducted a Multiple Indicator Cluster Survey (MICS) to collect internationally comparable data on a wide range of indicators. The survey revealed that almost 90% of the drinking water at household level contained the *E. coli* bacteria, presenting a serious health threat to citizens.

The poor and marginalized people living in rural and peri-urban settlements are most in need for improved and safe drinking water, appropriate forms of sanitation and access to water for other domestic purposes (Crow, 2001). Studies carried out in different areas of the world indicate that most of the sources of domestic water have an alarming level of microbiological pollution (Mpakam, 2009; Oladipo et al., 2009; Prasanna and Reddy, 2009; Kuitcha et al., 2010; Khaniki et al., 2010; Oyediji et al., 2010). In 2012, there was a cholera outbreak in Sierra Leone, according to WHO report (2012), there was 18,919 cases reported with 273 deaths. Cholera is a water borne disease that is caused by drinking contaminated water. Report from epidemiology (CDC, 2012) research has shown that cholera is predominant in sub-Saharan Africa where clean water and sanitation remains a major problem.

The objective of this study was to examine, the bacteriological and physicochemical characteristics of five local hand dug wells consumed at Blama, Small-Bo chiefdom, in the Kenema District, eastern province of Sierra Leone, and hence find a suitable remedy to help improve the quality of these residential wells and also ensured that water quality test is conducted on all residential wells before it is being consumed.

MATERIALS AND METHODS

Description of study area

Blama is the chiefdom headquarter town of Small-Bo, in the Kenema District, Eastern Sierra Leone. It lies approximately 12 miles away from Kenema. It is found on Latitude 7° 52' 29" N and Longitude 11° 20' 43" W. Blama is a fairly big town with an estimated population of 8,146 (SSL, 2021 population census of cities). The major activity of the people of this community is farming and animal husbandry. Five hand dug wells drawn from five different locations, were selected for this study. The five hand dug wells were selected for this research base on the availability of water in the well throughout the year. Google map locator was used to map out the sample collection site. The description of the sample collection area is illustrated in Figure 1.



Figure 1. A map showing the area of study.

Description of sampling area

Five local hand dug wells located at Blama, Small-Bo Chiefdom, in the Kenema District were selected for this research at random. The names of the five wells are as follows: 5 Koribondo Road well, 4 Jimmy Section well, 6 Jabbie Street well, 3 Jabbie Street well, and 19 Koribondo Road well. These five hands dug wells were used by the locals of that community for drinking and agricultural activities. The study started in December, 2020, and run through May, 2021, a six months intensive water quality examination. These five hands dug wells were selected for this research based on the availability of water in them throughout the year without drying up.

Sampling

A sterilized cup with a string tied to the cup was used to collect water from the well. The sterilized container was rinsed three times with the water sample to be tested for. The water sample was centrally poured into the sterilized container (500 ml), to avoid water touching the inside mouth surface of the container, in order to avoid contamination. The water sample was then transported to the laboratory (Directorate of water resources, in the Ministry of Water Resources, Bo City) for physicochemical and bacteriological assessment.

Sample collection and analysis

Physical parameters

The analysis for the physical parameters was conducted according to instructional manual (Wagtech International, We30210).

Total dissolve solid and electrical conductivity

In the examination of electrical conductivity ($\mu\text{S}/\text{cm}$) and total dissolved solids (mg/L) of the water sample, a digital conductivity with electrode was employed to determine the concentration of TDS and EC after the electrode was switched on and duplicate values recorded. A clean tissue paper was used to wipe the electrode dry before being reused.

pH

A digital pH meter with electrode was used to measure the pH. It was done by inserting the electrode into the water sample and the electrode turned on, the values were taken in duplicates.

Turbidity

A Photometer, 7100 was used. In the determination of the level of turbidity, a blank solution was prepared to calibrate the photometer. A test tube containing 10 ml of water was placed in the basin and covered with light black cap and power turned on. Duplicate values were recorded. It is measured in nephelometric turbidity unit (NTU).

