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Full Length Research Paper

Bacterial contamination of water points of the upper Mfoundi watershed, Yaounde, Cameroon

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More than 80% of the population of the peri-urban area of Yaoundé (Cameroon), do not have access to drinking water and resort to wells, springs and rivers to satisfy this need. The bacteriological quality of such water sources is doubtful because of their proximity to both point and diffuse sources of pollution and can thus present public health risks. In order to evaluate the bacteriological quality of water in peri-urban areas of Yaounde, samples were taken from springs, wells and rivers and analyzed according to World Health Organisation (WHO) standards. Results showed that the total colony count is diversified: *Acinetobacter* sp, *Citrobacter* sp, *Enterobacter* sp, *Enterobacter cloacae*, *Escherichia coli*, *Klebsiella pneumonia*, *Levinea* sp, *Proteus vulgaris* and *Pseudomonas* sp are present. Faecal coliforms and faecal streptococci are abundant reaching 34053±94225.5 and 15107.6±50515 CFU/100 ml respectively. These results show that the bacteriological quality of water points of precarious quarters in Yaoundé belongs to class D according to WHO. This level of pollution indicates a significant degradation of the water and emphasises the need for developing appropriate sanitation strategies.

Key words: Coliforms, pollution, public health, *Streptococci*, Yaoundé.

INTRODUCTION

Sub-Saharan African countries like Cameroon are experiencing rapid demographic growth, urbanisation and the expansion of industrial activities. Uncontrolled settlement in these urban centres, coupled with limited financial resources, has rendered the provision of potable water to the population largely inadequate and at times impossible (Kuitcha et al., 2008; Ndjama et al., 2008). About 51% of the population in Douala is connected to the potable water network provided by CAMWATER (Ndjama et al., 2008) while the rate of connection is only 40% in Yaoundé (Kuitcha et al., 2008). In fact, less than 40% of the population of Cameroon has access to potable water (Tanawa et al., 2002). The vast majority is thus compelled to turn to alternative sources like springs, wells and streams whose bacteriological quality is greatly compromised by their proximity to both point and diffuse sources of pollution. Studies carried out in different areas of Cameroon indicate that most of the sources of domestic water have an alarming level of microbiological pollution (Katte et al., 2003; Tita et al., 2009; Mpakam, 2009).

Urbanisation and the expansion of industrial activities come along with the production of large quantities of solid and liquid waste. These quite often do not receive the appropriate treatment before being discharged into the environment. Industrial effluents discharged in the environment are sometimes 10 to 100 times more concentrated in pollutants than the WHO standards (Katte et al., 2003). Furthermore, approximately one quarter of the Cameroonian population does not have

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access to adequate sanitation systems (Katte et al., 2003). The presence of autonomous sanitation systems increases the risk of contamination of surface and underground water resources (Coulibaly et al., 2004; Kuitcha et al., 2008; Ndjama et al., 2008).

The majority of health problems which African countries face are water related: malaria, typhoid, bilharzias, diarrhoeal diseases, cholera, dysenteries (Kuitcha et al., 2008; Ndjama et al., 2008). These diseases are debilitating to the labour force and so retard the economic development of the country and render the fight against poverty futile (Donkor, 2003). They represent about two-thirds of all the diseases in Cameroon and are responsible for approximately 50% of the cases of death recorded (Katte et al., 2003).

There is a direct link between access to potable water and the reduction in epidemic diseases as well as infant survival rates. That is why most programs for sustainable development lay emphasis on the improvement of the quality of, and the access to water. The evaluation of fresh water resources for reliability and quality, together with the identification of potential sources, which is a precondition to the sustainable management of water resources, has not been systematically carried out in Cameroon (Katte et al., 2003). Consequently, the extent of the pollution of water supplies is not yet fully appreciated.

The general objective of this study is to evaluate the bacteriological quality of some water points used by an important fringe of the population in the peri-urban area of Yaoundé. The specific objective is to determine the specific bacterial enrichment, the bacterial abundance and the origin of bacterial pollution of the water points. This is in view to contribute to the setting up of strategies to control pollution and improve public health.

