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Study of the Microbiological Quality of Groundwater in the Don Bosco District of Mimboman in the City of Yaoundé, Cameroon

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Abstract: Groundwater is a precious and essential natural resource for many uses. Its use for food or hygiene purposes requires an excellent microbiological quality to avoid waterborne diseases. The study objective as to investigate the bacteriological quality of groundwater in the "Don Bosco", area located at Mimboman in the city of Yaoundé. Household surveys were conducted to identify the main source of drinking water supply. After identification of the different boreholes, water samples were taken from 10 boreholes. Bacteria were isolated after filtering 100 ml of the sample from each borehole through a 0.45 µm microporosity membrane. This membrane was then deposited on the surface of agar plates incubated at 37°C and 44°C for 24 +/- 2h. After subculturing on different media, the pure bacterial isolates were identified by their cultural and biochemical characteristics. A total of 95 households were surveyed and it was found that the main source of drinking water was boreholes (65.5%). The probable sources of pollution were latrines located above the boreholes (8/10), followed by a lack of disinfection after 6 months (7/10). Bacteriological analyses showed that the borehole water consumed by the population of Don Bosco does not meet WHO standards with a non-conformity of 50% for total flora, 38.8% for total coliforms, 31.5% for faecal coliforms and 31.5% for faecal streptococci. Six (06) general and bacterial species were isolated: group D streptococci (30%), *Escherichia coli* (30%), *Shigella* (5%), *Salmonella* (5%), *Yersinia enterocolitica* (5%) and *Aeromonas* (5%). In this study, the detection of a variety of germs in ground water indicates that these waters are unfit for consumption. As a result, there is an urgent need to move the latrines in question and to proceed with regular and appropriate disinfection of the wells in the Don Bosco area in Mimboman district, to guarantee a life quality for the population that consumes this water.

Keywords: Groundwater, Bacteria, Contamination, Mimboman

1. Introduction

Water is an essential element of biological life; it represents about 60% of the body mass of a human being. Water is not only a vital nutrient, but it is also involved in many essential physiological functions as digestion, absorption, thermoregulation and waste elimination [1]. Water is the most fundamental nutrient for live survival [2].

Therefore, the main requirements are not only to have an adequate quantitative supply of water, but also to have a good quality of water that must be considered safe for human consumption. This is both a vital public health promise and an essential element of environmental safety. According to the World Health Organization (WHO), in 2005, 1.8 million people, comprised of 90% of children under five years of age, mostly living in developing countries, died from waterborne diseases with a prevalence of 19% each year. Moreover, 88% of diarrheal diseases are due to poor water quality, inadequate sanitation and poor hygiene [3]. Groundwater accounts for about 97% of total inland freshwater liquid water. According to Merzoug [4], 75-90% of the world's population uses water from groundwater sources. Some research on groundwater quality has concluded that groundwater pollution is of geological and anthropogenic origin, including sewage infiltration and the use of chemical fertilizers in agriculture. Others revealed that groundwater pollution is linked to the presence of septic tanks, the lack of treatment, the lack of a sewage network and the non-respect of public hygiene conditions. In Kumba Cameroon, in 2019 microbiological tests revealed that 74% of water samples fall into the category of water with a high health risk [5]. In Yaoundé in 2011, only 10,000 m^3 of water were available for the population out of an estimated need of 250,000 m^3 of water per day [6]. This lack of water is due to the anarchic growth of neighborhoods in the city of Yaoundé, which pushes the population to move to peri-urban areas where public water distribution networks are absent. It should also be noted that those who use these public networks complain not only about the cost, but also about the quality of this water, especially as a source of drinking water. According to the guidelines of the World Health Organization (WHO) [7, 8]. Drinking water should not present any significant health risk during a lifetime of consumption, hence the interest in studying the bacteriological quality of groundwater in the Don Bosco area in the Mimboman district of the city of Yaoundé to measure the health risks to which the population that uses it for its food needs is exposed.

