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Determination of Water quality and Chlorine demand in Traditional wells of Marais district (Daloa, Côte d'Ivoire)

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Abstract : Water intended for human consumption must not contain dangerous chemicals or microorganisms harmful to health. In Daloa, 95.7% of households in precarious neighborhoods use traditional wells because they are not connected to the drinking water network.The present study aimed to assess the chlorine demand in well water in the Marais district of Daloa.25 water samples were taken from 25 wells and physicochemical and microbiological analyzes were carried out before determining the chlorine demand. The results showed that the temperature, pH and conductivity mean values were 27.97±0.33°C, 5.45±0.79 and 868.99±269.78 µs/cm respectively. The means concentrations of calcium, magnesium and chlorides were 42.88±27.17 mg/L, 29.81±16.26 mg/L and 33.4±14.64 mg/L respectively. The average number of Total Coliforms and Fecal Coliforms was greater than the WHO guideline value of 10 CFU/100 mL for Total Coliforms and 0 CFU/100 mL Fecal Coliforms.Fecal Streptococci, Sulfite Reducing Anaerobes and Salmonellae were almost absent in wells water. The dose at the break-point ranged from 2 to 3 mg/L with residual chlorine ranging from 0.3 to 1.7 mg/L. The chlorine demand of these waters was between 0.3 and 1.8 mg/L.These large variations were due to the presence of mineral compounds.
Key words : Chlorination, microbial contamination, residual chlorine,Well water.

Introduction

Drinking water is crucial for good nutrition and human health.According to the report of the World Health Organization[1], five million childrens die each year from diarrheal diseases due to contamination of food or drinking water.Water intended for human consumption must therefore not contain dangerous chemicals or microorganisms harmful to health.Thus, maintaining the quality of drinking water remains a constant and major concern of all the drinking water treatment and distribution actors[2].In addition, according to a joint WHO and

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UNICEF report[3], 30% of the world's population do not have access to domestic drinking water supply services, especially in developing countries.In these countries, basic service infrastructures does not keep pace with population growth coupled with anarchic urbanization.In Côte d'Ivoire, more than 8 million people or 43% of the population lack basic sanitation facilities and more than 4 million people still drink water from unimproved sources[4].In Daloa, capital of the Haut-Sassandra region, 64.03% of waterborne diseases are thought to be associated with the consumption of well water[5].In this city, 95.7% of households in precarious neighborhoods are not connected to the Côte d'Ivoire Water Distribution Company[6].These populations use traditional well water, the quality of which is not guaranteed[5], this is the case in the Marais neighborhood.The shallow water tables and the unhealthy environment are sources of pollution of these wells. The quality of these waters is regularly threatened.It is therefore necessary to carry out an appropriate treatment before their consumption[7].The elimination of microorganisms in these waters by disinfection is one of the objectives of this treatment.Disinfection makes it possible to obtain mineralogically drinkable water while maintaining a residual disinfectant in it to prevent the survival of microorganisms and prevent the risk of potential contamination[8].There are many methods used for disinfection purposes.They are provided by chemical oxidants such as chlorine, chlorine dioxide, ozone and by physical processes such as the use of ultra-violet radiation[9].Because of its effectiveness, its persistence and for economic reasons, chlorine is used preferentially over other oxidants[10].The objective of this study was to evaluate the quantity of chlorine necessary to neutralize all pathogenic microorganisms in well water while keeping a dose of residual chlorine in order to ensure the protection of these waters against possible contaminations.

Material sand methods

Study area

The city of Daloa is located in the center west of Côte d'Ivoire in the Haut-Sassandra region between 6°53 north latitude and 6°27 west longitude. It covers an area of 5305 km^2 and is made up of 33 neighborhoods including the Marais district.

