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Assessing the microbiological quality of borehole and well water in Ferkéssedougou, Côte d'Ivoire

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ABSTRACT: Because of the high subscription costs to the distribution network and water bills, access to running water for domestic use remains unaffordable to many inhabitants in cities and villages in the northern regions of Côte d'Ivoire. Thus, borehole and wells water is thus used as alternative to meet daily water needs, most often without a proper knowledge of the quality of such waters. This study aimed at evaluating the microbiological quality of borehole and well water in Ferkessédougou, one of the major cities in north Côte d'Ivoire. Chemical analyses were carried out on water sampled from 7 wells and 3 boreholes randomly selected across the study area. The results indicated that the average static level of the wells ranged from 0.5 m to 7.0 m. Water pHs were acidic to neutral and varied between 5.1 and 6.9. Faecal coliforms, Escherichia coli and intestinal enterococci were the main bacteria found in wells water, with proportions ranging between 2100 and 19000 CFU/100 ml, 120 and 5200 CFU/100 ml, and 30 and 240 CFU/100 ml, respectively. Only one borehole reported the presence of faecal coliforms (150 CFU/100 ml) and E. coli (15 CFU/100 ml). This faecal water pollution highlighted the poor sanitation conditions and unsuitability of water sourced from boreholes and wells to human consumption, indicating the need for adequate treatment of water prior to its use to avoid public health issues.

KEYWORDS: drinking water, faecal bacteria, microbiological quality, boreholes, wells.

1 INTRODUCTION

Access to drinking water and sanitation represents a daily struggle for thousands of individuals in cities and villages in low- and middle-income countries [1,2,3]. In 2022, 6 billion people used safely managed drinking-water services – that is, they used improved water sources located on premises, available when needed, and free from contamination. The remaining 2.2 billion people without safely managed services in 2022 included: 1.5 billion people with basic services, meaning an improved water source located within a round trip of 30 minutes; 292 million people with limited services, or an improved water source requiring more than 30 minutes to collect water; 296 million people taking water from unprotected wells and springs; and 115 million people collecting untreated surface water from lakes, ponds, rivers and streams. Sharp geographic, sociocultural and economic inequalities persist, not only between rural and urban areas but also in towns and cities where people living in low-income, informal or illegal settlements usually have less access to improved sources of drinking-water than other residents. In 2022, globally, at least 1.7 billion people use a drinking water source contaminated with faeces. Microbial contamination of drinking-water as a result of contamination with faeces poses the greatest risk to drinking-water safety [4]. The supply of drinking water to populations is therefore a major concern on a global scale. Furthermore, the microbiological quality of drinking water is a major concern worldwide due to its impact on public health [5]. Water intended to human consumption and/or household needs must not contain pathogenic microorganisms such as anaerobic sulphite-reducing germs, coliforms, and streptococci [6]. In various regions worldwide, water quality is impaired by the contamination of microorganisms of faecal origins, the excessive use of agrochemicals, uncontrolled water discharges from households and industries [7,8], indicating the need of adequate treatments for safe consumption.

Access to running drinking water remains one of the key challenges faced by populations in villages and cities because of the cost of subscription to the distribution network, and the costs of bills, which is unaffordable to a large proportion of the population in a context of growing impoverishment. To cope with the lack of access to the running water distribution network, people most often rely on groundwater from wells and boreholes to meet their water needs [9]. However, the water from these sources may contain pathogenic microorganisms, undesirable and even toxic substances which can be harmful to individuals and cause serious public health issues [10,11,12]. Yet, many people still use untreated water from rivers, wells, and boreholes as drinking water in villages and cities, resulting in the occurrence of water-borne diseases. Among the water-borne diseases, the deadliest is diarrhea, which fatality toll can reach 2.21 million victims per year globally [13]. Microbiologically contaminated drinking water can transmit diseases such as diarrhoea, cholera, dysentery, typhoid and polio and is estimated to cause approximately 505 000 diarrhoeal deaths each year [14]. It is therefore important to ensure the potability of boreholes and wells water through adequate treatment prior to their use when required.