2. Materials and Methods

2.1. Collection and Transport Procedure

2.1.1. Collection

Sample collection is one of the most important steps in the evaluation of the microbiological water quality. It was performed under strict aseptic conditions.

After disinfecting the sampling sites with a hydro-alcoholic solution (70° alcohol), we flamed and then opened the tap to let the water flow for 2 or 4 minutes [9], and then filled the 100 ml sterile bottles prepared beforehand in the laboratory. The lid of the bottles intended to receive the sample was removed just before the introduction of the sample, this one being in no case in contact with the hands of the sampler. We then immediately closed the bottles after filling them, identifying them with a code (marking the bottle with the sample number corresponding to the collection point), and then placing them in a cooler containing the ice accumulators. The water sample identification form and the water point vulnerability assessment form were then completed.

2.1.2. Transport of the Sample

After collection, the vials were legibly labeled and transported to the Medical Diagnostic Center (MDC) bacteriology laboratory in a dark, cold (+/- 4°C) place in a cooler with ice packs (iso19458 standards), accompanied by a card with all the necessary information (date, time, and collection site).

2.2. Bacteriological Analyses

Bacteriological analyses are intended to highlight the presence of germs based on the search for and counting of these in the samples to be analyzed. The germs sought according to the quality references of the WHO 2012 are: [10; 11].

1. Total flora: < 10 germs/ml
2. Coliforms: 0/100 ml
3. Escherichia coli: 0/100 ml
4. Fecal Streptococci: 0/100 ml

2.2.1. Sample Concentration by Membrane Filtration

The plating method was almost the same for total coliforms, fecal coliforms, total germ, and fecal streptococci. Only the culture media and incubation conditions differed [10, 12].

To count the number of bacteria suspended in the water sample, a 100 ml volume of water sample was filtered through a nitrocellulose membrane, microporosity 0.45 µm. The filter was then placed on an isolation medium, incubated at 37°C for 24 to 48 h for total coliforms, total germs, and fecal streptococci, and 44°C for 24 to 48 h for fecal coliforms [12]. The number of colonies found was expressed as the average Colony Forming Unit (CFU/mL) (NF S93-315, 2008).

Sterile water for injection (WFI) purchased from pharmacies was used as a control.

2.2.2. Identification of Bacteria

The identification was done after observation of the cultural characteristics on our different media, then after the realization of GRAM control, a subculture on different specific media was followed [13, 14].

1) Faecal enterococci or group D streptococci: seeding was done on BEA medium (bile esculin agar) and incubation at 37°C for 24±2 hours; translucent colonies surrounded by a black halo will be observed.
2) Escherichia coli, salmonella: plating was done on BGA (brilliant green agar) medium and incubation at 37°C for 24±2 hours.
3) Total germs or total flora: The plating was done on glucose Tryptone agar (TGEA) which is a medium developed for the research and enumeration of microorganisms in water, milk, and dairy products.

4) Total coliforms: Inoculation was done in hektoin agar and incubation were at 37°C for 24±2 hours;

After performing the oxidase and catalase tests, the pure bacterial isolates were identified using the commercial biochemical arrays API 20E for the identification of Enterobacteriaceae and API 20 NE for the identification of bacteria classified as non-fermentative [15-17].

2.3. Data Processing and Analysis

Data were collected, processed, and analyzed by Excel software (version 2010). The results were presented in tables and graphs.

2.4. Results

2.4.1. Main Source of Drinking Water Supply

In order to identify the main source of drinking water supply in the population of Don Bosco Mimboman, a survey was conducted among 95 households, which allowed us to demonstrate that the main source of drinking water supply in this locality would be the borehole (57/95) (Figure 1).