Choice of wells and sampling

The identification and selection of the wells were made after a field survey focusing on the socioeconomic characteristics of households, access to drinking water, methods of using well water, maintenance of these structures, their position in relation to the septic tanks, their depth as well as the treatments applied to this water.In total, 25 wells numbered P1 to P25 were retained and sampled (Figure 1). The water samples were taken in the morning using a bucket fitted with a graduated rope.These samples were stored in 500 mL polyethylene bottles previously rinsed with distilled water and then with well water. They were then transported to the laboratory in a cooler containing ice for analysis.pH, temperature and conductivity were measured in situ during sampling using a PHYWE brand multi-parameter.

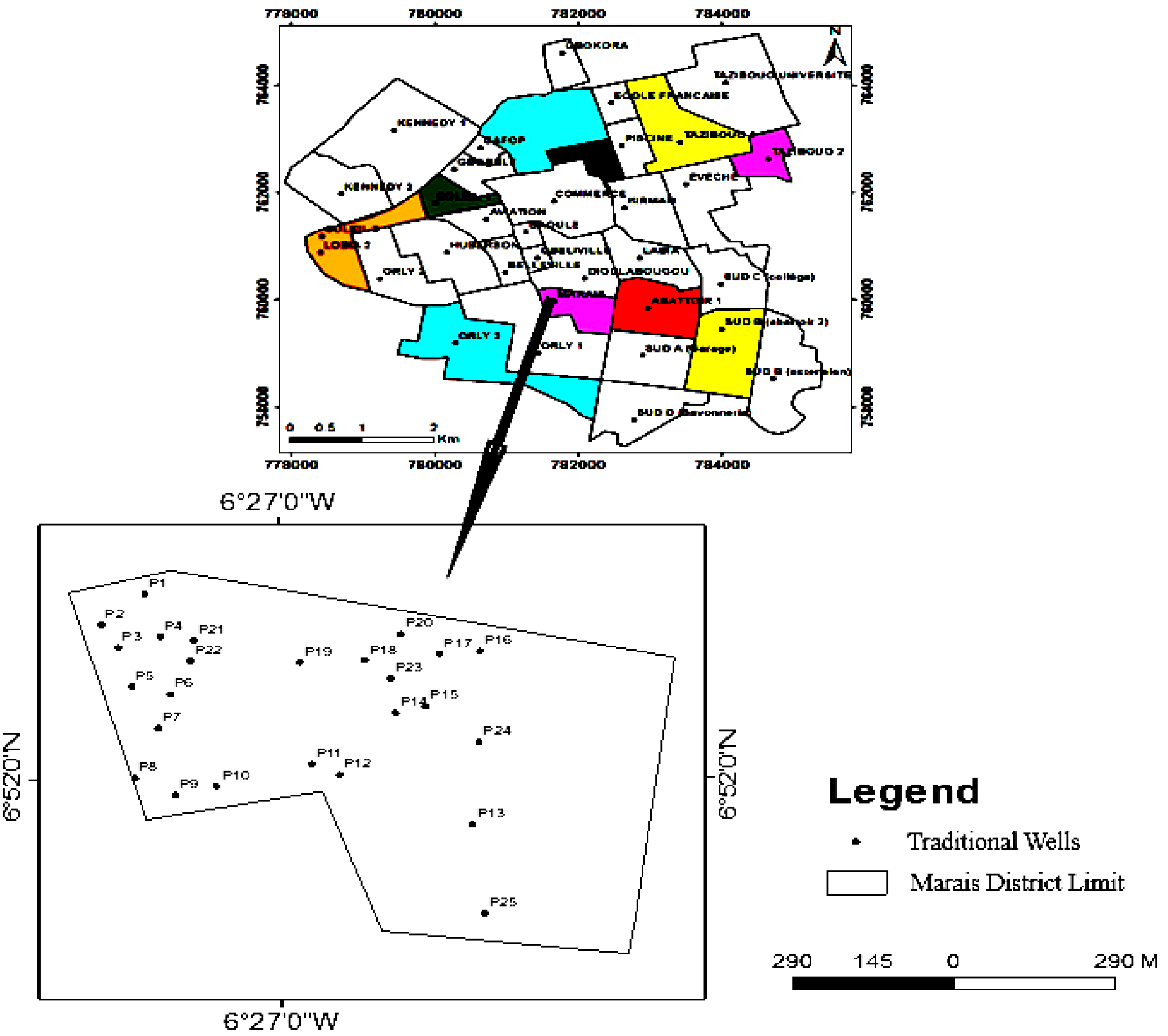

Figure 1: Location of sampling wells in the study area

Physico-chemical analyzes

In the laboratory, Total Hardness (TH), calcium, magnesium and chlorides were determined by the titrimetric method with EDTA. Turbidity was also measured using a PANNA brand turbidimeter.Total coliforms, thermotolerant coliforms and streptococci, salmonella and sulphite reducing anaerobes were enumerated before the chlorine demand determination by the break point method described by Rodier (2009).The residual chlorinewas determined by the iodometric method.The chlorine demand was determined by deducting the residual from the amount of chlorine added.

Chlorine Demand = Known Dose - Residual Chlorine

Results

General characteristics of wells

The general characteristics of the wells studied reveal that 84% of them had a level less than 10 m from the ground surface.The copings of 96% of the wells were cemented but 68% had a wooden cover.72% of these wells were within 15 m of the latrines.

Physico-chemical characteristics of well water