According to [15], during the past decades, the pace of development has accelerated in several regions in rural areas and cities in Côte d'Ivoire, with an increased rate of urbanization to the detriment of natural spaces and landscapes. Such an urbanization has resulted in increased water demands, coupled with uncontrolled and poorly managed wastewater discharges. Studies carried out on the water resources of Côte d'Ivoire by [16,17,18,19,20], reported numerous sources of pollutions in both surface water and groundwater. Wastewater effluents are most often discharged into the environment, which contaminate boreholes and wells as they are not covered and contributes to the degradation of the water quality [21]. In the northern regions of Côte d'Ivoire, the environmental conditions, namely the semi-arid and climatic conditions, exacerbate water scarcity, which in turn increases the risks of water-borne diseases and vulnerability of households to water-related public health issues as they would rely on water sourced from wells and boreholes. A good knowledge of the quality of borehole and wells water is therefore critical to ensure the wellbeing of these populations since it allows for the identification of suitable physico-chemical treatments and measures required for the safe water consumption.

This study aimed at (1) quantifying the microbiological quality of borehole and wells water in the city of Ferkessédougou based on faecal contamination indicators, and (2) identifying the health risks associated with the use of this drinking water. The results of this study can serve as a basis to develop adequate strategies to achieve the targets 1 and 2 of the Sustainable Development Goal 6 in Ferkessédougou and other cities across Côte d'Ivoire.

2 Materials And Methods

2.1 Study Area And Selection Of Boreholes And Wells

The study was carried out in Ferkessédougou, the administrative capital of the Tchologo region in Côte d'Ivoire (Figure 1). The city consists of 15 districts with a population estimated at ca. 160 267 inhabitants [22]. The major activities are agriculture and trade.

The boreholes and wells were selected based on different criteria including the location, water use (human or non-human), water treatment before consumption (e.g., disinfection using hypochlorite), water static level, and the protection system of the well or borehole. Out of 30 wells identified, seven wells located in the suburbs Residential, Pargnonkaha, Zindel, Customs, Mossibougou, Kafalovogo and N'bagnan, and three boreholes located in Fangakaha, Tiebigué and Douane were retained (Figure 2).

