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SANITATION PRACTICES AND MICROBIAL QUALITY OF DRINKING WATER IN OPEN DEFAECATION FREE AND OPEN DEFAECATION COMMUNITIES IN THE SAVELUGU MUNICIPALITY

N. Bakobie, A. R. Ibrahim And A. B. Duwiejuah*
(N. B.: Department of Environment, Water and Waste Engineering, School of Engineering, University for Development Studies, Tamale, Ghana; A. R. I.: Ecotourism and Environmental Management, Faculty of Natural Resources and Environment, University for Development Studies, Nyankpala Campus, Tamale, Ghana; A. B. D.: Department of Biotechnology and Molecular Biology, Faculty of Biosciences, University for Development Studies, Tamale, Ghana).
**Corresponding author's email: abalu096@gmail.com*

ABSTRACT

Open defaecation leads to faecal matter contamination of drinking water which can cause water borne diseases. The study assessed the linkage between sanitation practices and microbial quality of drinking water of open defaecation free and open defaecation communities in the Savelugu Municipality. A cross-sectional survey of 170 households was conducted in five open defaecation free and five open defaecation communities in the Savelugu Municipality. A total of 78 samples were collected from water sources and households and analysed for *Escherichia coli*, *Salmonella* spp and *Shigella* spp. Sanitation facilities used by the residents included pit latrine (88.24%), no latrine (11.17%), and flush (0.59%). The study observed improper disposal of children faeces in the communities. *E. coli* count ranged from 0 to 15 CFU/100 ml in open defaecation free communities and 0 to 32 CFU/100 ml in open defaecation communities. The microbial load in the drinking water from open defaecation communities was higher than open defaecation free communities. Open defaecation practice leads to contamination of household water probable due to unsanitary. Community Led Total Sanitation (CLTS) should be encouraged in open defaecation communities.

Keywords: Community Led Total Sanitation, drinking water, open defaecation, open defaecation free, *Salmonella* spp

Introduction

In developing countries, most people do not have any form of sanitation services and access to clean water. As a result, millions of people are suffering from hygiene, water, and sanitation related diseases such as trachoma, skin diseases and diarrhoea (Muhammed *et al.,* 2016). According to World Health Organisation (2017) 159 million people largely rely on surface water sources like rivers for drinking water whilst 423 million rely on unprotected springs for water that is connected to transmission of water-associated diseases.

The United Nations have affirmed sanitation as a right for human beings (WHO & UNICEF, 2015). However, 2.6 billion people have no access to enhance sanitation whilst approximately 1.3 billion people are practising open defaecation, in nearly all developing nations and mostly in rural areas (WHO & UNICEF, 2015). Lack of adequate sanitation contributes to contamination of drinking water particularly due to open defaecation which has health effect on the public. Open defaecation elimination is therefore seen as a main health outcome. The transfer of several diseases of microbial origin are through water which serves as vehicles. WHO reported that 1.8 billion people drink water polluted with *Escherichia coli*, which is an indicator of fresh faecal matter contamination (Bain *et al.,* 2014)?

In Africa, Ghana has been ranked second in open defaecation, with almost 5 million people without any toilet facility (WHO & UNICEF, 2015). In Ghana, 18.75% people are reported to have been practising open defaecation in 2015 (World Bank, 2015). The prevalence of open defaecation practice is about 89% in the Upper East Region without any form of latrine, about 72% in Northern Region and about 71% in Upper West Region (WHO & UNICEF, 2015).

Open defaecation deteriorates drinking water quality making it unfit for the purpose of drinking and increasing chances of water related diseases. Three people out of every five drink faeces contaminated water increasing people risk of contracting diseases which include cholera and diarrhoea. Diarrhoea causes over 3,600 deaths of Ghanaian children every year and cholera outbreaks happening in the cities frequently (United Nations International Children's Emergency Fund, 2017).