MATERIALS AND METHODS

Study area

The study was carried out in the upper Mfoundi watershed in Yaoundé (Cameroon). Yaoundé is an urban zone of approximately 256 km², limited by latitudes 03°45' and 04°00' N and longitudes 11°20' and 11°40' E (Santoir and Bopda, 1995). The population of Yaoundé was estimated at 1500000 inhabitants in the year 2000, has a growth rate ranging between 3.5 and 6.2%, resulting in a very rapid and uncontrollable spatial expansion. The population density varies between 3.2 and 5.69 inhabitants/km^2 (Bruneau, 1999).

The relief is characterized by an alternation of hills and plains. The highly domesticated landscape was initially semi–deciduous forest (Bruneau, 1999). Yaoundé town is drained by a number of perennial rivers including the Mfoundi, Mefou and Mfoulou (Olivry, 1986). The geological substratum is made of fractured embrechites constituting exploitable reservoirs for wells and boreholes. It is covered by sandy-clay alluvia in thalwegs, and laterites on the flanks of hills (Yongeu-Fouateu, 1986). Yaoundé has an equatorial climate with four seasons comprising a long dry season (December-February), short rainy season (March-June), short dry season (July-August) and a long rainy season (September-November) (Suchel, 1972). The average annual rainfall is 1600 mm and an average temperature of 23°C.

For this work investigations were carried out in wells, springs and rivers found in Mbankolo, Etoa-Meki, Ngousso, Nkol-Eton, Rue Manguier, Etoudi and Tongolo quarters all of which are situated within the upper Mfoundi watershed in Yaoundé (Figure 1).

Sampling

Sampling was carried out from March 2006 to February 2007 in wells and springs selected from different topographic levels and concerned those that are most solicited by the populations. 12 collection points were identified for sampling: 6 wells (P1 - P6) of depths varying from 1.5 to 9 m; 3 springs (S1 - S3) and 3 rivers (E1 - E3). At each sampling point, 0.5 l samples of water were collected in sterile glass bottles and immediately transported to the laboratory in an ice bucket at 4°C for analysis.

Bacteriological analyses

The bacteria indicators of pollution, faecal coliforms and faecal streptococci, were analysed together and the pathogenic bacteria (*Salmonella*, *Shigella*, *Vibrio cholerae*, *Enterobacter*, *Citrobacter* and *Pseudomonas*) identified. The analyses were carried out in Centre Pasteur, Yaoundé, and at the Plant Physiology laboratory of the University of Yaoundé I. Faecal coliforms and faecal *Streptococci* were enumerated using the membrane filter technique described by Ford (Marchal et al., 1991) and the results expressed in Colony Forming Units per 100 ml of water (CFU/100 ml). Specific pathogens were identified on Hectoen agar after enrichment on Rappaport (APHA, 1992), and presumptive colonies confirmed biochemically according to the usual criteria (Ford, 1994).

Statistical analyses

All the data were analysed using SAS software. Calculated averages are accompanied by the standard deviations. The Kolmigorov-Smirnoff test was used to test the normality of the data. In the absence of normality, the averages were compared thanks to the Kruskall Wallis nonparametric test and Wilcoxon two sample test. Probability for significance was set at $p \leq 0.05$.

RESULTS AND DISCUSSION

Species richness of the total colony counts in the water points

The study showed that the water points of the peri-urban quarters of Yaoundé contain faecal coliforms and faecal *Streptococci*. The main species identified were *Acinetobacter* sp, *Citrobacter* sp, *Enterobacter* sp, *E. cloacae*, *E. coli*, *K. pneumonia*, *Levinea* sp, *Proteus vulgaris*, *Pseudomonas* sp, and *Enterococci* (Table 1). The species richness varied from one water point to another: *Pseudomonas* sp, *K. pneumonia*, *Enterobacter* sp, *Proteus vulgaris* and *Enterococci* were present in all the water points whereas *Acinetobacter* sp and *E. cloacae* were present only in

