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Research Article

Point-of-Use Water Treatment Methods and the Microbiological Quality of Drinking Water in a Peri-Urban Community of Bonendale, Douala IV, Cameroon

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Abstract

Background: The study aimed at assessing the knowledge of Bonendale populations related to safe drinking water; determine the microbiological quality and the household treatment practices of drinking water at the point of use (PoU).

Methods: The study was descriptive and cross-sectional, conducted between November 2017 and November 2018 in Bonendale, Douala IV. A systematic random sampling method was used to select 237 households.

Results: The main source of drinking water in the study population was dug wells (64.9%). The major activity around the boreholes was agriculture 50% (6/12) while agriculture and livestock rearing were practiced around 34.3% (12/35) and 42.8% (15/35) of dug wells respectively. Nearly half 110 (46.4%) of respondents had a good knowledge of physical properties of drinking water. Fifty-nine water samples out of a total of 60 tested (98.3%) were contaminated by coliform bacteria. Analysis of water samples indicated that 47.6% (10/21) of dug wells, 37.0% (10/27) of Camwater, and 41.2% (5/12) of boreholes had a total coliform count varying between 101-1000 CFU/100mL. And only a single Camwater water sample 1 (137%) had a coliform count of 0 CFU/100mL.

Conclusion: These findings indicated the poor microbiological quality of point water used by Bonendale populations representing an important potential health risk of water-borne diseases. The results also reveal that a very high proportion of households treat their PoU before drinking.

Keywords: Bonendale; Drinking water; Dug wells; Boreholes; Camwater; Coliform

Introduction

Waterborne Diseases (WBDs) are diseases usually caused by consuming water contaminated with human or animal feaces and/or urine infected by pathogenic viruses, bacteria, protozoa, or helminths [1]. World Health Organization estimates that more than 2.1 billion people globally lack access to clean water 663 million people still use unimproved sources, resulting in nearly 2.2 million deaths annually, of which 1.4 million are children [2]. Recent estimates by World Health Organization (WHO) on drinking water point out that 159 million people depend on water from surface sources (rivers, springs) and 423 million take water from unprotected springs linked to transmission of WBDs [3]. Globally, it is estimated that over 18 million people use Household Water Treatment and Safe Storage (HWTS), with 12.8 million using chlorination with liquid or tablet, 2.1 million using solar disinfection, 934,000 using flocculation/chlorination, 700,000 using biosand filtration, and 350,000 using ceramic filtration [4]. The cornerstone of the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) to scaling-up health benefits associated with potable drinking water is the HWTS that recommends treatment of contaminated drinking water and to prevent contamination during collection, transport, and use in homes [1]. Only 18.2% of households in Africa treat water at the household level. However, the region has the highest number of populations dependent on unimproved water sources [2]. The use of HWTS methods could not only improve the microbiological quality of household drinking water [1] (WHO, 2012), but also prevent at least 9.1% of the global burden of disease and 6.3% of all deaths [5]. Access to safe drinking water for domestic use has become a major challenge, especially in sub-Saharan Africa, owing to its fast growing population.

Cameroon has made substantial progress in recent years in improving water supplies in urban settings. African Ministers' Council on Water (AMCOW) estimated that the proportion of people with access to safe drinking water in Cameroon moved from 50 percent in 1990 to 74 percent in 2008 [6]. This accounts for 8 million out of 20 million people that had access to safe drinking water during the aforementioned period [7]. Although, the country is endowed with a 19.192x103 m^3 of interior renewable water per capita per annum [8], access to potable drinking water is still a privilege to many households especially in rural and urban slum settings. Furthermore, the inadequate and poor quality of water supply, ill-maintained water pipelines and sewer lines, messy disposal of human, animal, and

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household wastes, unawareness about good sanitation and personal hygiene practices are some factors responsible for microbiological contamination of water in Cameroon.

An estimated 92% of urban Cameroon has access to an “improved” drinking water source as defined by the WHO/UNICEF Joint Monitoring Programme [7]. This does not guarantee safe water, because a large proportion of such sources may be subjected to contamination, especially through unsafe water handling and storage practices [7]. Moreover, surveys of microbial water quality throughout Cameroon have shown extensive faecal contamination of drinking water supplies. Recent studies reported that in Douala, 83% of wells analyzed were faecally contaminated and the most affected people by WBDs were children under 5 years [9]. In the West Region of Cameroon, Mabvouna-Biguioh [10] found out that, of 22 water samples collected, 20 contained coliform bacteria, which could be associated with high risk of diarrheal disease outbreaks, such as cholera.