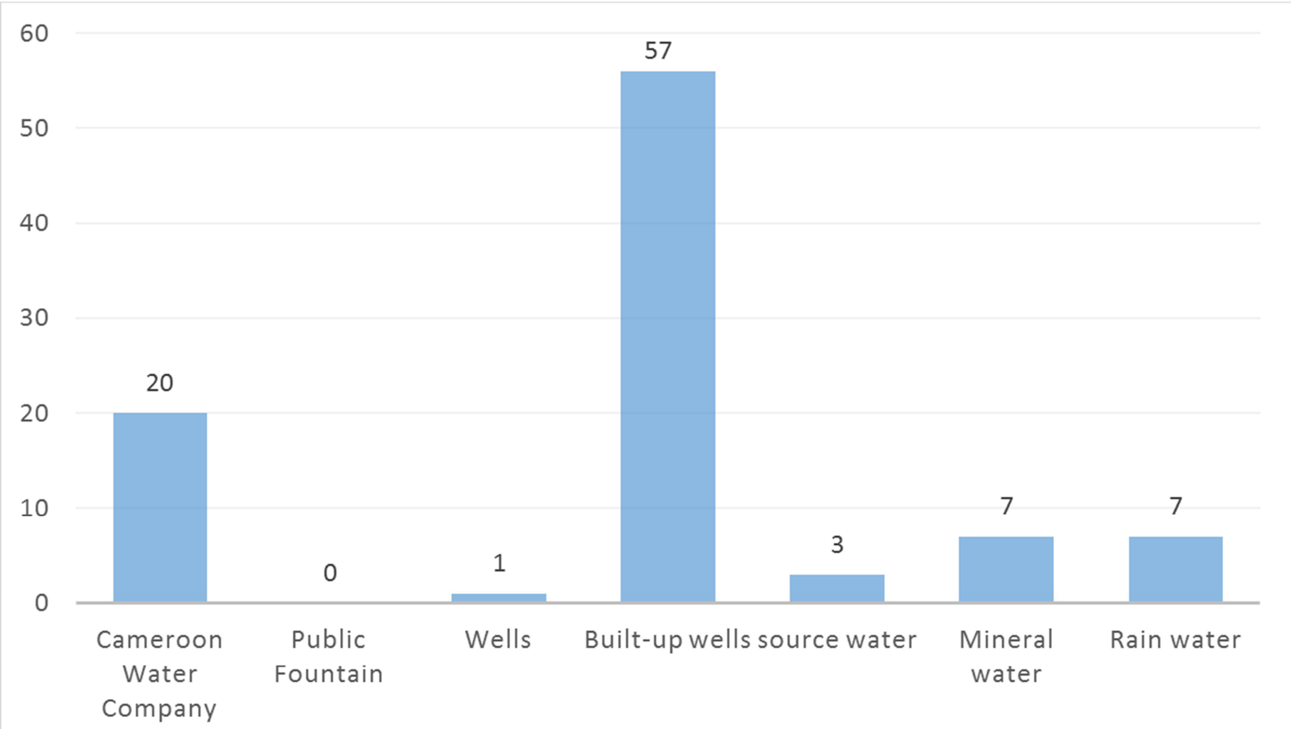

Figure 1. *Main sources of drinking water supply.*

2.4.2. Probable Sources of Contamination

Among the 4 probable sources of contamination mentioned in our study, such as: Latrine located less than 15 m from a borehole; Garbage deposits near boreholes; Absence of disinfection (less than 6 months); Latrines located at the top of boreholes, the probable source of contamination was latrines located at the top of boreholes (8/10).

2.4.3. Microbiological Quality of Borehole Water

Total flora:

The microbiological analysis carried out showed us after enumeration that our water points had high loads of bacteria. The total germs at 37°Care bacteria of intestinal origin (human or animal). To see if the number of germs likely to be present in the well water in the Don Bosco Mimboman district respected international standards, the colonies were counted at each well and expressed in CFU/ml. The results show that boreholes F8 and F9 have the highest number of colonies of total germs, i.e., a rate of 15 CFU/mL (Table 1).