Temperature

The examination for temperature was done by placing the digital thermometer into the water sample and electrode switched on; duplicated values were recorded in $^{\circ}\text{C}$.

Chemical characteristics determination

WAGTECH PHOTOMETER, 7100, was used to investigate the chemical characteristics. Before the analysis, references were drawn from the operational manual. A blank solution (reference, $0.00 \text{ mg}/\text{L}$) was first prepared to calibrate the photometer. A test tube containing 10 ml water sample was placed one tablet (chemical), it was then crushed and stirred to allow a homogenous mixture and allowed to stand for 10 min for full colouration. It was then inserted in the cell holder and lid closed. The photometer was adjusted to the appropriate wavelength and power turned on, the concentrate of each sample was recorded in mg/L .

Microbial determination***Total coliform count, E. coli, and faecal coliform***

500 ml of each of the five samples collected from the wells was transported to the water quality directorate for the examination of *E. coli*, faecal coliform and non-faecal coliform. WHO permissible standard for the presence of faecal coliform in water is 0 count/100 ml. The membrane filtration method was used to assess the bacteriological parameters, after the culture media had been produced. The water samples were allowed to pass through a membrane pore space of $0.45 \mu\text{m}$, bacteria were trapped on the membrane surface. The membrane was placed in a Petri dish containing —m-Faecal coliform broth (PARK Scientific Limited) and was incubated at 44°C for 18 to 24 h. Examination was done based on colour indicator, blue-green for *E. coli* and pink for non-faecal coliform colonies.

RESULTS AND DISCUSSION

The results of the physicochemical and bacteriological parameters of the five hand dug wells used for drinking and agricultural activities were presented in statistical methods (mean, variance, and standard deviation). The results of the various samples are illustrated in Tables 1 to 5.

Physicochemical parameters

From the results, the mean temperature of all the water samples was examined. 5 Koribondo Rd (28.62°C), 4 Jimmy Section (28.12°C), 6 Jabbie Street (28.50°C), 3 Jabbie Street (28.32°C) and 19 Koribondo Road (28.52°C) fell outside the World Health Organization (WHO) permissible limits. WHO does not have any temperature standard for safe water, but recommended that safe water must have a temperature of 25°C at a pH of 7. Environmental factors such as soil nature, the depth of water level and other anthropogenic matters can influence the temperature of drinking water. Weather patterns have also been known to increase or decrease the temperature of water. In water quality examination, temperature plays a pivotal role in influencing both the absorption of chemical and the multiplication of microbial organism.

The mean pH obtained for all the water samples (Tables 1 to 5) was analysed: 5 Koribondo Road (6.67), 4 Jimmy Section (6.64), 6 Jabbie Street (6.30), 3 Jabbie Street (6.55), and 19 Koribondo Road (6.73), fell within the WHO permissible limits, except the 6 Jabbie Street water sample, that recorded a low pH mean value. WHO recommended that drinking water should have pH of 6.5

to 8.5. An increased carbon dioxide concentration may therefore lower pH, whereas a decrease may cause it to rise (WHO, 2003). The pH of most raw water lies within the range of 6.5 to 8.5 (WHO, 2003).

From Tables 1 to 5, the mean electrical conductivity and the total dissolved solids for all the water samples were analysed: 5 Koribondo Road (129.38 $\mu\text{S/cm}$, 63.63 ppm), 4 Jimmy Section (145.07 $\mu\text{S/cm}$, 72.72 ppm), 6 Jabbie Street (158.52 $\mu\text{S/cm}$, 79.30 ppm), 3 Jabbie Street (114.85 $\mu\text{S/cm}$, 57.08 ppm), and 19 Koribondo Road (95.03 $\mu\text{S/cm}$; 47.08 ppm) fell within the WHO permissible limits. WHO recommended standard for electrical conductivity and the total dissolved solids in drinking water is <450 $\mu\text{S/cm}$ and <248 ppm, respectively.