To achieve success in universal access to safe drinking Water, Sanitation and Hygiene (WASH) for households, schools, and healthcare facilities by 2030 as recommended by WHO/UNICEF, WASH interventions such as access to water (water quality, water quantity, and distance to water), sanitation access (access to improved latrines, latrine maintenance, and feacal sludge management), and hygiene practices (hand washing before eating and/or after defecation, soap use, and water treatment and storage practices) need to be accelerated [11]. In addition, HWTS including boiling, chlorinating, and filtering water, with safe storage could offer a solution for addressing challenges posed by the quality of water at the PoU. Several reports have shown that chlorination can be effective in improving the quality of drinking water and in preventing diarrhea [1].

Previous data have indicated contaminated water supply in the city of Dschang [12], Yaounde [13] and Douala [14]. However, Bonendale (Douala IV) in the peri-urban area of Douala city was not included. Moreover, interventions to encourage households to use PoU water treatment methods are scanty in Cameroon. Therefore, the study aim at assessing the practices and knowledge of Bonendale populations related to safe drinking water, determine the microbiological quality and household treatment practices of drinking water at the PoU.

Materials and Methods

Study area

Administratively, the Douala IV District is made up of Bonaberi, Bonendale, Cap Cameroun, and Manoka. The focus of this study is Bonendale, a wetland, situated on the southern part of national road N°5 linking Douala to Bafoussam. The climate is bimodal with a dry season for about 6 months (October-March), and a rainy season that also lasts for 6 months (April-September) [15]. During the rainy season, the average annual rainfall in the study area is 4000 mm/year, and the average monthly temperature is 33°C [16]. The main economic activities include agriculture, livestock rearing, petit business, fishing, and commercial bike riding.

Study design

The study was descriptive and cross-sectional, conducted between November 2017 and November 2018 in Bonendale, Douala IV. Participants were selected using a systematic random sampling method.

Study populations and sampling procedure

The total number of population living in Bonendale is 65.000 consisting of 35.000 households. The sample size was determined by using the following formula; $n=z^2$ p (1-p)/e. where, n=Sample size, Z=the standard normal deviation of 95% (z=1.96), P=estimated proportion of population 14.4% [17], and e= precision degree=0.05. The minimum-targeted sample size was 190 households. Every tenth house was selected and one member of the household head (the husband, wife, or adult of >18) in every nth house was interviewed. The selected first house was that of Chief and subsequently participants who consented to the study.

Data Collection Method

Household surveys

A total of 240 questionnaires were prepared in French and English, pre-tested in 20 household heads in the neighboring Bojongo community to determine its clarity and comprehension. Surveys were conducted in Bonendale with the assistance of community health workers. However, those that could not express themselves in French or English were interviewed in Pidgin (Local English). A household was defined as the entity in which people live together and have a meal from a common cooking facility, and a household head was defined as the person who is perceived by members of the household as the key decision-maker in the family [18]. The head of the household was asked about knowledge of the physical quality of drinking water, and the type of water treatment methods used, and was confirmed with observation.

Water sample collection

For the bacteriological analysis, water samples were collected directly from the PoU that were Cameroon National Water Company (Camwater) taps, dug wells, and boreholes. Before the collection, the bottles were first washed in dilute hydrochloric acid and then thoroughly rinsed with distilled water and finally autoclaved. At the water sampling site (Camwater supply), sampling water was allowed to run for 2 minutes, the taps were sterilized with ignited cotton wool soaked in alcohol aseptically. The sampling bottles were rinsed 3 times with the sampling water before it was filled, capped, and labeled. Dug well water samples were collected using a bucket attached to a rope. A total of 60 water samples were collected from three different water sources and distributed as follow; Camwater (n=27), dug wells (n=21), and boreholes (n=12). All sampling bottles were placed in a cool box and transported to University Buea, Department of Microbiology and Parasitology, Faculty of Science for the bacteriological analysis within 2 hours of collection. The microbiological quality of Water was assessed using colony counts on Violet Red Bile Agar (VRBA).

