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Microbiological Quality of Schoolchildren's Drinking Water in the Rural Communes of Coalla and Manni in the Eastern Region of Burkina Faso

Drinking Water Quality of Schoolchildren

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Abstract

Background: The issue of access to drinking water is gradually being solved in rural Burkina Faso by the building of structures to capture groundwater, such as boreholes. Well maintained, they allow people to have access to safe water for their different needs. However contamination of these boreholes can occur in case of lack of hygiene and sanitation in the immediate environment or during water transportation with unclean containers or during water storage in households. As part of the implementation of LAAFIA project in the Eastern region of Burkina Faso, Helvetas Swiss Inter co-operation Burkina is involved in the education of the beneficiary communities of boreholes and latrines, mainly schoolchildren to adopt adequate hygiene and sanitation practices. The objective of this baseline study was therefore to evaluate the microbiological quality of the boreholes, households and schoolchildren drinking water before the starting of the educational component of this project.

Material and Methods: This descriptive cross-sectional study was conducted from 14 to 28 December 2016 (dry season) in the rural communes of Coalla and Manni in the Eastern region of Burkina Faso. Drinking water samples from schoolchildren, households and boreholes were collected aseptically and analyzed for total coliforms, *E. coli* and faecal streptococci. The membrane filtration method (0.45 mm diameter) was used for water analysis. Rapid *E.coli* specific culture medium (Biorad, France) was used to isolate total coliforms and *E. coli*, and Bile Esculin Azide medium for faecal streptococci. The media were examined after 18-24h of culture at 44.5°C and the results obtained were interpreted according to WHO standards 2011.

Results: A total of 251 water samples including boreholes water (18 samples), household water (128 samples) and schoolchildren water (105 samples) were collected and analyzed. No microorganisms was found in 66.7% (12/18) of the boreholes water samples compared to 11.7% (15/128) of the household water samples and 5.6% (8/105) of the schoolchildren water samples. Overall, schoolchildren' water were the most polluted with a cumulative presence of total coliforms, *E. coli* and faecal streptococci at 22.8% (24/105) followed by households water at 21.1% (27/128).

Conclusion: These baseline study's results confirm the good microbiological quality of the boreholes' water that they are the main sources of water supply for the rural communes of Coalla and Manni. Unfortunately, secondary contaminations make this water "unsafe" for household consumption and especially for children and schoolchildren. Emphasis must therefore be placed on improving individual and collective hygiene, and sanitation practices, water treatment and conservation techniques at home and in schools in order to reduce the risk of secondary contamination of drinking water.

Key words: Eastern Region Burkina Faso; borehole water; household water; schoolchildren drinking water; microbiological quality of water

Introduction

Diseases associated with unsafe drinking water cause many deaths worldwide each year [1]. Insufficient sanitation and poor hygiene practices are increasing the number of deaths in developing countries where water supply systems and sanitation facilities are not yet widespread in rural areas. Microbiological evaluation of water by assessing the presence of indicator organisms including total coliforms, *E. coli* and enterocci is the cornestone for water quality monitoring for human consumption. Total coliforms are *Enterobacteria* present in the digestive tracts of humans and animals and theirs wastes. They are also found in plant and soil. They are mainly used as an indicator of the efficiency of water treatment, the integrity of the distribution system as well as indicators of bacterial re-growth after treatment [2-5]. *E. coli* is a thermo tolerant coliform always presents in high number in human and animal faeces and can survive for a few months in water, soil and plants [2-5]. Its detection in water is a specific indication of recent fecal contamination and must therefore be considered as reflecting the possible presence of fecal or enteric pathogenic microorganisms [2,5]. Fecal streptococci are not pathogenic but their presence in water intended for consumption is evidence of old fecal contamination [4,5].