The physicochemical characteristics are presented in Table 1. The average values of temperature, pH, conductivity, turbidity and total hardness were 27.97±0.33°C, 5.45±0,79, 868.99±269.78 µs/cm, 7.44±7.79 NTU and 7.28±3.56°f respectively.Unlike the temperature, which varied very little from one well to another, the electrical conductivity and the total hardness of the water varied significantly from one well to another.pH values showedthe acidic character of these waters. As for calcium ions, magnesium ions and chloride ions, the average values recorded were 42.88±27.17 mg/L for calcium ions, 29.81±16.26 mg/L for magnesium ions and 33.4±14.64 mg/L for chloride ions.

Table 1: Physico-chemical characteristics of well water

Water Parameters	Minimum	Maximum	Mean value
Temperature (°C)	27.00	29.50	27.97±0.33
pH	3.60	6.60	5.45±0.79
Conductivity (µs/cm)	352.90	1423.50	868.99±269.78
Turbidity (NTU)	0.46	36.20	7.44±7.79
Total Hardness (°f)	2.06	18.50	7.28±3.56
Calcium ions (mg/L)	8.00	132.00	42.88±27.17
Magnesium ions (mg/L)	3.00	56.00	29.81±16.26
Chloride ions (mg/L)	11.72	74.54	33.4±14.64

Microbiological characteristics of well water

The bacteriological quality of the well water in the area was assessed from the enumeration of a few germs indicative of faecal contamination and germs potentially pathogenic for the consumer.The results are reported in Table 2.The average number of total and fecal coliforms was less than 15 while that of fecal streptococcus and anaerobic sulfite reducing was less than 1.Salmonella were almost absent in the environment.

Table 2: Microbiological characteristics of well water

Germs	Total Coliforms and Fecal Coliforms	Fecal Streptococci and Anaerobic Sulphite Reducing	Salmonella
Average number in 100 mL	<15	<1	Absent

Chlorine Demand

The dose values at the break-point showed that the wells studied can be grouped into three categories.The first category had a break-point dose of 2 mg/L. It consisted of 6 wells (P2, P6, P15, P17, P19, P23).The second category consisted of 9 wells (P3, P4, P5, P9, P12, P13, P16, P20, P25) and it had a break-point dose of 2.5 mg/L.The third category had a break-point dose of 3 mg/L and it consisted of 10 wells (P1, P7, P8, P10, P11, P14, P18, P21, P22, P24).