Northern Ghana has seen the coming and support of many partners with lots of monies going into the WASH (water, sanitation and hygiene) sector and yet the impact seem to be very minimal. The study was to assess the linkage between sanitation practices and microbial quality of drinking water of open defaecation free and open defaecation communities in the Savelugu Municipality.

Experimental

Study area

The study was carried out in some open defaecation free communities (Chahiyili, Lagbani, Damdu, Zaazi-Kukuo and Zaazi) and open defaecation communities (Libga, Balshei, Kanshegu, Yemo and Duko) of the Savelugu Municipal in the Northern Region, Ghana. Savelugu Municipality shares boundaries with East Mampurusi District to the North, Karaga District to the East, Tamale Metro to the South and Kumbungu to the West (Ghana Statistical Service, 2012). It has a total projected land size of 2022.6 sq km with 149 total communities out of which only 14 communities are open defaecation free. The Municipality lies between longitudes 0º 36 and 0º 57 West and latitude 9.6247222 and 9º 34 North (Ghana Statistical Service, 2012).

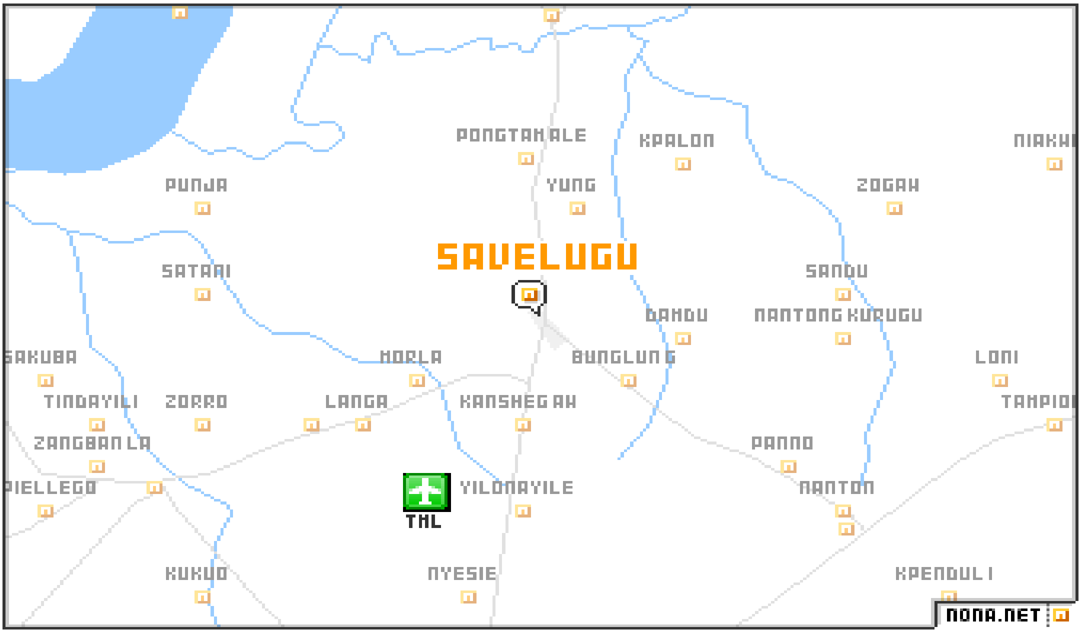

Fig. 1: Map of Savelugu Municipality.

Qualitative data

The Yamane formula was used at a 92% confidence and with 8% margin of error

$$n = \frac{N}{1+N(\partial^2)}$$

N = sample frame, 1 = a constant, n = sample size, and a margin of error, ∂ = 0.008.

The total population in the ten communities (five open defaecation free and five open defaecation communities) was 4,191 representing the sample frame and the sample size worked out to be 170, using the formula above.