From Tables 1 to 5, the mean Turbidity value for all the water samples examined was: 5 Koribondo Road (0.04 NTU), 4 Jimmy Section (0.04 NTU), 6 Jabbie Street (0.69 NTU), 3 Jabbie Street (1.04 NTU), and 19 Koribondo Road (0.38 NTU) fell within the WHO acceptable limits. WHO standard for turbidity of acceptable water drinking was <5.0 NTU.

From Tables 1 to 5, the chemical characteristics for all the water samples examined fell within the WHO permissible limits for safe water. The chemical characteristics for the various wells were as follows: 5 Koribondo Road (R. Chlorine 0.00 mg/L, Magnesium 6.33 mg/L, Potassium 1.73 mg/L Nitrite 0.11 mg/L, Fluoride 0.01 mg/L, Iron 0.02 mg/L, Ammonia 0.00 mg/L, Copper 0.00 mg/L); 4 Jimmy Section (R. Chlorine 0.00 mg/L, Magnesium 11.33 mg/L, Potassium 2.52 mg/L, Nitrite

0.06 mg/L, Fluoride 0.01 mg/L, Iron 0.01 mg/L, Ammonia 0.00 mg/L, Copper 0.00 mg/L); 6 Jabbie Street (R. Chlorine 0.00 mg/L, Magnesium 11.67 mg/L, Potassium 2.30 mg/L, Nitrite 0.32 mg/L, Fluoride 0.06 mg/L, Iron 0.00 mg/L, Ammonia 0.00 mg/L, Copper 0.00 mg/L); 3 Jabbie Street (R. Chlorine 0.00 mg/L, Magnesium 2.27 mg/L, Potassium 1.07 mg/L, Nitrite 0.28 mg/L, Fluoride 0.00 mg/L, Iron 0.00 mg/L, Ammonia 0.00 mg/L, Copper 0.00 mg/L); 19 Koribondo Road (R. Chlorine 0.00 mg/L, Magnesium 12.33 mg/L, Potassium 2.07 mg/L, Nitrite 0.52 mg/L, Fluoride 0.01 mg/L, Iron 0.01 mg/L, Ammonia 0.00 mg/L, Copper 0.00 mg/L). All the chemical parameters analysed are within the WHO limits.

Microbial parameters

E. coli and faecal coliform

Tables 1 to 5 show no presence of *E. coli* and faecal coliform in all the water samples examined, 5 Koribondo Road (0.00 cfu/100 ml, 0.00 cfu/100 ml), 4 Jimmy Section (0.00 cfu/100 ml, 0.00 cfu/100 ml), 6 Jabbie Street (0.00 cfu/100 ml, 0.00 cfu/100 ml), 3 Jabbie Street (0.00 cfu/100 ml, 0.00 cfu/100 ml), 19 Koribondo Road (0.00 cfu/100 ml, 0.00 cfu/100 ml).

Non-faecal coliform

The results from Tables 1 to 5 show a high mean value of non-faecal coliform in all the water samples analysed: 5 Koribondo Road (13.33 cfu/100 ml), 4 Jimmy Section (15.00 cfu/100 ml), 6 Jabbie Street (13.00 cfu/100 ml), 3 Jabbie Street (12.33 cfu/100 ml), and 19 Koribondo Road (12.83 cfu/100 ml). The mean values of all the five samples examined fell outside WHO permissible limits. WHO permissible limits for non-faecal coliform is <10 cfu in 100 ml. The high concentration of non-faecal coliform in the water samples could be associated with environmental factors such as soil nature, decay of organic matter, and leakage from septic tank.

A similar study conducted to determine the bacteriological contamination of ground water sources, revealed that non-faecal coliforms were found in all the wells and boreholes sampled analysed (Jeremiah and Jonathan, 2018). Traditionally, total coliform bacteria have been used to indicate the presence of fecal contamination; however, this parameter has been found to exist and grow in soil and water environments and is therefore considered a poor parameter for measuring the presence of pathogens (Stevens et al., 2003). Total coliform bacteria are not acceptable indicators of the sanitary quality of rural water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies, (WHO, 1997).