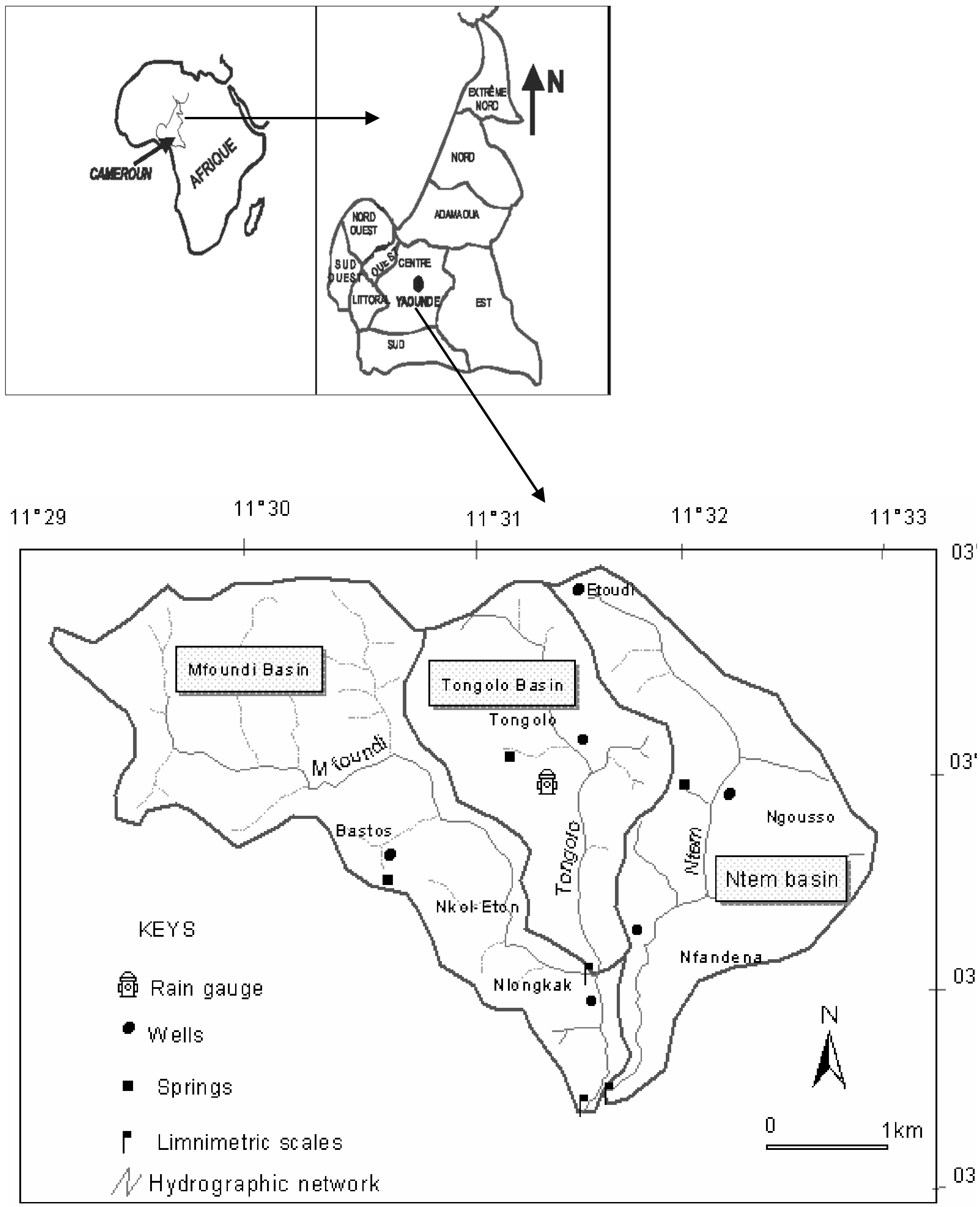

Figure 1. Localization of water points of the upper Mfoundi watershed, Yaounde, Cameroon.

the wells and rivers, respectively (Table 1).

Coliform counts are used to evaluate the hygienic status of water and any presence of the coliform group in water indicates contact with sewage (Markosova and Jezek, 1994). Faecal coliforms such as *E. coli* are prevalent in the digestive tracts of warm-blooded animals and their presence in water is definite evidence of faecal contamination and the potential risk of zoonotic pathogens (Entry and Farmer, 2001). Most of the identified micro-organisms are indeed causative agents of water-borne diseases and may thus justify the high presence of diarrheal diseases (24%) in the households of many quarters in Yaoundé (Kuitcha et al., 2008). *Enterococci* are not pathogenic to man but their presence in high number could indicate the presence of pathogenic bacteria (Galaf and Ghannam, 2003). The absence of *Salmonella* and *V. cholerae* in water points corroborates the very weak presence of typhoid (0.07%) and the absence of cholera in the households studied by Kuitcha et al. (2008).