Burkina Faso, like most of developing countries, has a high prevalence of diseases related to unsafe water, poor hygiene practices and unimproved sanitation, which have a negative impact on people' health and consequently on the economy of the country [6,7]. The main indicators on accessibility to safe drinking water, best hygiene practices and improved sanitation showed that 82% of the population of Burkina Faso has access to safe water sources. In rural areas, this access varies from 39% to 76%. Fifty percent of rural populations practice open defecation and only 38% have improved latrines [8]. Fortunately, many studies have shown that the adoption of preventive measures including good hygiene practices and improved sanitation and the consumption of safe water can reduce the frequency of diseases associated with unsafe water and unimproved sanitation. To significantly improve hygiene and sanitation conditions, building of adequate structures and their appropriation by the communities are necessary. HELVETAS Swiss Inter cooperation through LAAFIA project ("Family sanitation project in the province of Gnagna") focuses on raising awareness and educating beneficiary communities of boreholes and latrines about adequate hygiene and sanitation practices. The objective of this baseline study was to assess the microbiological quality of boreholes water, household and schoolchildren drinking water before the implementation of the project mentioned above.

Material and Methods

Study area

The study took place in the Eastern region of Burkina Faso, specifically in the province of Gnagna. This province covers an area of 8577 km2 for 455.719 inhabitants [9]. The province of Gnagna comprises 7 departments including the departments of Manni and Coalla. These two departments account respectively 90,621 and 56,843 inhabitants [10]. The villages of Kulfo, Madori, Pugdiari, Kouriga, Dakiri, Bantoampera and Barhiaga of the commune of Manni and the villages of Doyana, Gnimpiema, Nieba and Tindangou of Coalla commune are involved in the present study. Livestock is the first activity of the populations of these two rural communes, followed by agriculture. Rainfall in the region is 500 to 700 mm of water per year. A temporary river, Faga is the main collector of surface water in the rural commune of Coalla. Access to drinking water in this eastern region of Burkina Faso increased from 45.84% in 2006 to 47.25% in 2011. That year, the rural communes of Coalla and Manni had an access rate to drinking water of 47.7% and 64.6% respectively. There were 134 and 190 completed boreholes (equipped with pumps) with a functionality rate of 81.34% and 85.79% in the rural communes of Coalla and Manni respectively [11].

Type of study

This study was a cross-sectional and prospective survey. Field data collection took place from 14 to 28 December 2016 (dry season) in the province of Gnagna in the Eastern region of Burkina Faso. It used an "exposed" versus "not exposed" approach, i.e. schools/households with intervention versus schools/households without intervention. The matching consisted in choosing a school in the village or in the neighboring locality which will not benefit from intervention of the LAAFIA project but which would have very similar characteristics to those of the school of intervention on a certain number of defined variables. The target villages have been selected by HELVETAS Swiss Intercooperation: Gnimpema, Tindangou of the rural commune of Coalla and Koulfo, Madori, Pougdiari, Kouriga of the rural commune of Manni. The control villages are Nieba and Doyana in the rural commune of Coalla and Dakiri, Bantoampera and Barhiaga in the rural commune of Manni. The schools that were the subject of the baseline survey are shown in Figure 1 and their characteristics are presented in Table 1. The sample size was calculated according to the formula n = t2p (1-p)/m2 (n: sample size, t: confidence level at 95%, p: prevalence of parasite infection in children, m: margin of error at 5%) and schoolchildren constituted the population of the study. Schoolchildren were randomly selected after a proportional distribution of schoolchildren according to the sex-ratio and the total number of schoolchildren in the school and in the classes. The selected households were those with schoolchildren included in the study.

Water sampling

The water samples were collected aseptically in 100 ml borosilicate flasks, in boreholes, drinking water storage containers of schoolchildren at school and in households (cans, barrels, jars, buckets, etc....). The water samples collected were placed in a cooler maintained at 4°C and transported to the laboratory of the "Institut de Recherche en Science de la Santé" (IRSS) in Ouagadougou. Water samples were analyzed within 48 hours after sampling.