2.4.4. Compliance after Culture of Total Flora

It is observed from Figure 2 that 50% of the water points were non-compliant with WHO standards with colony counts well above the standard (<15 CFU/mL) and only 50% compliant with colony counts (<15 CFU/mL).

Table 1. *Colony count of total flora after filtration in CFU/ml.*

Boreholes	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
Number of colonies in CFU/ml	7	64	2	1	74	22	4	>300	>300	2

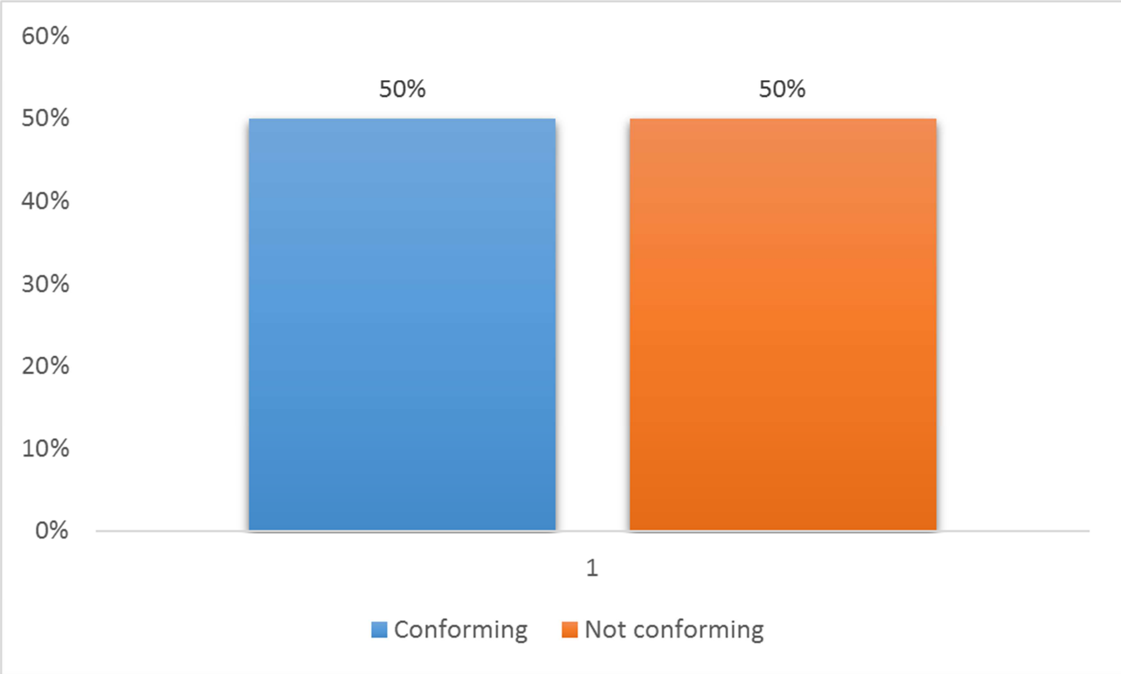

Figure 2. *Percentage of conforming of total flora after culture.*

2.4.5. Pollution Indicators

The results of the microbiological analyses show that the borehole waters were all contaminated by most of the germs sought. They were strongly contaminated by total mesophilic flora and fecal contamination germs as shown by the presence of high concentrations of total coliforms, followed by fecal streptococci and fecal coliforms. For each of these germs, the respective percentages of non-compliance are of 38.8%; 31.5%; and 31.5% compared to the very strict quality criteria (0 CFU/mL) of the WHO Figure 3.

