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Assessment of the quality of water in wells at Bépanda quarter, Douala-Cameroon, by use of the indicator bacteria of faecal contamination

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ABSTRACT

Objective: A bacteriological study was carried out over five months to assess the water quality of seven wells located in the same quarter Bépanda (Douala). These wells were selected according to their presence of a near source of pollution, the number of users and the prevalence of total coliform.
Methodology and results: Faecal coliform (FC) and faecal streptococci (FS) were analysed using the membrane filter technique with specific culture media Mac Conkey and Slanetz and Bartley agar, respectively. Counts of these bacteria were well above standards established by Word Health Organization for primary human contact (FC < 100 CFU/100 ml and FS < 100 CFU/100 ml), and varied from 10^2 to 21.10^4 CFU/100 ml for total coliform, 10^2 to 45.10^3 CFU/100 ml for faecal coliform and to 10 to 24.10^1 CFU/100 ml for faecal streptococci.
Conclusion and application: It was concluded that users of water from the investigated wells are risk of contracting waterborne diseases. This calls for prompt intervention to mitigate the socio-economic and health impacts of water-borne diseases in these urban communities. Moreover, this study showed the challenges for health and water resources in Cameroon and presumably other developing countries.
Keys words: Environment, Health, Pollution, Water

INTRODUCTION

Among many other factors related to human health, water is implicated in the transmission of infectious diseases. Globally, approximately 5,000 deaths in the world are caused daily by infectious waterborne microorganisms (Cartley-carlson, 1993; Prüss and Havelaar, 2001). Groundwater represents one of the principal sources of fresh water and hence it assumes an enormous importance in the domestic and industrial activities. In view of the groundwater being used for potable purposes, its quality remains one of the major issues of concern. Groundwater is one of the aquatic biotopes that contains varied microflora.

The use of water from wells, without any previous treatment, can involve serious health problems due to the potential presence of pollutants and pathogenic bacteria. Unhygienic peridomestic sanitation and unsafe environments lead to the incidence of waterborne illness and place children at risk of death (Ezzati et al., 2002; Guilbert, 2003). More than half of the reported waterborne disease outbreaks have been linked to contaminated groundwater (Craun et al., 1997). Ingestion of contaminated water due to lack of hygiene and sanitation contributes to about 1.5 millions child deaths and around 88% of them from diarrhoea per year (Ezzati et al., 2002; Guilbert, 2003).

Groundwater constitutes the main sources of drinking water supply in most African cities for example in Douala, the economic capital of Cameroon As a result of anarchistic urbanization, pit latrines and water wells are in close proximity and in same with dwelling place. Also industrial companies which are a majority are not equipped with appropriated sewage drainage pipes (Ndjama et al., 2008). In addition, the supply of drinking water which is a major objective of the government is far from being achieved by all the populations (Ndjama et al., 2008). Less than 20 million m^3 of water are distributed annually by the single society "Societé Nationale des Eaux du Cameroun" (SNEC), for a population estimated at three million inhabitants. This low volume of drinking water obliges most of the population to resort to spring waters and wells whose microbiological quality is unknown.

The aim of this study was to determine the bacteriological quality of water from wells used at Bépanda quarter (Douala city) by enumerating in these waters indicator bacteria of faecal contamination. For this, total coliform (TC), faecal coliform (FC) and faecal streptococci (FS) were counted, with the knowledge that FC and FS have been shown to be better indicators of faecal pollution and suggest the presence of other potential human enteric pathogens in water such as the hepatitis A virus (Craun et al., 1997). In addition, coliform bacteria in the environment may themselves represent a health risk.

MATERIALS AND METHODS

Study site description and sampling: Douala is located between 4°04' at latitude north and 9°45' at longitude East, with rainfall average of 2900 mm per year. Temperature variations are between 26° and 31°C, the soil is clay and sandy. In this area, groundwater supplies are the major water resources for a large part of population. These communities rely only on untreated well water as a source for their multiple domestic activities, like laundry, car washing, bathing, watering of crops for raw consumption, drinking and animal watering. In this preliminary work, only wells located in the quarter named Bépanda were chosen for this investigations (figure 1), given the great vulnerability of this area to a contamination.