Data collection

A cross-sectional survey of 170 households was conducted in five open defaecation free and five open defaecation communities in the Savelugu Municipality. A cluster sampling technique was used to select open defaecation free and open defaecation communities from the Savelugu Municipality. Simple random sampling technique was then used to select 85 households from each community. Households with proximity to water sources and sources of drinking water within the study areas were given much consideration. A questionnaire was administered to 170 respondents. Information on access to sanitation and the disposing factors in relation to water pollution were obtained through observation and using questionnaire. The respondents consented and were assured of confidentiality before the face-face interview was conducted in the study.

Household water sample collection

Samples were collected on weekly basis for three weeks from January to March 2018. A total of 78 samples were taken from water sources and household for *Escherichia coli*, *Salmonella* spp and *Shigella* spp. Each sampling bottle was rinsed three times with the water sample before filling. Samples were collected into 500 ml plastic bottles after the content was rinsed three times with the sampling water at the site. Sample bottles were labelled appropriately and immediately placed in cold ice chests and transported to the water quality laboratory of the World Vision International, Savelugu for analysis.

Bacteria analysis of water samples

Using membrane filter technique, 100 ml of water sample was passed through the membrane using vacuum system and a filter funnel. Water samples were collected aseptically. The appropriate culture medium was selective with respect to the target microorganisms. Sterile forceps were used to remove membrane filter from case and placed into the filter assembly. The lip of the pouring sample container was flamed before the water sample was poured into the filter funnel. The vacuum pump was turned on and water sample was allowed to draw out completely through the filter paper. The forceps was then flamed before it used to remove the membrane filter from the funnel. The filter paper was then placed in the Petri dish containing Methylene Blue (EMB) Agar for *E. coli*, and Xylose-Lysine Deoxycholate (XLD) Agar for *Salmonella* spp and *Shigella* spp. The Petri dish was then incubated for 18 - 24 hours incubated at 37°C (*E. coli*) and 18 - 24 hours at 37°C (*Salmonella* spp and *Shigella* spp). Discrete colonies formed were then enumerated and calculated using the formula; bacteria colonies per 100 mL = bacteria colonies counted all divided by the mL of sample used × 100 (American Public Health Association (APHA), 2017).

Principal component analysis (PCA)

Principal component analysis was used to compare the variability of bacteria at the open defaecation free and open defaecation communities. The model is a linear grouping of variables elucidating the matrix variance structure that condense the different data into a small number of principal component. The correlation between the bacteria counts in the drinking water were determined using Pearson's correlation.

Results

Demographic characteristics of the respondents

Of the 170 respondents interviewed, 67.65% of the respondents were females (n=115) whilst 32.35% were males (n=55) (Table 1). The age of the respondents ranged from less than 24 (43.52%), 25 - 44 years was 29.42%, 45 - 64 years was 21.18% and 65 years and above was 5.88% (Table 1). The respondents' education levels were no formal education (72.35%), primary (13.53%), senior high school (11.74%), and tertiary (2.35%) (Table 1). The marital status of the respondents were married (40%), single (44.12%) and widowed (15.88%) (Table 1).

TABLE 1
Demographic characteristics of the respondents.

Gender	Frequency (N = 170)	Percent (%)
Male	55	32.35
Female	115	67.65
Total	170	100
Age		
Less than 24 years	74	43.52
25 - 44 years	50	29.42
45 - 64 years	36	21.18
65+ years	10	5.88
Total	170	100
Education		
Primary/JHS Level	23	13.53
SHS	20	11.74
Tertiary	4	2.35
No formal	123	72.35
Total	170	100
Marital status		
Married	68	40
Widowed	27	15.88
Single	75	44.12
Total	170	100

Sanitation types in communities and cultural issues hindering

The kind of sanitation facilities used by the respondents included pit latrine (88.24%), no latrine (11.17%), and flush (0.59%) (Table 2). The respondents that did not share latrine in the household were 92.5% and those that shared latrine were 5.88% (Table 2). This study found household size of two to three persons that shared latrine to be 5.29%, four to five persons were 1.18% and those that did not share were 93.53% (Table 2).

TABLE 2

Sanitation types in the communities and cultural issues hindering.