An exception is *E. coli*, a thermotolerant coliform, the most numerous of the total coliform group found in animal or human faeces, rarely grows in the environment and is considered the most specific indicator of fecal contamination in drinking-water (WHO, 2004). The presence of *E. coli* provides strong evidence of recent fecal contamination (WHO, 2004, Stevens et al., 2003).

well at 4 Jimmy Section, Blama). The highest pH was recorded by Table 5 (Hand dug well at 19 Koribondo Road, Blama) and the lowest by Table 3 (Hand dug well at 6 Jabbie Street, Blama). All the chemical parameters measured fall within the WHO permissible standards.

From Figure 3, the highest non faecal coli was recorded by Table 2 (Hand dug well at 4 Jimmy Section, Blama), followed by Table 1 (Hand dug well at 5 Koribondo Road, Blama), the lowest was recorded by Table 5 (Hand dug well at 19 Koribondo Road, Blama). All the non faecal coliform recorded for the five wells fell above the WHO permissible bracket (non-faecal coliformis <10 cfu in 100 ml. The high level of non-faecal coliform in all the five samples could be as a result of contaminated water or animal waste that moves quickly down the groundwater, resulting in the variation of non-faecal coliform level.

Conclusion

The objective of this research is to determine the potability of five hand dug wells used for drinking and agriculture activities in Blama, Small-Bo chiefdom,

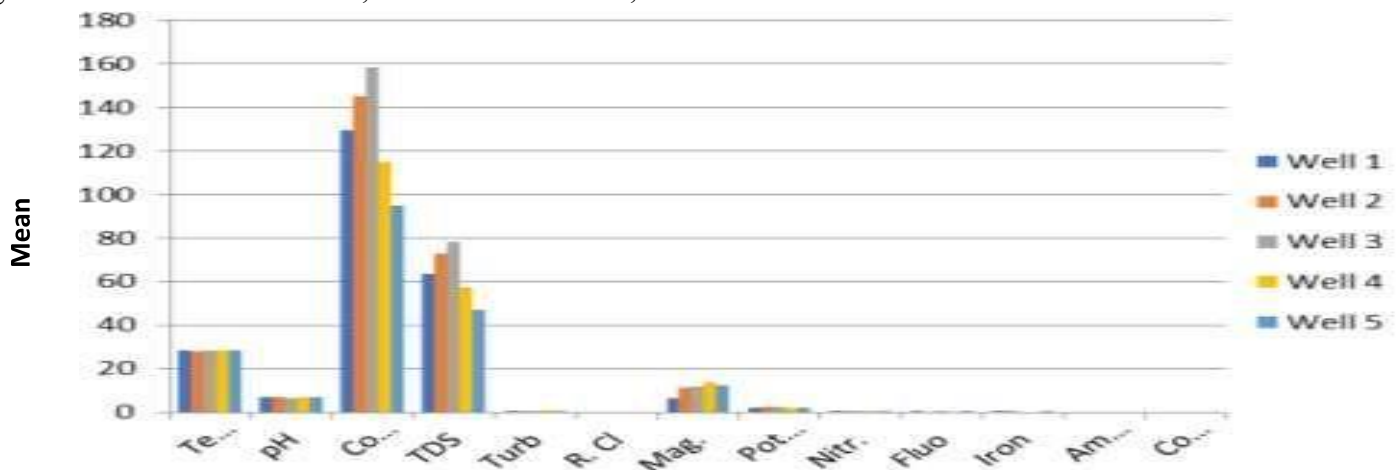


Figure 3. The mean physicochemical parameters of the five hands-dug well.

Kenema District, Eastern, Sierra Leone. In as much as safe drinking water plays a fundamental role in the life of all living organisms, it is therefore incumbent on us all to maintain its hygienic component properly. From the results of the analysis, it can be said that the physicochemical and microbial parameters of all the water samples examined are within the WHO permissible limits, except for the non-faecal coliform presences in all the water samples analysed which exceed the WHO limits and the lack of residual chlorine in all the water samples. It can therefore be concluded that all the water samples examined are safe and fit for drinking.

CONFLICT OF INTERSTS

The authors have not declared any conflict of interests.

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