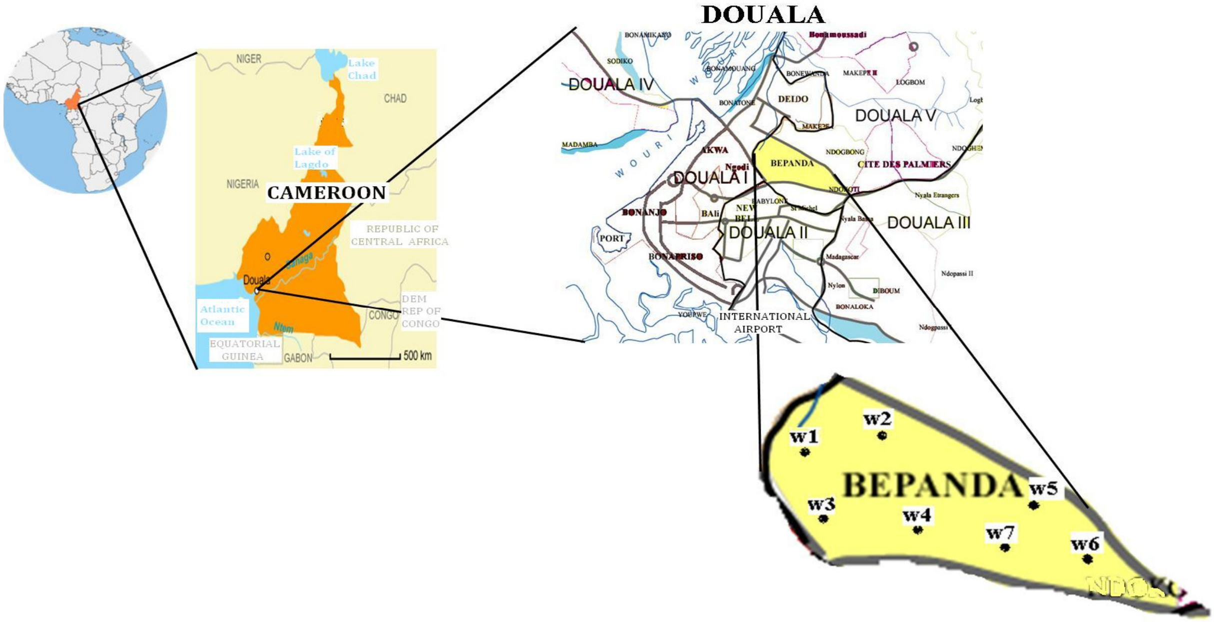

Figure 1: Map of the groundwater in Bépanda quarter and its geographical location at Douala in Cameroon within the African continent. Sampling points are designed by W, followed by subscript 1, 2, 3, 4, 5, 6 and 7.

In 2004, above 70% of death cases were registered in Bépanda, when Douala was threatened by a cholera epidemic (Délégation de la Santé du Littoral, 2004). Bépanda stretches on about 400 ha with about 350 inhabitants.

Samples were collected 4 times per month over a period of 5 months, in seven wells (W_1, W_2, W_3, W_4, W_5, W_6, and W_7) that were all close to latrines (< 10 m). Also, apart from the second well that was 27 m deep, all the others were between 1.5 and 6 m deep. These wells occasionally received chlorine treatment from the urban community. A complete description of characteristics and the environment of prospected wells are summarized in Table 1. Selection was focused on wells used by a great number of peoples from the population, the distance from the pollution source (latrines) and the depth of the wells. The well (W_2), which is 27 m deep (), was taken as the control.

Table 1: Description of the characteristics and the environment of studied wells

Wells	Depth(m)	Maintenance*	Wall (m)	Pollution source	Distance from pollution source (m)	Use
W_1	4	bad	0,5	latrines and domestic sewer	8	cooking, bathing, laundry
W_2	27	Satisfactory	1,2	latrines	7	drinking, cooking, bathing, laundry
W_3	1	bad	1	latrines, domestic sewer, rubbish	1	bathing, laundry
W_4	0,75	bad	1	latrines, domestic sewer	1	bathing, laundry
W_5	1,5	bad	absent	domestic sewer, rubbish	11	cooking, bathing, laundry washing food, brushing teeth
W_6	2	Bad	1	latrines	2,5	bathing, laundry washing food,
W_7	6	bad	0,9	latrines	5	cooking, laundry bathing, washing food,

* Maintenance refer to hygienic efforts observed for the preservation of the good quality of water in the well, this included among others: availability or not of a well cover, management of the bucket used to collect water from the well, frequency of disinfection treatment of water in the well when this was applicable.