Microbiological analysis

The microbiological quality of water from boreholes, from households and schoolchildren containers was assessed by

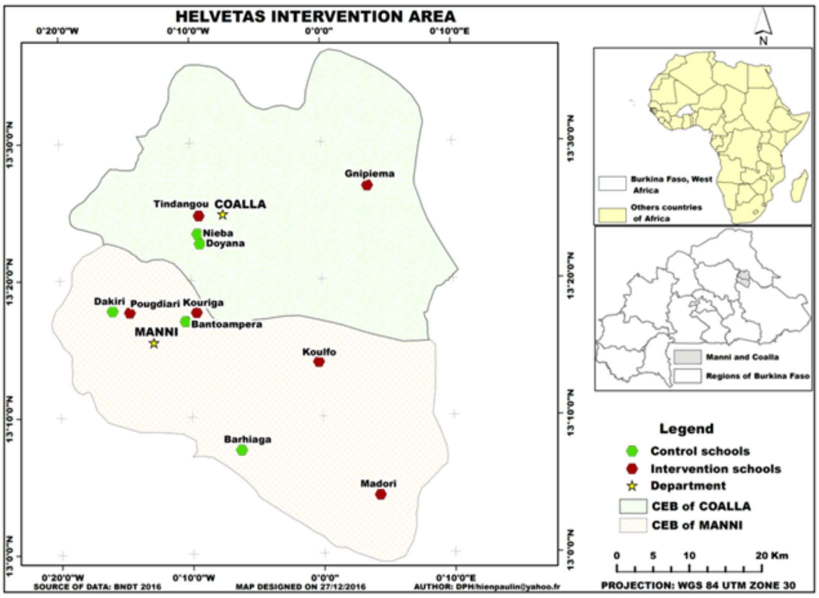

Figure 1: Location of intervention and control schools in the rural communes of Coalla and Manni

Table 1: Characteristics of selected schools

			Source of water in the school	Drinking water in the classroom	Hand washing equipment in the school	Functional latrine in the school	Schoolchildren in the school	Schoolchildren in the selected classroom	Selected school children
Coalla	Intervention	Gnimpiema	Yes	No	No	Yes	46	43	12
		Tindangou	Yes	No	No	Yes*	116	58	10
	Control	Nieba	No	No	No	Yes	40	40	6
		Doyana	Yes	No	No	Yes	135	27	10
Manni	Intervention	Koulfo	Yes	No	No	Yes	265	48	10
		Madori	Yes	No	No	Yes	92	32	8
		Pougdiari	Yes*	No	Yes*	Yes	225	37	10
		Kouriga	Yes	No	Yes*	Yes	75	75	10
	Control	Dakiri	Yes	No	No	Yes	321	35	12
		Bantoampera	No	No	No	Yes	139	39	12
		Barhiaga	Yes	No	No	Yes	40	40	10

Yes*: Exist but no functional

identifying and counting indicators organisms, fecal coliforms, *E. coli* and fecal streptococci. The membrane filtration method (0.45 mm diameter) was used for water analysis. Rapid *E.coli* specific culture medium (Biorad, France) was used to isolate total coliforms and *E. coli*, and Bile Esculin Azide medium for faecal streptococci. The media were examined after 18-24 hours of culture at 44.5°C. The results have been interpreted according to WHO standard 2011 [12]. Which stand that all water intended for human consumption must be free of indicator organisms, 0 faecal coliform, *E. coli* and faecal streptococci for 100 ml.

Statistical analyzes

Data were collected on Excel Software and analyzed with XLSTAT. The Student's test was used to compare the means of indicators organisms in the different drinking water sources. The Chi square test was used to compare the proportions of non contaminated water in different drinking water sources.

Ethical consideration

This baseline study was approved by the "Comité d'éthique pour la recherche en santé, Ministère de la Santé" and "Ministère de l'Enseignement Supérieur de la Recherche Scientifique et de l'Innovation" of Burkina Faso.