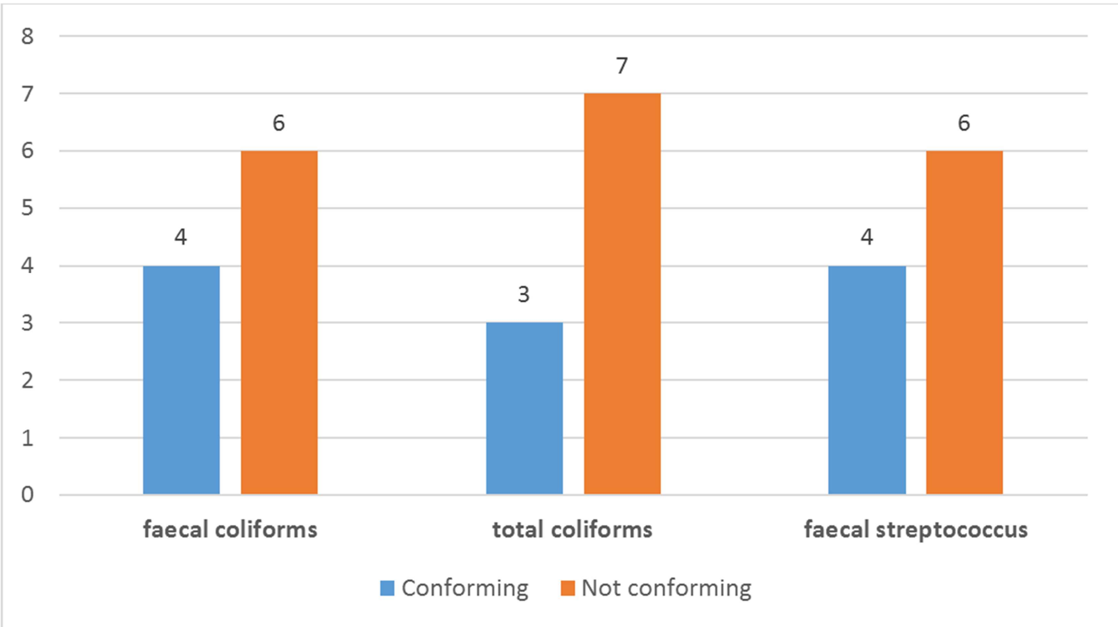

Figure 3. *Distribution of boreholes according to the conformity of the flora after culture.*

2.4.6. Microorganisms Isolated

We were able to isolate six bacterial genera and species: group D streptococci, *Escherichia coli, Shigella, Salmonella, Yersinia* enterocolitica and *aeromonas*. The most represented were Group D Streptococci and *Escherichia coli,* with a respective percentage of 30% each (Figure 4).