Water sampling collection, analytic and counting method: Samples were collected in 250 ml sterile Pyrex bottles, immediately stored in a dark refrigerator box and transported to the laboratory at the University of Douala for analyses. The period between the sample collection and laboratory analyses was in all cases < 6 h. In the laboratory, sub samples for each of the wells under study were analysed for three bacterial indicators of faecal pollution: total Coliform (TC), faecal Coliform (FC) and faecal streptococci (FS). All these bacteria were enumerated by the membrane filtration technique, utilizing sterile gridded cellulose filters of 0.45µm nominal pore size (47 mm diameter) (APHA, 1992). For each sample, funnels and supports for the vacuum filtration system were sterilized before use by autoclaving for 20 min at 120°C and were decontaminated between samples by flaming. Appropriate sample dilutions for each sampling site were performed in triplicate, depending on the bacterial concentrations. For this, 10 ml of a serial dilution in sterile Ringers solution were filtered using gridded membranes. These membranes were then placed on a specific sterile medium contained in 55 mm diameter sterile petri dishes and incubated inverted at an appropriated temperature. TC and FC were grown on Mac Conkey agar from laboratory Conda de Madrid (Spain) at 37 and 44°C respectively for 24 hours. FS were grown on Slanetz and Bartley agar (Pasteur Institute) at 37°C for two days. A blank with sterile Ringers solution was routinely examined for control of contamination on the equipment and the stock media.

Statistics: The comparison among well water points was done using the One Way Analysis of Variance (ANOVA test). Multiple Comparison Procedures (Student-Newman-Keuls Method) was used to compare wells two by two. (Schwartz, 1984)

RESULTS AND DISCUSSION

The abundance of the TC, FC and FS underwent high spatial and temporal fluctuations (Figure. 2).