What kind of toilet facility	Frequency (N = 170)	Percent (%)
Flush	1	0.59
Pit latrine	150	88.24
No latrine	19	11.17
Total	170	100
Do you share the latrine with any household		
Yes	10	5.88
No	160	94.12
Total	170	100
How many household use the latrine		
2-3 persons	9	5.29
4.5 persons	2	1.18
None	159	93.53
Total	170	100
Do women and girls use the latrine		
Yes	169	99.41
No	1	0.59
Total	170	100
Do men and boys use the latrine		
Yes	169	99.41
No	1	0.59
Total	170	100

Factors associated with domestic water contamination

Households faecal disposal practices

The methods of the child faeces disposal in the households were doing nothing (48.82%), burying (32.35%), and disposal into the latrine (18.82%) (Table 3). Also, 94.71% of the respondents admitted that they used to defaecate in bush / shrubs / forest in the community before CLTS, 3.53% defaecate in around the community and only 1.76 defaecate in public toilet (Table 3). The reasons for these practices were they did not have latrine (48%), to burry or cover the faeces (18.5%) and the place is close (31.80%) (Table 3). The survey showed 68.82% of the respondents admitted nothing good comes from defaecating openly (Table 3). Also, 79.41% of the respondents admitted exposure to snakes and scorpions when engaged in open defaecation.

TABLE 3

Households faecal disposal practices.

Last time the youngest child passed stool what was done to it	Frequency (N = 170)	Percent (%)
Buried	55	32.35
Disposed in the latrine	32	18.82
Nothing	83	48.82
Total	170	100
Where did you defaecate before CLTS		
Around the community	6	3.53
Bush / shrubs / forest in the community	161	94.71
Public toilet	3	1.76
Total	170	100
Why you did defaecate there		
Did not have latrine	83	48
To burry or cover the faeces	32	18.50
The place is close	55	31.80
Total	170	100
What good did you observe defaecating there		
Separated our faeces from the community	42	24.71
Covered our nudity	11	6.47
Nothing good	117	68.82
Total	170	100
What bad did you observe defaecating there		
Exposure to snakes and scorpions	135	79.41
Exposure of our nudity	19	11.18
It is our cemetery	9	5.29
Others	7	4.12

Improvement of general well-being of the communities

Out of the 170 respondents, 94.70% respondents said CLTS had improved their well-being in the communities, only 5.30% people said CLTS had not improved their well-being in the communities (Table 4). Citing examples such as making them clean the whole community at least once every week, children not falling sick regularly, and they were now enjoying natural air due to clean and non-smelly environment.

How sanitation can be maintained

Out of the 170 respondents, 11.77% were of the view that Municipal Environmental Health and Sanitation Unit (MEHSU) should continuously monitoring their communities, 30.58% said the continuous training of their sanitation committees will help sustain CLTS/ sanitation in their communities, whilst 57.65% said help from the Municipal Assembly will help sustain CLTS (Table 5).

TABLE 4

How CLTS/sanitation can be sustained.

Activity	Frequency (N = 170)	Percent (%)
By continuous monitoring by the MEHSU	20	11.77
By continuous training of the sanitation committee	52	30.58
Help from the Municipal Assembly	98	57.65
Total	170	100

Household water sources and treatment in the communities

In the study, 91.18% of the respondents depend on borehole water (improved source of water) and only 8.82% depend on river / dam water (unimproved). Mostly, women who fetched water for the household uses of which majority spent 5 - 50 minutes to supply the household water. Also, 4.71% people responded they treated their household water whilst 95.29% respondents said they did not treat their water (Table 5). The various methods of water treatment in the households in various communities included filtration (63.50%) and addition of alum (36.5%) (Table 5).

TABLE 5

Household water sources and treatment in the communities.