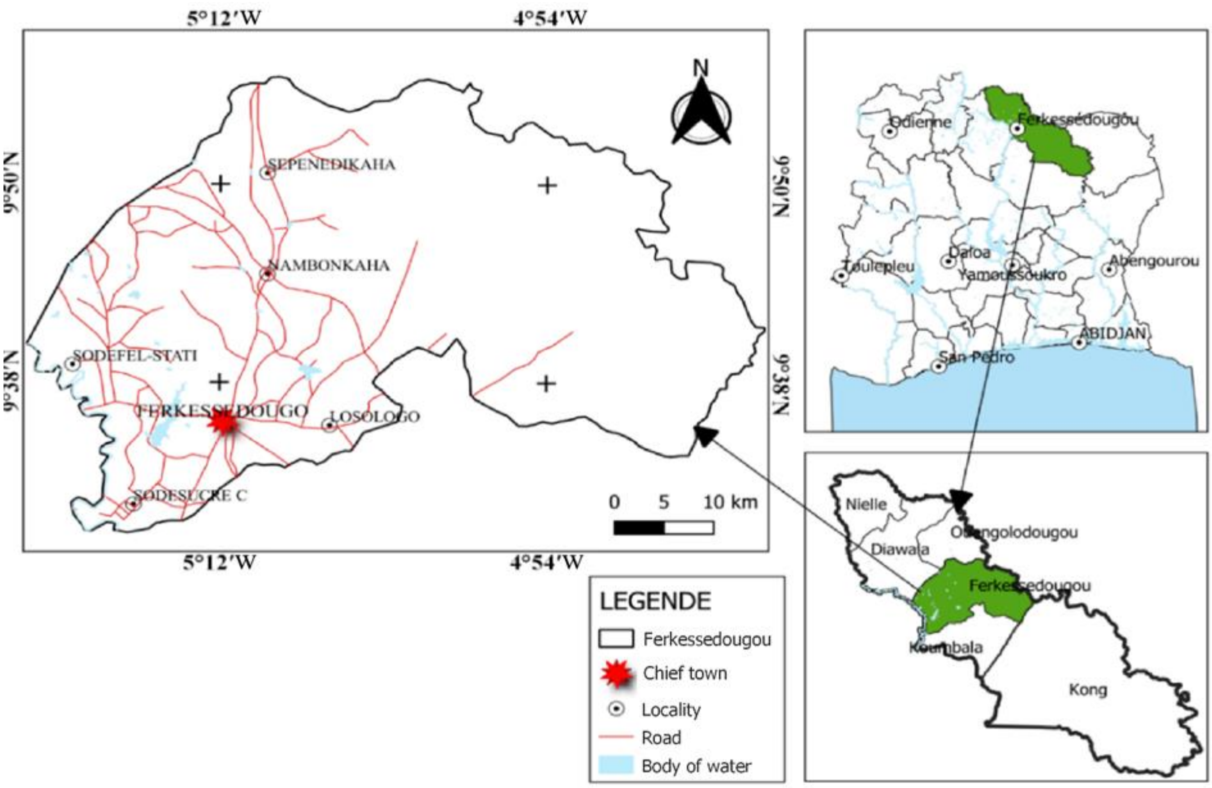

Fig. 1. Map of the study area

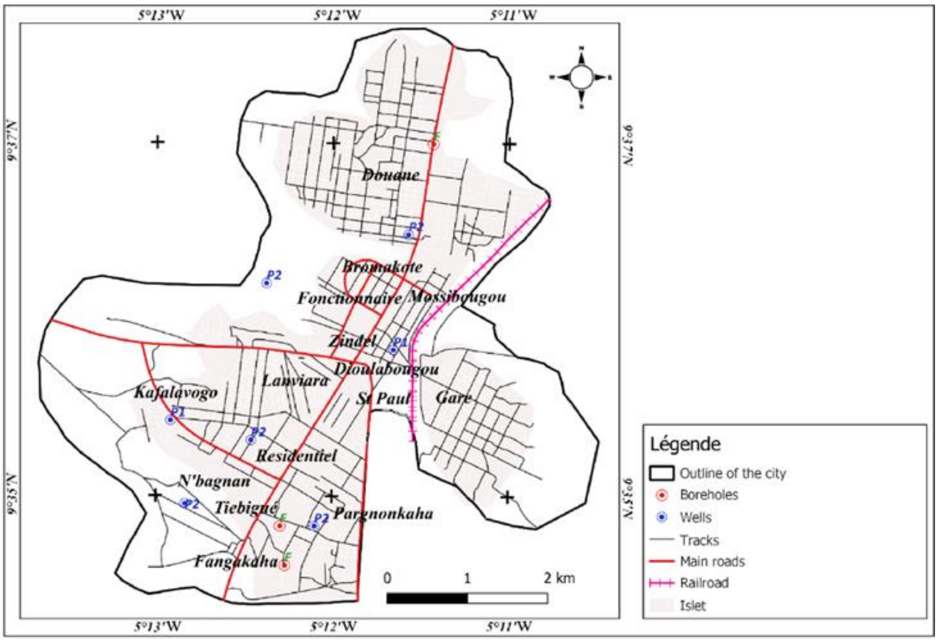

Fig. 2. Locations of the sampling wells and boreholes in Ferkessédougou

2.2 WATER SAMPLING AND QUALITY ANALYSIS

Water samplings were carried out in August 2021 during the rainy season. Each 1-litre capacity bottle was rinsed three times with the sampled water before being filled and hermetically sealed. The bottles were then transported to the laboratory in coolers containing cold packs at 4 °C. Water static levels for the each of the surveyed boreholes and wells were measured using a piezometric probe. The pH was measured in situ using a glass electrode (electrometric method). After calibrating the Consort C 380 brand pH-meter, the pH value was taken upon stabilization of the reading index.