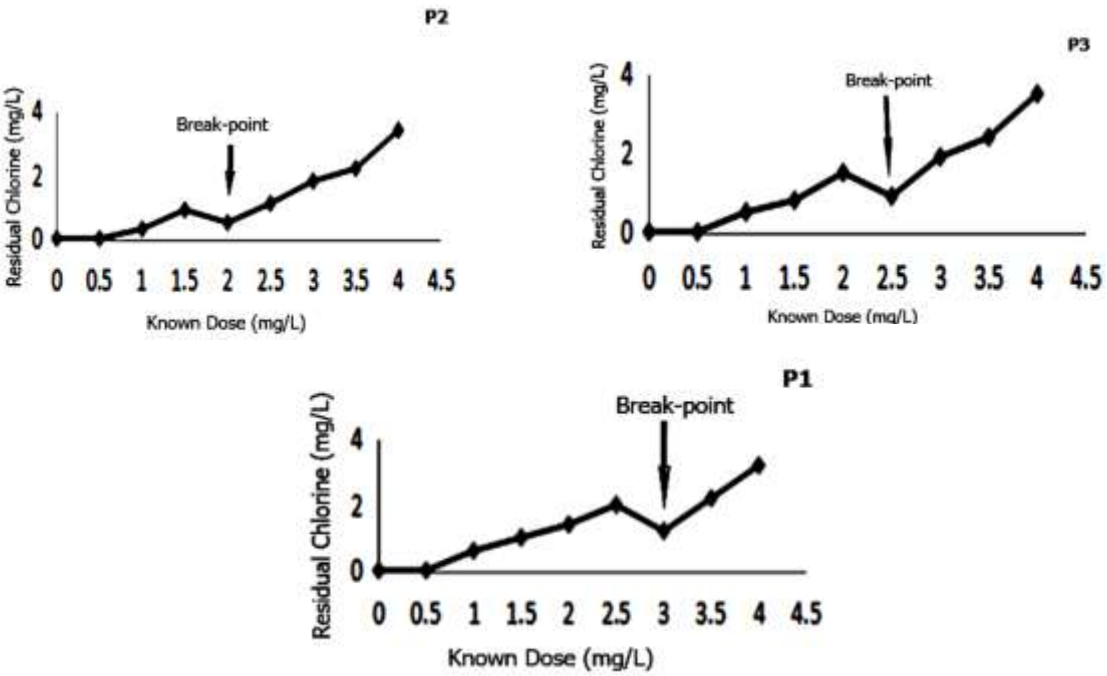

Figure 2: Break-point graphic of the three categories of wells

Figure 3 presents a summary of the process of chlorine demand in the studied wells water. The residual chlorine concentrations in the water were between 0.3 to 1.7 mg/L from the doses added at the break pointand the doses consumed by microorganisms and minerals varied from 0.3 to 1.8 mg/L.