Bacteriological analysis of PoU water

To assess water quality, samples were analyzed for coliform bacteria using a VRBA based on crystal violet and bile salts which primarily inhibit the growth of the Gram-positive accompanying bacterial flora. Degradation of lactose to acid is indicated by the pH indicator neutral red, which changes its colour to red, and by precipitation of bile acids within 24 hours at 30°C. Forty-one point five grams of the medium were suspended in one liter of distilled water, mixed well, and dissolved by heating with frequent agitation. The mixture was boiled for one minute until complete dissolution. The color of the prepared medium was purple-red. The prepared media were stored at 8-15 ºC before usage. For the pour plate method, 1 ml of the desired dilution was by placing in a sterile Petri dish, and 15 ml of the prepared medium was added, cooled to 45-50 ºC while rotating gently before allowing it to solidify. Once solidified, a second layer of the medium was poured to a depth of 5 mm and allowed to solidify. The Petri dishes were inverted and incubated at temperatures of 35ºC for 24-48 hours. The colonies which indicated a red colour were enumerated as positive colonies for coliform and were reported as colony-forming units (CFU) per 100 mL [19].

Statistical analysis

The data were entered into Excel, cleaned, and exported to SPSS software version 20.0 (IBM. New York, USA) for analysis. The results were presented in the form of frequency tables and figures. Knowledge, of respondents regarding water quality, was graded as good, average and low.

Ethical considerations

Approval to carry out the study was obtained from the Institutional Review Board of the University of Douala. Permissions were sought from the Chief of Bonendale I and II. Thereafter, informed consent was obtained from the respondents before administering the questionnaire. The respondents were assured of their right to withdraw from the interview at any time they would wish during the exercise.

Results

Socio-demographic characteristics of the respondents

Of the 237 enrolled households who completed the questionnaire, 62.4% (148/237) were men and 37.6 % (89/237) were females (Table 1). Subjects aged 20-29 years were most represented 32.1% (76/237), with the population aged 30-39 years made up of 11.8% (28/237) of the study population. The majority of the study participants have attended secondary school with 31.2% (74/237), tertiary education 25.3% (60/237), and 14.7% (35/237) had no formal education. Most of the respondents were self-employed 48.5% (115/237), workers 20.3% (48/237), and unemployment stood at 31.2% (74/237).

Sources of drinking water in bonendale

Sources of drinking water, which include dug wells 64.9% (154237) (Figure 1), boreholes 24.5% (58/237), and Camwater distribution network 10.6% (25/237). However, some respondents opined that they used multiple sources of water such as Camwater/dug wells 57.8% (137237) and Camwater/borehole 22.3% (53/237).

Activities around the water sources

Agriculture and livestock rearing were practiced around 34.3% (12/35) and 42.8% (15/35) of dug wells respectively (Table 1,2). Fourteen percent of dug wells were located near the abattoirs. The main activities around the boreholes were agriculture 50% (6/12) and livestock rearing 33.3% (4/12).

Knowledge of physical properties of drinking water and hygiene practices of participants

When respondents were asked about the qualities of safe drinking water, their responses were categorized as good (visually clear, free from germs, odourless, tasteless) 46.4% (110/237), average (visually clear, free from germs) 29.5% (70/237), and low (visually clear) 57 (24.0%) as shown in (Table 3). With regard to the hygiene practices of participants, 53.6% (127/237) mentioned that they regularly wash their hands, 75.5% (127/237) stored their water in a clean covered container and the vast majority do cohabit with animals 84.8% (201/237).

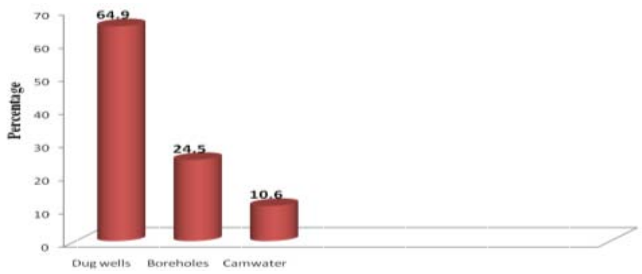

Figure 1: Drinking-water sources.

Table 1: Socio-demographics characteristics.

Variables	Frequency	Percentage
Sex		
Male	148	62.4
Female	89	37.6
Age		
<20 years	32	13.5
20-29 years	76	32.1
30-39 years	28	11.8
40-49 ans	71	29.9
>50 years	30	12.6
Level of education		
No formal	35	14.7
Primary	68	28.7
Secondary	74	31.2
Tertiary	60	25.3
Occupation		
Workers	48	20.3
Self-employed	115	48.5
Jobless	74	31.2

Bacteriological quality

Fifty-nine water samples tested out of a total of 60 tested (98.3%) were contaminated by coliform bacteria, which indicate contamination by human and animal faeces. Analysis of water samples indicated that 47.6% (10/21) of dug wells, 37.0% (10/27) of Camwater, and 41.2% (5/12) of boreholes had a total coliform count varying between 101-1000 and only a single Camwater water sample 1 (137%) had a coliform count of 0 CFU/100ml (Table 4) that is in conformity with WHO guideline for drinking water. Classification risk indicated that 3 (14.3%), 10 (47.6%), and 8 (38.1%) of dug wells water samples had an intermediate, high, very high-risk score for coliform bacteria respectively.