Results

A total of 251 water samples of boreholes (18 samples), household (128 samples) and schoolchildren (105 samples) were collected and analyzed. The results showed that 66.7% (12/18) of boreholes water samples were free of contamination indicator organisms compared to 11.7% (15/128) of household water and 5.6% (8/105) of schoolchildren water. Two samples (11.1%) of boreholes water contained both fecal coliforms and fecal streptococci. Fecal coliforms, *E. coli*, and fecal streptococci were cumulatively isolated in 21.1% (27/128) samples of household water and 22.8% (24/105) samples of schoolchildren water.

Taking into account individual contamination indicator organism, boreholes were the least polluted: 27.8% of samples with fecal coliforms, 0% with *E. coli* and 16.7% containing fecal streptococci. Water samples from household were contaminated with fecal coliforms 79.7%, *E. coli* 22.7% and fecal streptococci 29.7%. Schoolchildren water samples were found to be the most polluted: 84.8% with fecal coliforms, 23.8% with *E. coli* and 76.2% with fecal streptococci [Table 2]. The differences between water samples from boreholes, household and schoolchildren were significant proven a secondary contamination of household and schoolchildren drinking water.

Table 2: Distribution of faecal indicator organisms in different sources of water and mean of UFC in the samples of sources of water

Recommanded parameters	Boreholes N: 18	Household N: 128	Schoolchildren N: 105
FC/100ml			
0	13 (72.2%)	26 (20.3%)	16 (15.2%)
10-100	3 (16.7%)	24 (18.8%)	11 (10.5%)
	46.7 UFC	57.5 UFC	45.5 UFC
> 100	2 (11.1%)	78 (60.9%)	78 (74.3%)
	505 UFC	2324.7 UFC	3753.3 UFC
P value < 0.0001			
***E. coli*/100 ml**			
0	18 (100%)	99 (77.3%)	80 (76.2%)
10-100	0	21 (16.4%)	14 (13.3%)
		25.7 UFC	46.4 UFC
> 100	0	8 (6.3%)	11 (10.5%)
		572.5 UFC	2141 UFC
P value : 0.018			
FS/100 ml			
0	15 (83.3%)	41 (32%)	25 (23.8%)
10-100	2 (11.1%)	53 (41.4%)	43 (41%)
	50 UFC	45.9 UFC	47 UFC
> 100	1 (5.6%)	34 (26.5%)	37 (35.2%)
	200 UFC	1036.2 UFC	1354.3 UFC
P value : 0.041			

FC: Faecal coliforms; FS: Faecal streptococci; UFC: Unit forming colony

The distribution of contamination indicator bacteria according to the village's location in the rural communes of Manni and Coalla is presented in Table 3. In rural commune of Manni, 5 (50%), 10 (11.8%) and 7 (10.4%) water samples from boreholes, household and schoolchildren were free of indicator organisms. In the villages from the rural commune of Coalla, no indicator organisms was found in 7 (87.5%), 5 (11.6%) and 1 (2.6%) water samples collected from boreholes, household and schoolchildren containers. There is no statistical difference between water samples from Manni and Coalla.

The LAAFIA project proposes to implement actions to improve the quality of drinking water in some villages in the rural communes of Manni and Coalla. These "intervention" villages were compared with "control" villages without any intervention. The distribution of contamination indicator bacteria in the intervention and control villages are presented in Table 4. In the intervention villages, 81.8% (9), 6.8% (5) and 5.1% (3) of water samples from boreholes, households and schoolchildren respectively, are free of indicator microorganisms, while 42.9% (3), 18.2% (10) and 10.9% (5) of water samples collected from

Table 3: Distribution of faecal indicator organisms in different sources of water villages in the rural communes of Manni and Coalla