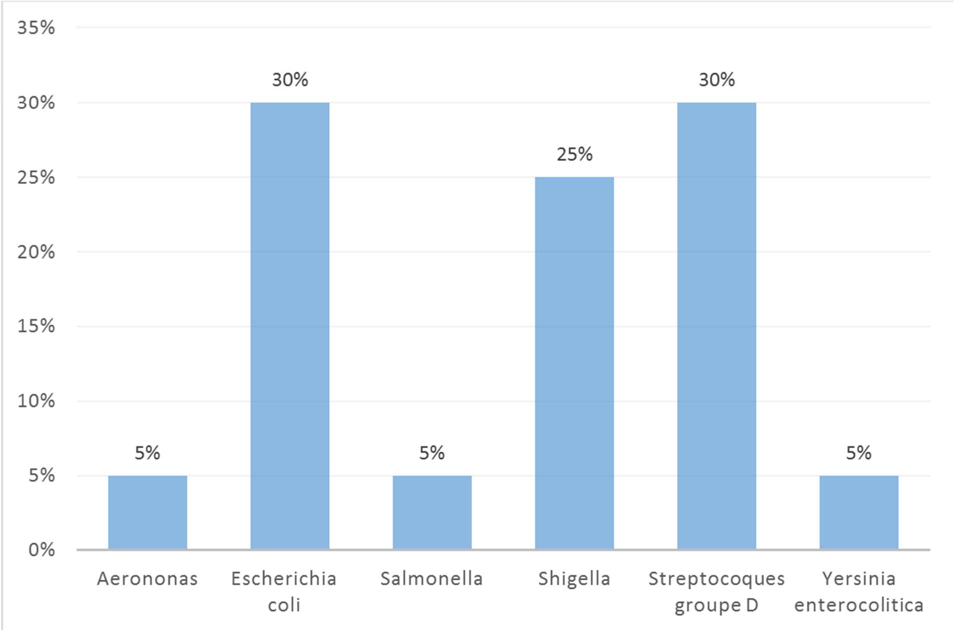

Figure 4. *Distribution of bacterial genera and species.*

3. Discussion

All the results obtained are closely related to existing data in this field. Thus, the comparison of our results with those of previous studies led to several findings. The main source of drinking water for the population of Don Bosco Mimboman is the borehole (57/95). Our data obtained after a survey of these households are similar to those obtained by Briand *et al.* in 2009 in Dakar [18], who, with a view to finding the main source of household water supply in Dakar, showed that the populations of the neighborhoods studied have a preference for borehole water, which they consider to be of better quality than the public water supply. According to the authors, their choice of underground water is due to problems such as bad colour, undesirable taste, frequent water cuts, low water pressure at the tap and the very high cost of water from the public distribution network.

The main source of pollution of the borehole water was the proximity of the latrines located at the top of the boreholes (8/10), as was the case in the study conducted by Sokegbe *et al*. 2017 in Lomé [19], where 62.96% of the households had their latrines less than 15 meters from the water source. This result justifies the need to better orientate the drilling sites in our different living areas in order to eliminate waterborne diseases after consumption of its waste water.

The microbiological analysis carried out showed that our water points had high bacterial loads, which could be explained by the exposure of the structures to biological pollution, i.e. the non-respect of the rules and conditions for the creation of boreholes, the proximity of latrines, and the uncontrolled discharge of effluents and household waste into the environment. Our results are similar to those of Nanfack *et al*, 2014 [20] who stated that the poor quality of these waters could be explained not only by the lack of sanitation, but also by the unhealthy environment due to the lack of hygiene around these water sources. Furthermore, we obtained a non-compliance rate of 50% of the water points were non-compliant with a colony count well above the standard (<15 CFU/mL) and only 50% compliant with a colony count (<15 CFU/mL).

According to the Pollution Indicators we obtained 38.8% of total coliforms; 31.5% faecal coliforms and 31.5% faecal streptococci. Our results are similar to those of Nono *et al.* in 2001 [21], which show that the contamination of water by total germs could be due to the poor protection of boreholes, ignorance of the rules, and neighbouring pollution (cattle breeding, existence of septic tanks and latrines). In addition, the absence of a sanitation system in large numbers of faecal streptococci in the borehole water attests to the contamination of the water by faecal matter stored in the latrines.

The determination of microorganisms in the Don Bosco borehole water showed a diversity of bacterial genera and species isolated, the most represented being group D streptococci and Escherichia coli, with a respective percentage of 30% each. Our results are similar to those of Souncy *et al*, in 2015 in Lomé [22] who found Escherichia coli as well as Bricha *et al* in 2007 [23] and they justified that the presence of these bacteria was due to sewage systems, septic tank sources, factory waste water and solid waste. In addition, contamination of wells depends on soil permeability, depth of the water table, lack of or inadequate sanitation facilities, poor waste management and the method of drawing water.

4. Conclusion

At the end of our study, the general objective was to evaluate the bacteriological quality of groundwater in the

Don Bosco Mimboman neighborhood in the city of Yaoundé, it was found that: the main source of drinking water supply for the population of the Don Bosco Mimboman neighborhood was the borehole. The most likely source of contamination was the latrines located above the boreholes. The bacterial genera and species isolated were group D streptococci, *Escherichia coli*, *Shigella, Salmonella, Yersinia enterocolitica* and *Aeromonas*. The detection of a variety of germs in the borehole water indicates that these waters are unfit for consumption. The urgent need is to relocate the latrines in question and to proceed to a regular and appropriate disinfection of wells of Don Bosco area of the district Mimboman, to guarantee a better quality of water and thus of life for the population which consumes it.

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