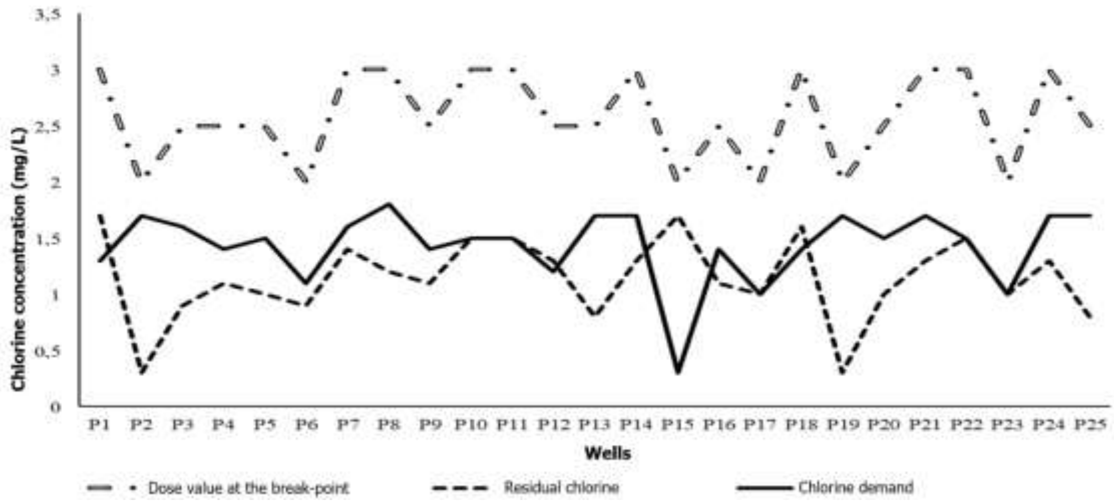

Figure 3: Variation of chlorine demand in wells water

Discussion

This study aims to determine the chlorine demand of wells water in the Marais district at Daloa. 72% of the wells studied were close to latrines or septic tanks.This proximity to latrines or septic tanks coupled with the shallow depth of these wells increasestheir vulnerability and promotes the proliferation of microbiological germs in the water according to Graham and Polizzotto[11].The physico-chemical characterization of these waters revealed that their temperature was high. The value of this parameter was therefore influenced by that of the ambient environment.This high temperature indicates that the water from these wells constitutes a good environment ofculture for microorganisms. pH value was between 4.0 and 6.6 reflecting the acidic character of the water.The values recorded for the well water of the Marais district were similar to those obtained by Ligban et al.[12] during the study of the hydrogeochemical process and origin of natural sources in the square degree of Daloa.In addition to temperature and pH, turbidity provides information on suspended and colloidal matter pollution in these waters. Its average value of 7.44 NTU can have significant effects on water quality.Indeed, high turbidity promotes the increase in the number of certain bacteria in the water, as highlightedby Power and Nagy[13] who demonstrated a correlation between this parameter and the development of heterotrophic aerobic and facultative anaerobic bacteria.Regarding conductivity, the values were between 352.9 and 1423.5 µs/cm. These valuesindicate that the well water studied is mineralized although it is less than 2000 µs/cm which is the value recommended by WHO[14].As for the calcium, magnesium and chloride ions, the concentrations obtained were lower than the maximum admissible values which are 100 mg/L for calcium, 50 mg/L for magnesium and 200 mg/L for chlorides.Examination of microbial contamination showed that the number of total coliforms and fecal coliforms was almost constant in the water from the wells sampled. The values obtained were greater than the guideline value for drinking water which is 10 CT/100 mL for total coliforms and 0 CF/100 mL for fecal coliforms[1].This contamination could come from domestic activities and would also be due to the direct exposure of wells to runoff water loaded with microorganisms. Fecal streptococci were almost absent.They had been found in trace amounts. As for the Salmonella, they were totally absent.In general, the biological quality of well water in Africa revealed that most traditional wells were polluted. Studies on well water in Burkina-Faso, Rwanda, Benin and Guinea Conakry have shown that 70% of traditional wells in Burkina-Faso, 55% of sources captured in Rwanda, 96% of traditional wells in Benin and 100% of traditional wells and sources captured in Guinea were polluted respectively[15].The position of the traditional wells in relation to the sources of pollution (waste dumps, wastewater and septic tanks), the poor layout of the wells (absence of coping and protection perimeter) and the shallow depth of the wells were factors that could explain the presence of microbiological germs in Daloa's wells.Regarding the disinfection of these waters, the immediate chlorine demand was not zero (0.5 mg/L). Immediate chlorine demand is the amount of chlorine consumed before it reacts with nitrogen compounds.After removal of inorganic compounds, mineral chloramines are formed and act as residual chlorine[16]. When all the nitrogen compounds have reacted with the chlorine, the added chlorine destroys the chloramines formed until a minimum is reached.

The break-point is thus reached. Additional doses of chlorine subsequently lead to an increase in the amount of chlorine already available.The recorded break-point doses ranged from 2 to 3 mg/L. This variation would be due to the presence of mineral compounds which would raise the values at the break-point[17].The chlorine demand of the wells water studied could also be linked to mineral compounds. The presence of chloride ions also causes a decrease in the potential for chlorine consumption[18].

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