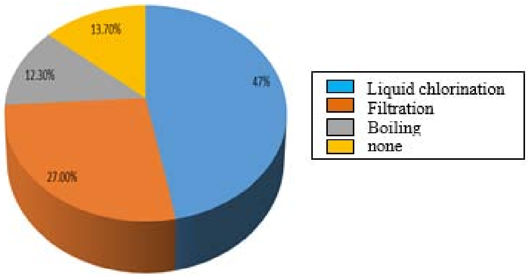

Figure 2: Treatment method for drinking water (n=237).

Table 2: Activities around the water sources.

Activities	Dug wells	Boreholes
Agriculture	12 (34.3%)	6 (50%)
Livestock rearing	15 (42.8%)	4 (33.3%)
Breweries	3 (8.6%)	2 (16.7%)
Abatoir	5 (14.3%)	0 (0.0%)
Total	35	12

Table 3: Knowledge of physical properties of drinking water and hygiene practices of participants.

Parameters	Frequency	Percentage
Knowledge of physical properties of drinking water		
Good	110	46.4
Average	70	29.5
Low	57	24
Yes/No Questions		
Hands washing before eating		
Yes	127	53.6%
No	110	45,4%
Conservation of water in a clean covered container		
Yes	179	75,5%
No	58	24,5%
Cohabitation with animals		
Yes	201	84,8%
No	36	11%

Water treatment methods

Participants' POU Water Treatment Methods (Figure 2). The proportion of households treating their water before drinking using any treatment methods was 86.3% (205/237). The most common methods were chlorination 47.0% (111/237) and filtration 27.0% (64/237). Other methods mentioned were boiling 12.3% (27/237). However, 13.7% (32/237) of households did not practice any forms of the aforementioned methods of water treatment.

Discussion

The study describes the microbiology water quality and the point-of-use water treatment methods use across in a peri-urban community of Bonendale, Douala IV, Cameroon, including the practices and knowledge of the study population related to drinking water.

Several studies have recognized that groundwater resources are abundant and unevenly distributed in different aquifers in Cameroon [20]. Almost two-thirds of the respondents used dug well as their source of drinking water and few are connected to pipe-borne water managed by Camwater. These findings are similar to that [21]. However, it contrasts with a study in Douala V, which showed that 42.30% of households used water from boreholes and 33.80% from Camwater, and only 5 % of households get their supplies through dug wells [9]. Similarly, residents of Bamboutos Division, West Region and Cameroon used springs (50%), dug wells (35%), and only 30% used boreholes [22]. In Benin City, Nigeria, boreholes were the principal sources of drinking water [23]. In a study analyzing boreholes in the Northern part of Cameroon, the Physico-chemical parameters showed that boreholes water have low to high mineralization. Borehole's water was contaminated by bacteria's indicators of faecal pollution. The study raised the need for household water treatment of water from borehole before consumption [24].

Previous surveys have indicated that, communities where the predominant drinking water sources are unimproved water (dug wells), it poses a serious health risk to the inhabitants, especially among children who often contact and suffered from diarrhea. Consequently, in this population lacking access to pipe potable water, HWTS may provide an alternative approach for improving water quality and ipso facto preventing WBDs diseases.

Anthropogenic activities around a water source may compromise the quality of the water in the long run. Agriculture and livestock rearing were the major activities practiced in the vicinity of dug wells. Farming and livestock's activities in the vicinity of the water source may also lead to faecal and agro-chemical contaminations. In a study conducted in Ndop plain, North West Cameroon, about 69% of the surface water sources had pH values below 6.5, low concentration of Ca^{2+} and Mg^{2+}, thus classify the water as soft (<57 mg/l $CaCO_3$). This could lead to health problems owing to the association between soft water and cardiovascular diseases [25].

Our data indicated that the study population has a good knowledge of quality drinking water as many referred to good quality as colourless,

Table 4: Coliform bacteria risk for PoU water samples in Bonendale.

