

Microbial Analysis of Drinking Water from Randomly Selected Boreholes and Shallow Wells around Hargeisa, Somaliland

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Abstract

Background: Shallow wells and boreholes are vital sources of potable water in Hargeisa. This water can be polluted by runoff, in particular during the rainy season, causing outbreaks of waterborne infections. **Objectives:** This research aimed at evaluating the microbial quality of shallow wells and boreholes water around Hargeisa, Somaliland. **Methods:** The total coliform and *Escherichia coli* count were done by using the membrane filtration method. Overall, 100 ml of each water sample was filtered via a 0.45 µm membrane filter, and then the filters were put on m-Endo agar plates that were incubated at 37 °C for 24 to 48 hours. **Results:** The mean value of total coliform counts for the boreholes and shallow wells ranged from 1.288×10^3 to 8.8×10^3 CFU/100ml, while the mean value of total *E. coli* counts also ranged from 3.5×10^2 to 4.429×10^3 CFU/100ml. Results from this study have demonstrated that all water sources (Arabsiyo, Dararweyne, Darasalaam, Dabaraqas, and Jaleelo) don't comply with the WHO guideline for drinking water. Results from the analysis of water samples of 28 wells demonstrated a significant correlation between total coliform and *E. coli* counts ($P = 0.01$). Therefore, this water is not fit for human consumption unless it is treated. **Conclusion:** This study has demonstrated that all results of both mean values of total coliform and *E. coli* counts from groundwater of selected shallow wells and boreholes were beyond WHO standards, so water from Arabsiyo, Jaleelo, Dabaraqas, Dararweyne, and Darasalaam requires treatment before human consumption.

Keywords

Membrane Filtration Method, Escherichia Coli, Coliform, Shallow Wells, Boreholes, Indole, Colony Forming Unit, Indole, Citrate, Triple Sugar Iron

1. Introduction

Water is an essential component of life. The sixth Sustainable Development Goal is to ensure universal access to safe and cheap drinking water for over 800 million people who do not have access to basic services, as well as to improve the accessibility and safety of services for over two million people [1] [2] [3]. Groundwater is the world's largest and most important source of fresh drinkable water on a global scale. Groundwater provides drinking water to an estimated 1.5 billion people worldwide and has shown to be the most reliable supply for satisfying rural water needs in Sub-Saharan Africa. Water quality issues, such as pollution, arise when groundwater is tapped from boreholes, especially when these wells are drilled near beneficiary communities and within homes. South Asia, East Asia, and Sub-Saharan Africa are home to the majority of these people [4] [5] [6].

According to WHO data, unpotable water, inadequate sanitation, and hygiene are responsible for 9.1% of global infections and 6.3 percent of all deaths. In many developing countries, microbial pollution affects all types of water sources, including piped water supply. Waterborne diseases affect 37.7 million people each year, with 1.5 million children dying from diarrhea and 73 million working days lost owing to infection [7] [8] [9]. Challenges of safe drinking water accessibility are many include urbanization, economic problems, and climate changes [10] [11] [12] [13]. Two-fifth of Africans don't have a developed water supply, 60.2% have access to a better drinking water source than 39.8% of Africans, and 36% have access to developed sanitary facilities. Pathogenic microorganisms from animal and human wastes in the water that has been obtained from various researches include bacteria, viruses, and parasites. The most prominent waterborne infection is diarrhea, which is caused by the consumption of unpotable water [14] [15] [16] [17] [18].

2. Materials and Methods

2.1. Study Site, Sample Design, and Study Period

Hargeisa is Somaliland's capital city. It is located in the Maroodi-jeex region of Somaliland, which is one of the country's western provinces. Its population is estimated to be over 1.2 million people. Its latitude and longitude are 9.56°N and 44.077°E, respectively. 35 percent of Hargeisa people have access to piped water from the Geedeeble aquifer, while the remaining 65 percent get their water from 100 wells around the city. Dabaraqas, Jaleelo, Dararweyne, Darasalaam, and Arabsiyo were picked as the five key areas near Hargeisa with the most commercial boreholes and shallow wells. This research was carried out from December 2020 to May 2021 [19] [20].

2.2. Sample Collection

In sterilized glass bottles, samples for microbiological examination were gathered. The bottle was not filled to the rim, leaving 20 mm of space for effec-

tive shaking. Within 4 hours, all samples were transported in an icebox and examined.

2.3. Microbiological Analysis of the Water Samples

The membrane filtering method was used to determine total coliform and *Escherichia coli*. A 0.45 µm membrane filter was used to filter 100 ml of each water sample, and the filters were then placed on m-Endo agar plates and incubated at 37°C for 24 to 48 hours.