Recommanded parameters	Boreholes water			Household water			Schoolchildren water		
	Manni	Coalla	*P value*	Manni	Coalla	P value	Manni	Coalla	P value
	N: 10	N: 8		N: 85	N: 43		N: 67	N: 38	
FC/100ml									
0	6 (60%)	7 (87.5%)	0.40	16 (18.8%)	10 (23.2%)	0.72	11 (16.4%)	5 (13.1%)	0.86
10-100	2 (20%)	1 (12.5%)		17 (20%)	7 (16.3%)	8 (11.9%)	3 (7.9%)		
	40 UFC	60 UFC		60 UFC	51.4 UFC	40 UFC	60 UFC		
> 100	2 (20%)	0 (0%)		52 (61.2%)	26 (60.5%)		48 (71.6%)	30 (79%)	
	505 UFC			2281.7 UFC	2410.8 UFC		3770.4 UFC	3726 UFC	
E. coli/100ml									
0	10 (100%)	8 (100%)		63 (74.1%)	36 (83.7%)	0.28	50 (74.6%)	30 (79%)	0.79
10-100	0	0		17 (20%)	4 (9.3%)	11 (16.4%)	3 (7.9%)		
				24.7 UFC	30 UFC	42.7 UFC	60 UFC		
> 100	0	0		5 (5.9%)	3 (7%)	6 (9%)	5 (13.1%)		
				672 UFC	406.7 UFC	3416.7 UFC	612 UFC		
FS/100 ml									
0	8 (80%)	7 (87.5%)		26 (30.6%)	15 (34.9%)		14 (20.9%)	11 (29%)	
10-100	1 (10%)	1 (12.5%)		36 (42.3%)	17 (39.5%)		28 (41.8%)	15 (39.5%)	
	80 UFC	20 UFC	1	49.7 UFC	37.7 UFC	0.77	46 UFC	50.7 UFC	0.5
> 100	1 (10%)	0		23 (27.1%)	11 (25.5%)		25 (37.3%)	12 (31.5%)	
	200 UFC			748.3 UFC	1638.2 UFC		1585.2 UFC	873.3 UFC	

FC: Fecal coliforms, FS: Fecal streptococci

boreholes, households and schoolchildren in the control villages are safe. For all contamination indicator bacteria, water samples from control villages are more contaminated than those of intervention villages (p value < 0.05).

Discussion

Water, essential for life, is the first constituent element of all living beings and their environment. However, since the end of the 19th century, water has been recognized as a vector of pathogenic microorganisms for humans. The demonstration of transmission of Vibrio cholerae and Salmonella typhi through water, then for many other pathogenic microorganisms (bacteria, viruses, parasites), led to the development of drinking water treatment in developed countries. Nowadays, waterborne diseases are the third leading cause of infant mortality in the world and a major concern for developing countries. In these countries, drinking water distribution systems do not generally reach the entire population. Worldwide, WHO estimates that 1.1 billion people do not have access to drinking water distribution system [13].

In Burkina Faso, despite the Government and its Technical and Financial Partners (TFPs) efforts as well as Non-Governmental Organizations (NGOs) in the water, sanitation and hygiene for people's access to safe drinking water and adequate sanitation services, the expectations for the availability of a quality "blue gold" are still enormous. This led the government in 2005 to set up a vast National Drinking Water Supply and Sanitation Program (PN-AEPA) by 2015, with the overall objective of halving

Table 4: Distribution of fecal indicator organisms in different sources of water and in intervention and control villages of the rural communes of Manni and Coalla