Coliform bacteria	Risk category	Dug wells (n=21)	Camwater (n=27)	Boreholes (n=12)
Cfu/mL	n (%)			
0	A (No risk)		1(3.7)	
1-10	B (low risk)		4(14.8)	2(16.7)
11-100	C(intermediate risk)	3(14.3)	12(44.4)	3(25)
101-1000	D(high risk)	10(47.6)	10(37.0)	5(41.2)
>1000	E(very high risk)	8(38.1)		2(16.7)

WHO (2011). Guideline for drinking water quality, vol.1.

free from germs, odourless, tasteless which are in accordance with WHO drinking water quality [26]. This observation was consistent with that of Ssemugabo [27], who showed that water consumers are conversant with safe drinking water standards. Likewise, a low level of knowledge about water quality was highlighted in a study in Santa, North West Cameroon where 58.13% of respondents said water safe enough to be consumed with low risk of harm while 21.8% said it is water that originates from pipe-borne water [28]. The poor knowledge of physical drinking water parameters by households could put the community at risk of WBDs and jeopardize their approach towards home treatment of water at the PoU. A pristine state of a drinking water source catchment protected from anthropogenic activities remains relatively free from biological and chemical contamination. Our findings revealed that agriculture and livestock were practiced around 34% and 42% of dug wells respectively. These findings are consistent with the observation recorded by [29]. The main activities around the boreholes were agriculture (46%) and livestock rearing (40%). Factors such as defecation in nature, presence of pit latrines, wastewater, agricultural activities, livestock rearing, farms, and discharges of chemicals, in industrial sites when close to drinking water sources are known to augment groundwater pollution [30].

Of the 60 water samples collected, 98.3% of sampled had the coliforms count above the recommended WHO standard of zero coliform per 100 mL. This observation poses a serious public health issue. The presence of coliform bacteria is an indication that disease-causing bacteria also may be present and that water is unsafe for drinking. The result is similar to the observation recorded in boreholes in Benin City Nigeria [23], which reported that all boreholes water sampled in the most crowded area of Benin City were contaminated. Treating drinking water in households can lead to improvement in the drinking water quality as well as the protection of the population from WBDs [31].

The proportion of households treating their water before drinking using any treatment methods was 86.3%. This finding is higher than the 46.2% recorded by Sridhar [32] in Kaduna) Nigeria. However, this contradicts the findings of Berhanu [33], which showed that the majority (73.5%) of the respondents didn't treat their water at the household level. In the present study, the most common methods were chlorination (47.0%) and filtration (27.0%). This is similar to observations recorded in residents of Bamboutos Division (40.02%), West Region Cameroon [22]. The use of these methods can be attributed to the fact that they are cheap and easily affordable by the populations as mentioned by [22] population. The results are contrary to the study by Ssemugabo [27]. Which showed that only 4.1% of households in a slum community in Kampala City used chlorination.

Wolf [34] reported that household that used chlorination of PoU water combined with safe storage was associated with a 36% reduction in the risk of diarrhea. In Cameroon, a study conducted in Douala 5th reported that the major form of treatment used by households was filteration (64%). The authors also reported that, the proportion of participants who mentioned not treating drinking water before consumption was 85.5% [35]. In the present study, only (12.3%) mentioned boiling water before consumption. Surprisingly, boiling is the most common means of treating water at home and the benchmark against which emerging PoU water treatment approaches are measured [35]. If practiced correctly, boiling is also one of the most effective, killing or deactivating all classes of waterborne pathogens, including bacterial spores and protozoan cysts that have shown resistance to chemical disinfection and viruses that are too small to be mechanically removed by microfiltration [36].

Limitations of the Study

This research measured the microbial water quality by using only coliform bacteria as an indicator of fecal pollution. The microbiological quality of drinking water could have been complemented with the determination of Escherichia coli. The study did not provide information on the physico-chemical parameters, an assessment of knowledge, attitudes, and practices on water, sanitation and hygiene in Bonendale.

Conclusion

These findings indicated the poor microbiological quality of point water used by Bonendale populations, which represents an important potential health risk of water-borne diseases. The results also reveal that a very high proportion of households treat their PoU water before drinking. The predominant treatment methods of PoU water in the study population were chlorination and filtration. Our findings point to the need to promote alternative HWTS such as boiling among others in the study area.

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Authors' Contributions

HN and BT participated in the conception and design of the study. JF-C and HN analysed the data and coordinated the data collection. BT drafted the first manuscript. All authors read and approved the final manuscript.

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