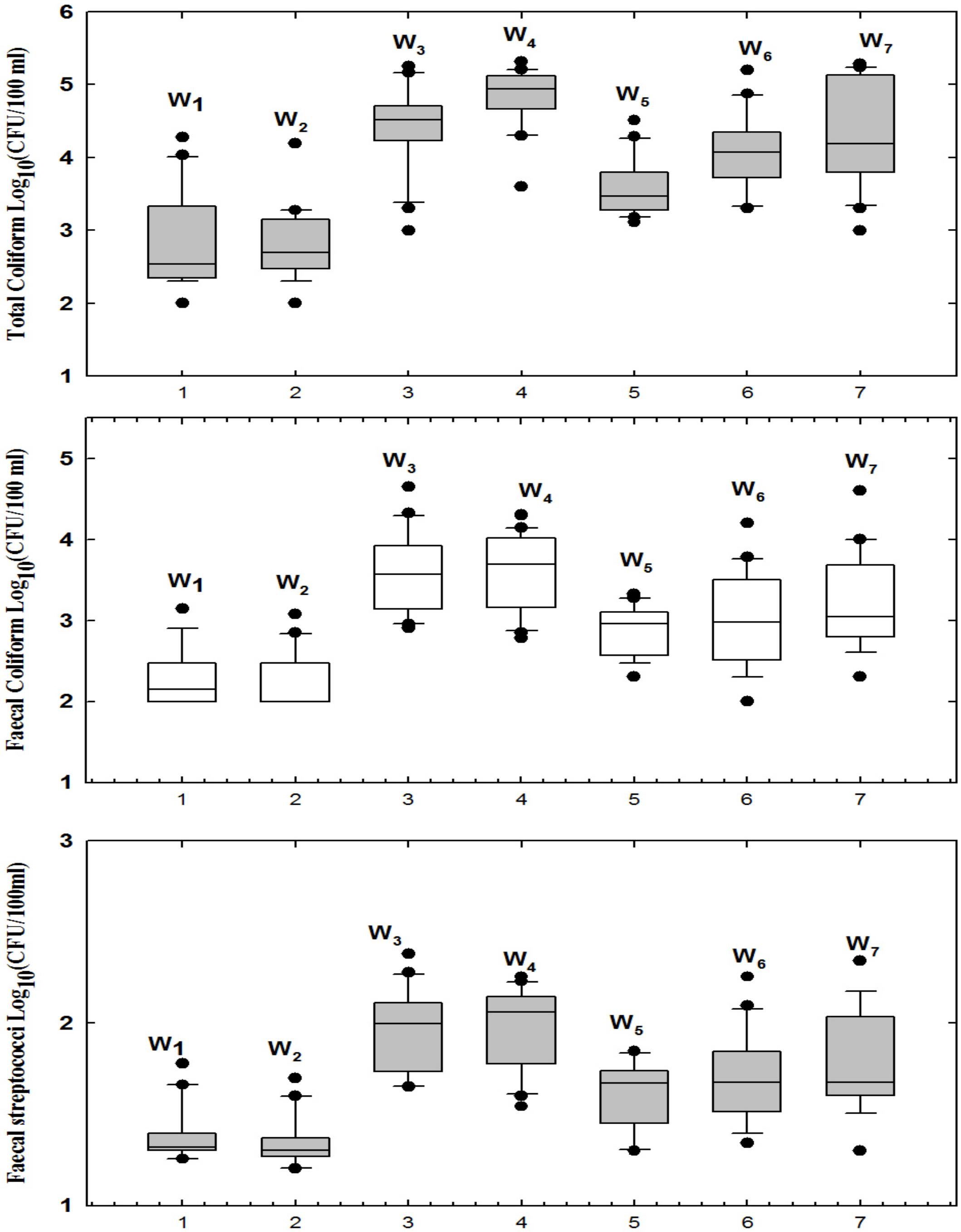

Figure 2: Box and whisker plots of the spatial distribution at Bépanda (Douala) of the level of total coliforms, feacal coliforms and feacal streptococci in the groundwater in Bépanda. Data are presented as box plots of first quartile (25th percentile), median value (50th percentile) and third quartile (75th percentile). Vertical bars on either side of the box plots represent the 5th and 95th percentiles, and black dots correspond to extreme values (lower than the 10th percentile or greater than the 90th percentile).

For all examined samples, densities counts of TC varied from 100 to 21 x 10^4 CFU/100 ml (Mean ± SD = 33 x 10^3 ± 51 x10^3 CFU/100 ml), with FC the variation was from 100 to 45 x 10^3 CFU/100 ml (Mean ± SD = 31 x10^2 ± 62 x10^2 CFU/100 ml) and for FS from 16 to 240 CFU/100 ml (Mean ± SD = 62 ± 48 CFU/100 ml). These values are high in comparison to those reported by Lamrani et al. (2008) from groundwater in Marrakesh. On the whole, water from 70 to 90% of all 7 wells tested was contaminated (> 200 CFU/100 ml detected) with faecal and total coliform respectively. In general, total coliform levels were higher than faecal coliform levels for all wells (Table 2).

Table 2: Bacterial contamination in the water of the 7 wells

Well	**Total coliform (CFU/100 ml)**					**Feacal coliform (CFU/100 ml)**					**Feacal streptococci (CFU/100 ml)**				
	Min	Max	Median	Mean	Std Dev	Min	Max	Median	Mean	Std Dev	Min	Max	Median	Mean	Std Dev
W_1	100	19000	350	2435	4674	100	1400	150	290	337	18	60	21	25.85	11.33
W_2	100	15700	500	1465	3396.5	100	1200	200	255	276.2	16	50	20	23.5	8.84
W_3	1000	178000	33000	4905	4995.1	800	44800	3750	7045	100.8	45	240	100	103.55	51.70
W_4	4000	208000	86500	8870	5461.8	600	20000	4950	6300	5530	35	180	115	104	46.21
W_5	1300	32400	2950	6040	7641.9	200	2100	900	960	533.5	20	70	47	45	15.53
W_6	2000	159000	12000	2365	3629	100	15800	950	2340	3550.3	22	180	47.5	58.2	38.36
W_7	1000	192000	15500	5605	7027.9	200	39500	1100	4495	8878.4	20	220	47.5	74.25	54.22

Although faecal streptococci concentrations range as high as 240 CFU/100 ml in W_3, only about 5% of samples are above 100 CFU/100 ml. One way Analysis of variance and multiple comparison procedures with Student-Newman-Keuls methods were employed to determine which wells were significantly different from each other in term of bacterial contamination. It was hypothesized that the shallower and less-protected wells (W_3, W_4, and W_5) would be more contaminated by bacteria than deeper wells such as W_2.