What is your main source of water for cooking and washing	Frequency (N = 170)	Percent (%)
Borehole	155	91.18
River/ dam	15	8.82
Who usually goes to the source to fetch water for your household		
Women	124	72.94
Men and women	28	14.12
Children	18	10.59
How long does it take to go there get water and come back		
5-15 mins	56	32.94
16-30 mins	44	25.88
31-40 mins	35	20.59
41-50 mins	26	15.29
60+ mins	9	5.29
Do you treat your water in any way to make it safer to drink		
Yes	8	4.71
No	162	95.29
What treatment method do you use		
Filtration	108	63.53
Addition of alum	62	36.47

Bacteria in drinking water in open defaecation free and open defaecation communities

E. coli count ranged from 0 to 15 CFU/100 ml with a mean of 1.05 CFU/100 ml in open defaecation free communities and 0 to 32 CFU/100 ml with a mean of 2.79 CFU/100 ml in open defaecation communities (Table 6). *Salmonella* spp ranged from 0 to 48 CFU/100 ml with a mean of 2.38 CFU/100 ml in open defaecation free communities and 0 to 48 CFU/100 ml with a mean of 3.23 CFU/100 ml in open defaecation communities (Table 6). *Shigella* spp ranged from 0 to 31 CFU/100 ml with a mean of 3.15 CFU/100 ml in open defaecation free communities and 0 to 172 CFU/100 ml with a mean of 18.08 CFU/100 ml in open defaecation communities (Table 6).

TABLE 6

E. coli, Salmonella spp and Shigella spp counts of the communities.

Sample site		*E. coli* (CFU/100 ml)	*Salmonella* spp (CFU/100 ml)	*Shigella* spp (CFU/100 ml)
Open defaecation free	Min	0	0	0
Open defaecation free	Max	15	31	48
Open defaecation free	Mean	1.05	3.15	2.38
Open defaecation	Min	0	0	0
Open defaecation	Max	32	172	48
Open defaecation	Mean	2.79	18.08	3.23

TABLE 7

Correlation matrix of the bacteria.

Variables	*E. coli*	*Salmonella* spp	*Shigella* spp
E. coli	**1**		
Salmonella spp	**0.869**	**1**	
Shigella spp	**0.227**	0.059	**1**

Values in bold are different from 0 with a significance level alpha = 0.05

The study showed 29% occurrence *E. coli*, 24% occurrence of *Salmonella* spp and *Shigella* spp in drinking water sampled from open defaecation free communities and 71% occurrence of *E. coli*, 76% occurrence of both *Salmonella* spp and *Shigella* spp in open defaecation communities (Figure 1).

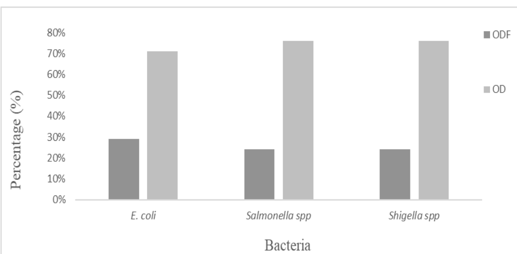

Fig. 1: Percentage of *E. coli*, *Salmonella* spp and *Shigella* spp occurrence in water sample.

Factors influencing bacteria contamination of the drinking water in open defaecation free and open defaecation communities

PCA was used to identify possible variability in bacteria count in sources of drinking water in the open defaecation free and open defaecation communities. Only one component of eigenvalue was greater than 1 extracted, accounting for 63.79% of total variance. The first two accounted for 97.17% of total variance, with PC1 (*E. coli* and *Salmonella* spp) accounting for the 63.79% of total variance (Figure 2). PC2 (*Shigella* spp) accounted for 32.38% of total variance, whilst PC3 accounted for 3.83% of total variance. This denoted the first distinction in the bacteria profiles in the open defaecation free and open defaecation communities (Figure 3).