Table 1. Bacterial species identified in the various water points in some quarters of Yaoundé (x = present).

Water points	Localisation	*Acinetobacter* sp	*Citrobacter* sp	*Enterobacter* sp	*E. cloacae*	*E. coli*	*K. pneumonia*	*Levinea* sp	*P. vulgaris*	*Pseudomonas* sp	Streptococcus
Rivers	Mfoundi (E1)		x	x		x	x			x	x
	Ntem (E2)				x		x		x	x	x
	Tongolo (E3)		x	x			x			x	x
Springs	Ngousso (S1)			x			x			x	x
	Tongolo (S2)			x			x			x	x
	Bastos (S3)						x		x	x	x
Wells	Elig-Edzoa (P1)			x		x	x		x	x	x
	Etoa-Meki (P2)		x				x	x		x	x
	Ngousso (P3)						x	x	x	x	x
	Tongolo (P4)		x			x	x			x	x
	Etoudi (P5)		x	x			x			x	x
	Nkol-Eton (P6)	x	x			x	x			x	x

Abundance of coliforms and streptococci in the various water points

The abundance of faecal coliforms and faecal *Streptococci* in the water points and the recommended threshold by the WHO are contained in Table 2. An average of 34053±94225.5 CFU/100 ml of faecal coliforms and 15107.6 ± 50515 CFU /100 ml of faecal streptococci were enumerated in the water points at Mbankolo, Etoa Meki, Ngousso, Nkol-Eton, Rue Manguier, Etoudi and Tongolo (Table 2). These bacterial loads indicate an excessive level of pollution of the water points as these values place them in class D according to the WHO classification (Katte et al., 2003). Similar conclusions were noted in spring water from California, Pentagon, Gendarmerie, Madagascar and Foreke quarters in Dschang (Katte et al., 2003) and also in the Nkoup River in Foumbot (Tita et al., 2009).

The results also show that the level of pollution is higher in rivers than in wells and springs (Table 2). This could be related to the fact that 27% of the households in the studied quarters discharge their solid and liquid wastes mainly into rivers against 0.07% in wells and 0% in springs, coupled with the fact that most latrines present in these quarters are locally constructed (73%) and are located near waterways (Kuitcha et al., 2008). Under such conditions, the rainy season would constitute a period of high risk of contamination due to runoff and overflow from poorly maintained latrines (Katte et al., 2003; Hunter et al., 2006). The high content of the faecal coliforms and faecal streptococci in the water could also result from the fact that in the rainy season the increase of water level in the ground accelerates the propagation of microbial pollutants which are on the ground or trapped in the unsaturated zone (Fernandez-Alvarez et al., 1992). Indeed, once a pollutant crosses the unsaturated zone, its propagation does not meet any obstacle. The trapped bacteria can be drawn by the flow of the water table towards wells and springs used for domestic chores (Djuikom et al., 2006; Nola et al., 2006).

The high levels of microbial pollution observed in the water points of the Mbankolo, Etoa Meki, Ngousso, Nkol-Eton, Rue Manguier, Etoudi and Tongolo, highlight the health hazards to which the populations of these quarters are exposed and call for urgent measures to redress the situation. The potential of these hazards are probably much higher considering that water related diseases occupy third place among the diseases which

Table 2. Number of faecal coliforms and faecal streptococci in the water points.

Waters points	Localisation	Faecal coliforms (CFU/100 ml)	Faecal *Streptococci* (CFU/100 ml)
Rivers	Mfoundi	47600 ± 59332.12	18160 ± 18024.76
	Ntem	106600 ± 107618.77	28600 ± 21211
	Tongolo	229400 ± 218533.29	122200 ± 139137.34
	H value	3.88	4.22
	P value	0.14	0.12
	Means	127866.67 ± 155254.57	56320 ± 89984.13
Springs	Ngousso	180 ± 103.68	148 ± 124.58
	Tongolo	563.20 ± 873.81	48.80 ± 86.18
	Bastos	278.80 ± 465.26	140.40 ± 260.24
	H value	0.65	1.53
	P value	0.72	0.47
	Means	340.67 ± 557.98	112.53 ± 167.60
Wells	Elig-Edzoa	2601.20 ± 4198.48	4179.20 ± 8850.40
	Etoa-Meki	3088.40 ± 3344.10	994 ± 1507.38
	Ngousso	3777 ± 4759.10	2552 ± 4965.52
	Tongolo	3332 ± 4207.51	368 ± 425.58
	Etoudi	2720 ± 4131.73	254 ± 423.17
	Nkol-Eton	2440.20 ± 4282.73	1135.60 ± 1236.6
	H value	1.27	1.89
	P value	0.94	0.86
	Means	2966.10±3786.15	1546.67 ± 4054.54