When considering the densities of TC, the degree of pollution of the different well under study exhibited variability that was statistically significant from one sample site to another ($P < 0.001$) of interest, results from Pairwise Multiple Comparison analysis (Student-Newman-Keuls Method) indicated statistical significant difference between W_4 and W_6 ($P < 0.001$), W_4 and W_2 ($P < 0.002$), W_4 and W_1 ($P < 0.002$), and no significant difference was observed between mean values of others wells. TC monthly averages point to W_4 as the relatively most contaminated well among all the others. This is not surprising, given the environment of this well: low depth, bad maintenance, and closeness to the latrines (Table 1). These results highlighted the presence of a faecal contamination source, knowing that in general, coliform bacteria are considered to be those bacterial species normally present in, and limited to, the gastrointestinal tract of vertebrates (Leclerc et al., 2001).

With FC and FS, the pollution level between the studied wells changed with statistically significant difference ($P < 0.001$) among samples sites. Results of multiple comparison tests showed statistically significant differences between several pairs of wells; like, W_3 and W_2 ($P < 0.003$), W_3 and W_1 ($P < 0.002$), W_3 and W_5 ($P < 0.006$), W_3 and W_6 ($P < 0.043$), W_4 and W_2 ($P < 0.010$), W_4 and W_1 ($P < 0.007$), W_4 and W_5 ($P < 0.015$). Accordingly, W_4 and W_3 were considered to belong to the same group of wells with bad water quality; as expected, total bacteria were elevated at site W_4 and W_3 compared to others sites. This presence of high concentrations of FC and FS is worrying, knowing that feacal coliforms and feacal streptococci are used as an indication of feacal contamination and reflect the risk of pathogens presence in the water (Gross et al., 2005). This is also an indication that the faecal contamination was not only recent, but rather occurred since a while (Jord˜ao.et al., 2002). At the end it was noted that, variable levels of difference were recorded between studied wells when considered in pair for TC, FC and FS. However, some of total coliform CFUs are most likely the results of benign bacteria that do not reflect sewage contamination of the groundwater and therefore total coliform CFUs were used only as a secondary indicator of contamination (Warner et al., 2008).

From the multiple comparison, it was also noted that, in spite of the high depth of W_2, its bacterial characteristics were not satisfactory; so it was concluded that there are many factors which influence the groundwater quality; among other things, the type of pollution source(s), the distance separating the well and the pollution source(s), the maintenance of the well, the nature of the ground, and many anthropogenic influences. The same conclusion was drawn by Belinda Barnes and David M. Gordon (2004) in developing methods that will allow identifying the source of the feacal contamination.

CONCLUSION

An analysis of the well water quality in the Bépanda city (Douala) by means of feacal indicators bacteria showed a bad general water quality, throughout the study. The maximum and minimum values of all the bacteriological parameters exceeded the acceptable limit for primary human contact recommended for FC < 100 CFU/100 ml and FS < 100 CFU/100 ml by the World Health Organization (1984). From the above studies, it has been found that as long as any source of pollution exists, water is maintained in bad quality even if the depth is low. The well W_2 which was chosen to be the control according its low depth had no better water quality.

These observations suggest that there were probably some hidden sources of pollution given that, coliform bacteria may enter the environment as a result of faecal contamination from humans, domestic animals and wildlife and as well as runoff from agricultural land, inadequate septic systems or sewer overflow. Severely deteriorated conditions were detected during the study in two wells (W_3 and W_4) due to the urban waste water discharge. The most affected parameters were TC and FC. These results indicate that the water reservoirs need to be treated regularly. Furthermore, public health authorities should make the public aware of the potential danger of the public water supply, and encourage in-house treatment of the water before consumption (because of the presence of some coli bacteria, all water should be treated by chlorination before being used). Specifically, the public should be informed that although the water smells and looks clean, it might contain infectious bacteria like V. cholerae O1 and O139 that can cause cholera or other diarrhea (Sirajul Islam et al., 2007).

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