2.4. Isolation of Total Coliform and *E. coli* Bacteria

Under aerobic conditions, all inoculated plates were incubated for 24 hours at 37°C. Plates were removed after incubation and colonies were counted. The total number of coliforms was calculated by multiplying the dilution factor by the number of colonies counted. Green sheen colonies were chosen from a pool of non-greenish sheen colonies and counted to determine the total number of *E. coli* colonies. Total *E. coli* count was estimated using a manner similar to total coliform count computation.

2.5. Enumeration of Total Coliforms and *E. coli* Count

Coliforms and *E. coli* bacteria were enumerated using a colony counter after incubation. Greenish sheen colonies were transferred to TSI, Tryptone water, and Citrate agar and cultured for 24 hours at 37°C. The biochemical identification of *E. coli* was the primary goal of this culture for specific colonies. In the result section, the results of biochemical identifications were reported.

3. Results

3.1. The Count of *E. coli* and Coliforms from Boreholes and Shallow Wells Water around Hargeisa

The mean of total coliform counts from 28 boreholes and shallow wells ranged from 1.288×10^3 to 8.8×10^3 CFU/100ml, whereas the mean of total *E. coli* counts ranged from 3.5×10^2 to 4.429×10^3 CFU/100ml, according to **Table 1**. The WHO standard for total coliforms and *E. coli* levels was exceeded [21]. There was not a single borehole or shallow well where the water sample had no *E. coli* or other coliforms colonies.

3.2. The Enumeration of *E. coli* and Coliforms from Shallow Wells Water around Hargeisa

The mean of total *E. coli* counts for the shallow wells ranged from 8×10^2 to 4.429×10^3 CFU/100ml, whereas the mean of total coliform counts likewise varied from 2.8×10^3 to 1.345×10^4 CFU/100ml, as shown in **Table 2**.

3.3. The Enumeration of *E. coli* and Coliforms from Boreholes Water around Hargeisa

The mean of total *E. coli* counts for the boreholes ranged from 5×10^2 to $2.551 \times$

Table 1. The Mean counts of *E. coli* and coliforms from boreholes and shallow wells around Hargeisa.

Microbes	Total coliform CFU/100ml	Total <i>E. coli</i> CFU/ml
WHO limit	0	0
Dararweyne	8.8×10^3	4.429×10^3
Arabsiyo	7.289×10^3	2.333×10^3
Dabaraqas	2.8×10^3	3.5×10^2
Jaleelo	8.3×10^3	1.933×10^3
Darasalaam	1.288×10^3	3.75×10^2

Table 2. Mean counts of *E. coli* and coliforms from shallow wells around Hargeisa.

Microbes	Total coliform CFU/100ml	Total <i>E. coli</i> CFU/ml
WHO limit	0	0
Dararweyne (7 wells)	8.8×10^3	4.429×10^3
Arabsiyo (1 well)	1.345×10^4	8×10^2
Dabaraqas (2 wells)	2.8×10^3	3.5×10^2
Jaleelo (2 wells)	1.1×10^4	2.65×10^3

10^3 CFU/100ml, whereas the mean of total coliform counts likewise varied from 1.288×10^3 to 6.409×10^3 CFU/100ml, as shown in **Table 3**.

3.4. Morphological and Biochemical Characteristics of *E. coli* Isolates from Water Samples

There were a total of twenty-eight water samples tested by the researcher. On m-Endo agar media, *E. coli* isolated from 28 water samples displayed three unique colony morphologies. On m-Endo agar, *E. coli* developed a distinct colony morphology: greenish sheen colonies. On the culture media, dark greenish and pink colonies occasionally developed. Total *E. coli* counts can be determined from bacterial growth on m-Endo agar plates after 24 hours of incubation at 37°C based on their colorful colony features. Tryptone water, TSI, and Citrate slant were used to identify *E. coli* colonies. They were inoculated and incubated for 24 hours at 37 degree celcius. After incubation, the findings were read. **Table 4** Table 4 summarized biochemical findings, colony morphology and Gram stain. One of the biochemical test was Triple Sugar Iron. A/A means slant and butt of the screw tube showed yellow color indicating that the PH of the media was acidic due to the fermentation of the sugars in the Triple Sugar Iron. . Each *E. coli* isolate from 28 water samples was stained with Gram staining. The tests for urease, oxidase, motility, sugar fermentation, MR, and VP were not performed.

4. Discussion

The findings of this study have shown that all water sources (Arabsiyo, Dararweyne, Darasalaam, Dabaraqas, and Jaleelo) failed to meet WHO drinking water

Table 3. Mean counts of *E. coli* and coliforms from boreholes around Hargeisa.

Microbes	Total coliform CFU/100ml	Total <i>E. coli</i> CFU/ml
WHO limit	0	0
Arabsiyo (7 wells)	6.409×10^3	2.552×10^3
Jaleelo (1 well)	2.9×10^3	5×10^2
Darasalaam (8 wells)	1.288×10^3	3.75×10^2

Table 4. Morphological and biochemical characteristics of *E. coli* isolates from water samples.