N=12 for the rivers and springs, N=18 for the wells; P - value is the significance level of the test H of Kruskall wallis. Categories established by WHO: With (0) Excel, B (1-10) acceptable, C (10-50) unacceptable, and D (> 50) excessively polluted (Katte et al., 2003).

prevail in Cameroon (Fonteh, 2003). These diseases are responsible for approximately 50% of the cases of deaths recorded in the country. In fact, in 2000, approximately 15% children of less than 5 years died in Cameroon mainly because of these diseases (Katte et al., 2003).

Origin of faecal coliforms and faecal streptococci in the water points

Table 3 presents the ratio of faecal coliforms to faecal *Streptococci* (FC/FS) at the various water points. These ratios show that the faecal coliforms and faecal *Streptococci* are varied in their origin. In the Mfoundi and Ntem rivers the bacteria have a mixed origin, with human prevalence (2< FC/FS< 4) whereas in Tongolo, the origin is uncertain (1< FC/FS < 2). The springs of Ngousso and Bastos also have a pollution of dubious origin whereas that of Tongolo seems to be exclusively human. With regard to wells, the pollution is of mixed origin with human prevalence in Etoa Meki and Nkol-Eton, and apparently of exclusive human origin at Tongolo and Etoudi (FC/FS > 4). In Elig-Edzoa, bacterial pollution is mainly of animal origin (FC/FS < 0.7) and in Ngousso, the origin is dubious. However, parameters such as temperature and the pH of water, the distance of the contamination source as well as the duration of the contaminants in water influence these ratios (Borrego and Romero, 1992). That is why Borrego and Romero (1992) recommend that the correlations be applied with care.

Conclusion

Bacteriological analysis of water samples has highlighted the high level of pollution in wells, springs and rivers of the investigated water points. The omnipresence of bacteria indicators of faecal contamination (faecal coliforms and faecal *Streptococci*), as well as the presence of pathogenic bacteria (*E. coli*; *Pneumoniae*, *Citrobacter*, *Pseudomonas* sp; *P. vulgaris* and *Enterobacter*) responsible for waterborne diseases, undoubtedly constitute a great threat for the inhabitants of these quarters who draw water from wells and springs for the major part of their needs. In order to tackle the incidence of water related diseases, urgent measures must be taken with regard to the hygiene of the water supply points. The state, through the

Table 3. Determination of the origin of pollution by the ratio of faecal coliforms to faecal streptococci (FC/FS).

Water points	Localisation	FC/FS	Nature of the contamination
Rivers	Mfoundi	2.62	Mixed with human predominance
	Ntem	3.73	Mixed with human predominance
	Tongolo	1.87	Dubious origin
Springs	Ngousso	1.22	Dubious origin
	Tongolo	11.54	Eclusively human
	Bastos	1.98	Dubious origin
Wells	Elig-Edzoa	0.62	Mainly or entirely animal origin
	Etoa-Meki	3.11	Mixed with human predominance
	Ngousso	1.48	Dubious origin
	Tongolo	9.05	Exclusively human
	Etoudi	10.71	Exclusively human
	Nkol-Eton	2.15	Mixed with human predominance

FC/FS < 0.7: Mainly or entirely of animal origin; 0.7< FC/FS < 1: mixed with animal prevalence; 1< FC/FS < 2 dubious Origin; 2< FC/FS < 4 Mixed with human prevalence; FC/FS > 4 exclusively human (Borrego and Romero, 1982).

CAMWATER and the municipalities should develop strategies to supply poor neighbourhoods of the city with safe and potable water either by extending the CAMWATER network, or by conducting campaigns to disinfect the water supply points. This could be achieved through solar disinfection, a method recognized by the WHO since 2005 and in effective use in Kenya.

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