Recommanded parameters	Boreholes water			Household water			Schoolchildren water		
	Intervention N: 11	Control N: 7	*P value*	Intervention N: 73	Control N: 55	P value	Intervention N: 59	Control N: 46	P value
FC/100ml									
0	9 (81.8%)	4 (57.1%)		10 (13.7%)	16 (29.1%)		3 (5.1%)	13 (28.3%)	
10-100	1 (9.1%)	2 (28.6%)		15 (20.5%)	9 (16.4%)		4 (6.8%)	6 (13%)	
	20 UFC	60 UFC	0.55	52 UFC	66.7 UFC	0.06	50 UFC	42.9 UFC	0.003
> 100	1 (9.1%)	1 (14.3%)		48 (65.8%)	30 (54.5%)		52 (88.1%)	27 (58.7%)	
	130 UFC	880 UFC		2070.6 UFC	2731.3 UFC		4088.1 UFC	3083.9 UFC	
E. coli/100ml									
0	11 (100%)	7 (100%)		58 (79.4%)	41 (74.5%)		39 (66.1%)	41 (89.1%)	
10-100	0	0		11 (15.1%)	10 (18.2%)		11 (18.6%)	3 (6.5%)	
				27.3 UFC	24 UFC	0.66	48.2 UFC	40 UFC	0.006
> 100	0	0		4 (5.5%)	4 (7.3%)		9 (15.3%)	2 (4.4%)	
				745 UFC	400 UFC		2342.2 UFC	1240 UFC	
FS/100 ml									
0	11 (100%)	4 (57.1%)		26 (35.6%)	15 (27.3%)		13 (22%)	12 (26.1%)	
10-100	0	2 (28.6%)		36 (49.3%)	17 (30.9%)		22 (37.3%)	21 (45.7%)	
		50 UFC	0.09	44.2 UFC	49.4 UFC	0.41	47.4 UFC	46.7 UFC	0.80
> 100	0	1 (14.3%)		11 (15.1%)	23 (41.8%)		24 (40.7%)	13 (28.3%)	
		200 UFC		1099.1 UFC	1006.1 UFC		1582.9 UFC	932.3 UFC	

FC: Faecal coliforms, FS: Faecal streptococci

the proportion of people not having adequate access to drinking water and sanitation, according to the standards, criteria and indicators adopted in this area [14]. Following PN-AEPA 2015, a new program for 2030, the National Drinking Water Supply Program (PN-AEP) was set up [15]. Indeed, access to a safe drinking water is now considered a right and not a need. It follows that the technical approach changes radically, mobilizing the resource where it is, to bring water to users, instead of trying to find resources necessarily close to users. However, it is now recognized that the conditions of transportation and conservation of water at the level of the consumer when they are not adequate, or the lack of sanitary infrastructure, latrines and hand washing devices in particular may contribute to annihilate all efforts to provide a safe drinking water from the source.

The report on the baseline situation of 6 villages benefiting from the LAAFIA project shown that in the intervention villages, 71% of their populations use boreholes water, 25% well water 3% surface water and 1% lowlands water [16]. The baseline survey in the rural communes of Coalla and Manni in Eastern region of Burkina Faso, aimed to evaluate the microbiological quality of schoolchildren drinking water, also boreholes and households water in order to take action to obtain clean and safe water for these populations. Indeed, the prevalence of diseases related to poor hygiene and unimproved sanitation (gastroenteritis, parasitosis, dermatosis) was 6.82% and 4.39% in the rural communes of Coalla and Manni respectively.

This survey showed that primary water sources, which are completed bore holes are generally not polluted. Of the 18 water samples collected in these boreholes, 12 (66.7%) are free of microorganisms. Indeed, the building of a complete borehole requires prior scientific studies to ensure the quality of the groundwater to be filled. This proves that boreholes water is safe and must be preferred by people. The absence of *E. coli* in boreholes water samples testifies to the absence of recent fecal contamination of these waters. On the other hand, the presence of fecal coli forms and fecal streptococci indicates a possible infiltration of plant detritus from humans and animals faeces into the water table. Indeed, in these rural communes of Coalla and Manni, livestock is the main activity of the population and 93.2% of them practice open defecation. In addition, 95.1% of showers' wastewater is discharged into the wild [11]. All these practices, added to the transhumant breeding practice, increased the presence of microorganisms in the soil that can easily pollute the water table. Risk behaviors have been reported near boreholes platforms such as washing, showering and watering animals [17]. In contrast to our study, the presence of *E. coli* has been reported in 24.3% and 22% boreholes water samples in the districts of Lume and Siraro respectively in rural Ethiopia [18]. The presence of *E. coli* and other contaminated indicator bacteria, total coliforms, faecal coliforms, and fecal streptococci have been reported in borehole waters in a study in Arusha, Tanzania [19].