2.3 METHOD FOR ANALYSING MICROBIOLOGICAL PARAMETERS

Following reference [23], the analytical technique was based on the qualitative and quantitative research of thermo-tolerant coliforms and faecal Streptococci in the water samples. For the enumeration of E. coli, faecal coliforms and intestinal enterococci, the spreading method on agar medium and the membrane filtration technique through a filtration ramp were used [24]. The culture medium used for the detection of E. coli and faecal coliforms was Chromocult Coliform Agar (CCA) and the enumeration of colonies was carried out after 24 hours of incubation at 44°C. The search for intestinal enterococci was carried out using the same culturing methods (plating and filtration) but on the Chromocult Enterococci Agar (CEA) culture medium incubated at 37°C for 24 to 48 hours. The results were expressed by Colony Forming Unit per 100 ml (CFU/100 ml) [25]. Table 1 shows the method of analysis of bacteriological parameters.

Table 1. Method of Analysis of bacteriological parameters [23]

Parameters	Method of Analysis	Culture medium	WHO standards
E coli	Seeding, membrane filtration, incubation at 44°C, counting of confirmed colonies	Chromocult Coliform Agar (CCA)	0 CFU/100 ml
Faecal coliforms	Membrane filtration, incubation at 44°C, counting of confirmed colonies	Chromocult Coliform Agar (CCA)	0 CFU/100 ml
Intestinal enterococci	Seeding, membrane filtration, incubation at 37°C, counting of confirmed colonies	Chromocult Enterococci Agar (CEA)	0 CFU/100 ml

3 RESULTS

3.1 STATIC WATER LEVELS AND PHYSICO-CHEMICAL WATER CHARACTERISTICS MEASURED IN SITU

Water levels in wells during the rainy season at the study sites were relatively close to the surface, with depths ranging from 0.5 m to 7.0 m. The minimum, average, maximum and standard deviations of pH values measured in situ for wells and boreholes are presented in Table 2. The average temperature in the selected boreholes and wells was 29°C. The pH was acidic to neutral, with average values being 5.15 ± 0.26 and 6.08 ± 0.50 in boreholes and wells, respectively. The acidic nature of the water was observed in all the selected wells and boreholes.

Table 2. pH of boreholes and wells water measured in situ at 29°C

Water source		pH
Boreholes	Average	5.15
	Minimum	5.66
	Maximum	6.1
	Standard deviation	0.268
Wells	Average	6.08
	Minimum	5.15
	Maximum	6.9
	Standard deviation	0.502

3.2 MICROBIOLOGICAL QUALITY OF BOREHOLES AND WELLS WATER

The results indicate that the borehole in Douane had an average concentration of indicator bacteria higher than the standard required for consumption. Borehole water in the other two suburbs (Tiebigué and Fangakaha) had bacterial concentrations falling within the standards for water consumption (Table 3). Regarding wells water, there was a marked proportion of bacteria indicative of faecal pollution, with proportions varying between 2100 and 19000 CFU/100 ml, 120 and 5200 CFU/100 ml, and 30 and 240 CFU/100 ml for faecal coliforms, E. coli and intestinal enterococci, respectively (Table 3). In the water from the three boreholes, only one borehole (Customs) reported the presence of faecal coliforms (150 CFU/100 ml) and E. coli (15 CFU/100 ml). The presence of these bacteria indicates a pollution of faecal origins, making these waters unfit for human consumption.

Table 3. Microbiological parameters of wells and boreholes water

Samples	Faecal coliforms	E. coli	Intestinal enterococci
	Unit : CFU/100 ml		
Borehole Tiebigué	0	0	0
Borehole Customs	150	15	0
Borehole Fangakaha	0	0	0
Well Kafalovogo	2100	120	30
Well Pargnonkaha	11900	980	80
Well customs	5900	3300	100
Well Residential	18000	5200	190
Well Mossi Dougou	4800	700	30
Well Zindel	19000	380	240
Well N'bagnan	3600	410	60

4 DISCUSSION

Boreholes and wells used for drinking water in Ferkessédougou were surveyed during the rainy season to evaluate their quality. Microbiological characteristics of these water were quantified and compared to corresponding WHO thresholds. The results indicated that the groundwater in Ferkessédougou was acidic, which confirmed previously reported conclusions [26]. Such acidity levels groundwater were in line with the levels found in other regions in Côte d'Ivoire [27]. According to reference [28], pH is one of the characteristic elements of groundwater in Côte d'Ivoire. This acidity originates from the decomposition of plant organic matter, characterized by CO_2 production in the top soil layers [29]. The hydration of CO_2 produces carbonic acid (H_2CO_3), which ionization results in H^+ ions. In Bamako, Mali, reference [30] also found acidic to neutral water from boreholes and wells, with values ranging from 4.45 to 7.48 and 4.45 to 7.14 for boreholes and wells, respectively. The water acidity was related to the siliceous and lateritic terrain of Bamako. For these authors, water with a pH of 7.2 to 7.8 is ideal for maintaining good health. Consuming liquids that are too acidic or too basic can upset this delicate balance, and lead to the development and growth of bacteria, viruses, fungi, yeasts and parasites.