Colony morphology	Gram stain	Cell morphology	Indole ¹	TSI	Citrate
Large greenish sheen, thick, moist, smooth opaque circular colonies	-	Short rod	+	A/A with gas	-
Medium-sized greenish, moist, smooth opaque, and circular colonies.	-	Short rod	+	A/A with gas	-
Medium-sized, dark greenish, moist, opaque, and circular colonies	-	Short rod	+	A/A with gas	-

guidelines. This highlighted a lack of safe and sanitary water supplies in Sub-Saharan Africa, which causes the people to suffer from water-borne diseases. Unless treated, water from the above-mentioned places is unsafe and unusable.

The presence of coliforms and *E. coli* in all water samples taken from boreholes and shallow wells suggested that the groundwater system had been heavily contaminated by animal and human feces. Many shallow wells and boreholes have been drilled in and near the river, allowing runoff to pollute the water during the rainy season. The majority of the boreholes have concrete caps, however, there are a few tiny reservoirs where water is collected once it is pumped from the boreholes. Because these little reservoirs aren't protected, they're vulnerable to contamination. Boreholes and shallow wells near human settlements and animal manures contaminated water after leaching. Water pollution was also aided by the ducts of water tanker trunks. Boreholes have not been repaired, and their concrete walls have large fissures. Water oozed out of the broken walls of the boreholes during the rainy season, causes microbial contamination of the water. Contaminated water was also found in shallow wells. They weren't dug down and weren't even covered. Pastoralists collected water by entering wells with their bare feet, contaminating the water.

The greatest mean of total *E. coli* count was found in Dararweyne shallow wells, whereas the second highest mean of total *E. coli* count was found in Jaleelo

¹This test shows the capacity of particular bacteria to break down the amino acid tryptophane to indole. Indole production test is important in the identification of Enterobacteria.

shallow wells. The lowest mean of total *E. coli* count was found in water collected from Dabaraqas shallow wells, while one Arabsiyo shallow well had the third-highest mean of total *E. coli* count. The shallow wells of Dararweyne, Dabaraqas, and Jaleelo are all nearby. The greatest mean of total coliform and *E. coli* levels were found in shallow wells in the three areas described above. The position of the shallow wells of Dararweyne, Jaleelo, and Dabaraqas along the river's bank is what contaminated the water. When it rains, untreated sewage from all over Hargeisa drains into the Dararweyne, Jaleelo, and Dabaraqas Rivers, which is one of the main causes of water contamination. They were all unprotected hand-dug wells. Water from these shallow wells is depleted in the winter, and they are hand-dug by local men regularly, so water is regularly polluted when the depth of shallow wells is increased by the owner to sell more water. When compared to the mean of total *E. coli* and coliform counts of Dabaraqas, Dararweyne, and Jaleelo shallow wells, the Arabsiyo area had only one shallow well with a lower mean of total *E. coli* and coliform count. Arabsiyo area had lower total coliform and *E. coli* counts. Darasalaam boreholes had the lowest total coliform and *E. coli* count when it is compared to the other four sites (Arabsiyo, Dararweyne, Jaleelo, and Dabaraqas). Results from the analysis of water samples of 28 wells demonstrated a significant correlation between total coliform and *E. coli* counts ($P = 0.01$).

A paper titled "Water Quality and Health Implications of Bottled Water Made in Somaliland" was published. This study focused mostly on water physicochemical analysis, but it also included microbiological standard tests such as total heterotrophic plate count, total coliform, and total fecal coliform count, all of which were performed using ISO9308. Selective media were used to grow *Enterococcus* and *Pseudomonas aeruginosa*. Two of the six bottled waters had a higher total heterotrophic plate count, two were on the borderline, and the remaining two bottled waters had no total plate count. There were no total coliforms or fecal coliforms [22].

All water samples from the selected five study areas were microbiologically polluted. Results from this study agreed with a study carried out in Jigjiga which is the capital city of the Somali region in Ethiopia in particular higher total coliform and *E. coli* counts [23]. Results from this study also coincided with a study conducted in Diridawa city which had higher coliform and *E. coli* counts [24]. Almost all of the water samples in this investigation had a high amount of fecal contamination, according to the findings. This means that none of the major water sources are protected or secure. As a result, the presence of *E. coli* and other coliforms puts human health at risk. The findings of this study's water samples matched those of a study done in Kenya's Marigat Urban Center [25].

5. Conclusion

The results of total coliform and *E. coli* counts from groundwater of selected shallow wells and boreholes were all found to be over WHO guidelines in this study. Before being consumed by humans, the water from Arabsiyo, Jaleelo, Da-

baraqas, Dararweyne, and Darasalaam must be treated.

6. Recommendations

- 1) Small reservoirs near boreholes should be cleaned and covered regularly.
- 2) Chlorine should be used to treat water.
- 3) The Hargeisa Water Agency should conduct a study to determine the source of contamination in the distribution system (water tanker trucks).

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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