Household's drinking water was contaminated by fecal coli forms 79.7%*, E. coli* 22.7% and fecal streptococci 68%. Households collected water for drinking and other domestic uses with jars, buckets, cans, drums from the water source to their home. These water containers are cleaned approximately twice a week in some intervention villages [16]. Water collection and transportation from water source to home is mainly devoted to women and children in African countries [20,21]. Sometimes, they have to travel long distances and carry very heavy water containers. This can lead to injuries to their necks, backs and hips [22]. Some women domestic activities (childcare, cooking, gardening, breeding, etc.) are all sources of hand contamination [23,24] that can contaminate again water during its transportation, while filling storage containers or using stored water. The water storage containers in households and the different users of this water are also sources of contamination of water stored at home. Indeed, the frequency of cleaning storage containers was estimated at twice a week and a single container (cup) was used for different uses [16]. Pickering, et al. found in their study in Dar es Salam that water stored at home contained 1.4 log CFU/100 ml *E.coli* and 1.8 log CFU/100 ml fecal streptococci than the source from which it originated [25]. A significant correlation was found between the average of fecal contamination indicator bacteria and that of the hands of household members [25]. All these bacteria found in water may contribute to the formation of biofilm layer with high assimilable organic carbon (AOC) source of the coli forms re-growth [26].

The results of our study show that 84.8% of the water collected from schoolchildren containers was contaminated with total coli forms, 23.8% by *E. coli* and 76.2% by fecal streptococci. Schoolchildren fill their "little can" with water stored at home or directly at school if there is a borehole. The little cans filling by children whose hands are contaminated by various bacteria [25,27] and also the use of "little cans" not always well cleaned increase the risk of their drinking water contamination. Our results show a gradual increase (significant to verify) of indicator organism from boreholes water to those of schoolchildren. Similar results were reported in 2016 in a survey of schoolchildren in the Central and Central West regions of Burkina Faso [28]. Successive contaminations are increasing among schoolchildren and can lead to diarrheal diseases related to the consumption of unsafe water [29, 30]. According to WHO, waterborne diseases are the third leading cause of child mortality worldwide. Indeed, 1.8 million people die of diarrhea each year and 90% of them are children under 5 years, the vast majority of them lived in developing countries. About 88% of these cases of diarrhea are attributable to the consumption of unsafe water and inadequate sanitation and hygiene conditions [31].

Regardless of the area of origin or area of intervention of the LAAFIA project, the quality of the water is generally poor and justifies the need to carry out sensitization and education activities of the communities of these villages: best hygiene and sanitation practices, water treatment and conservation techniques for human consumption. The LAAFIA project will systematically promote the treatment of home water using chlorine in households and schools. A simple drinking-water treatment technique using *Moringa oleifera* seeds significantly reduces the microbial contaminant load by 82-94% for fecal coli forms, 81-100% for *E. coli,* and 94-100% for fecal streptococci [32].

Conclusion

This baseline survey shows that the microbiological quality is bad of both in households and in schoolchildren water bottles. All of these results strongly recommend interventions to improve the water, hygiene and sanitation practices both in schools and in households. Interventions of LAAFIA project, in the districts of basic education of Coalla and Manni will improve the living conditions of the general population and schoolchildren in particular. It is therefore necessary to carry out health education by combining the information and education activities that encourage people to know how to be healthy, how to achieve it, to do what they can individually and collectively to conserve their health. These results also demonstrate the need to strengthen inadequate sanitation facilities in schools and build capacity of teachers in WASH modules for better schoolchildren education on hygiene, health and sanitation. The results of this baseline study show that, with limited resources, a good rapid assessment methodology can generate useful information that can be used to inform non-governmental organizations in the country. We encourage them to move resolutely towards more studies evaluating the effectiveness of their interventions, evaluations that are able to bring scientific evidence and therefore greater value to so many commendable efforts on their part in the field.

Authorship and Contributorship

SD, CN and GC drafted and wrote the manuscript. HZ analyzed and interpreted statistical data. AK and GT collected and analyzed water samples. PA and LS reviewed the manuscript.

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