Wells in the city of Ferkessédougou are dug manually and are generally shallow. They are therefore subject to infiltration of surface water and contamination from domestic wastewater. The protective walls of the wells, typically made of clay, collapse after heavy downpours, which enable contamination from diverse sources including form faecal origins [31]. In this study, the temperature of water from the selected boreholes and wells was close to ambient temperatures. It should be noted that water temperatures ranging from 28°C to 32°C are optimum conditions for the growth and proliferation of mesophilic microorganisms, which can result in the loss of water quality.

The microbiological analyses indicated the presence of faecal coliforms in all water samples. Wells water is more vulnerable to pollution from anthropogenic activities. Indeed, references [32,33] reported the presence of faecal coliforms and intestinal enterococci in wells water due to contamination of faecal origins. Intestinal enterococci and E. coli and faecal coliforms are indicators of faecal pollution and are largely of human origin. The presence of faecal coliforms confirms the influence of anthropogenic activities on the water quality in Ferkéssedougou. The *E. coli*/EI ratio was greater than 4 in the majority of the selected wells. This pollution of human origin comes from the septic tanks [34]. Our results are similar to those of previous reports on the evaluation of the quality of wells water for domestic use in disadvantaged neighbourhoods of four municipalities in Abidjan, Côte d'Ivoire [11,35,36,37]. The majority of wells are built in concessions where there are only showers and traditional latrines located near the showers or less than 15 m, the minimum distance recommended by the WHO. These wells are thus exposed to the infiltration of wastewater from these latrines and showers. The *E. coli*/EI ratio the P1 Zindel well was below 2, indicating a mixed contamination.

The quality of boreholes and wells water is variable and depends on several factors including the location of the borehole or well, and endogenous urban contamination sources. In our study the factors explaining the presence of bacteria in the selected wells can be related to the position of the wells in relation to waste dumps and wastewater points, the manual emptying of cesspits, the absence of adequate protection perimeter, the poor household waste management and behaviour (e.g., the drawing tools are often on the ground and are not disinfected before use, open defecation), the wandering of animals (poultry, dogs and cats, etc.) near the water sources, and the movements of groundwater between polluted and clean aquifers. It is important to emphasize that faecal coliforms and intestinal enterococci are good indicators of water contamination by faecal matter. These bacteria are always present in large quantities in animal and human waste and are barely found in soil and water which have not been subject to faecal pollution [38]. The correlations observed between the presence of these faecal contamination indicators and pathogenic bacteria, coupled with the precautionary principle, lead to the systematic elimination of all germs during treatment by water plants. According to reference [26], the water sourced from wells and boreholes in Ferkessedougou was safe regarding the WHO standards physico chemical parameters. But according to the microbiological parameters the water sourced from the same wells and boreholes in Ferkessedougou are not safe for drinking water.

5 CONCLUSION

We quantified the microbiological quality of drinking water sourced from boreholes and wells in Ferkessédougou. The results revealed that wells water was contaminated by substances of faecal origins, with Escherichia coli, faecal coliforms, and intestinal enterococci found in different proportions according to the wells, making such water unsuitable for human consumption if untreated. This water pollution was related to infiltration of wastewater from cesspools and nearby garbage dumps, inadequate perimeter protection, and the poor management of these groundwater sources. The vast majority of households in Ferkessédougou are unaware of the impact that poor sanitation habits and the poor management and maintenance of wells and boreholes can have on the microbiological quality of drinking water, increasing the risks and vulnerability to water-borne diseases. Given the poor quality of wells water due to the presence of germs, it is important to treat this water prior to its use and consumption.

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