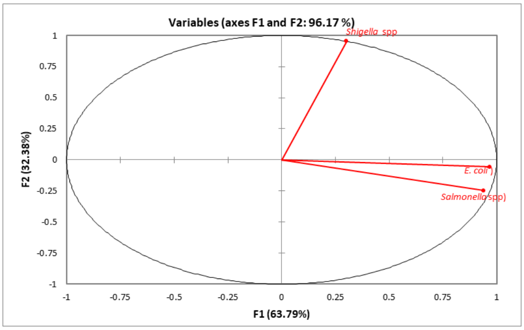

Fig. 2: Distribution of bacteria in the first and second principal component.

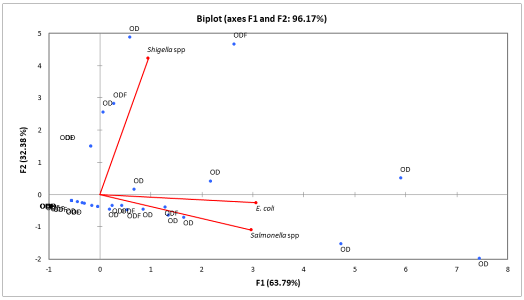

Fig. 3: PCA map of the 78 water samples from open defaecation free (ODF) and open defaecation (OD) communities and the bacteria.

Discussion

The all the people said they do not have any cultural issues hindering their use of latrines. The use of improved latrine is accompanied with good number of benefits to the household, an individual, and community (Bwire, 2010). The use and access to improved sanitation facilities can reduce open defaecation that prevent contamination of the environment with human faeces. The study also showed improper disposal of children faeces in both open defaecation and open defaecation free communities as almost half of the respondents said nothing is done to the child faeces. Improper disposal of child faeces have negative implications on the environment (Okullo *et al.*, 2017). Since children's faeces also contain germs like adult's faeces and it is essential to dispose them safely and quickly (Azage & Haile, 2015; Harris *et al.,* 2017).

Majority of the respondents admitted the use to open defaecate but the intervention of CLTS in open defaecation free communities have reduced the practice. The use of latrines have ensured a good sanitation, faecal-connected diseases prevention, or healthy environment such as cholera and diarrhoea (Azage & Haile, 2015). The type of treatment method they employ in treating their water are filtration, boiling and addition of alum. These types of treatments are being used depending on the source of the water.

Microbial load in the drinking water from open defaecation communities was higher than open defaecation free communities. Hence, open defaecation practice leads to contamination of household water probable due to inadequate protection (poorly covered, uncovered or open) and unsanitary water collection and storage containers in the communities. Similarly, Tambekar & Rajgire (2012) reported that drinking water in open defaecation free communities was 17% faecally contaminated whilst open defaecation was 48%. There was significant positive correlation between *E. coli* and *Salmonella* spp implying common unhygienic practices cause their contamination in the drinking water. Unhygienic practices has contributed to the loads of *E. coli* and *Salmonella* spp which could originate from faecal matter from livestock, human, and pet. Whilst flies could have contaminated the drinking water with *Shigella* spp as a transmission vector from polluted faecal waste.

Microbial contamination of drinking water is caused by lack of hygienic practices and could lead diseases such as typhoid, dysentery and diarrhoea. Unsanitary ways of handling drinking water at household, including contaminated hands and dippers, and unsatisfactory cleaning of vessels, which lead to accumulation of sediments and pathogens. Also, clothing, hands, food, and utensils can play a role in water contamination, mostly when domestic hygiene and sanitation are poor which can lead to occurrence of sanitation-related diseases such as cholera and typhoid (Odeleye & Idowu, 2015). This finding was lower than 71% *E. coli* occurrence in water samples in unproved water sources in Manonyane community in the Maseru District (Olowe *et al.,* 2016).

Conclusion

The study showed there are no cultural issues hindering the people access and use of latrines in the communities. Microbial contamination of drinking water was high in open defaecation communities than open defaecation free communities. There is a good linkage between microbiological quality of the drinking and sanitation practices in the communities. Unhygienic practices has contributed to the *E. coli* and *Salmonella* spp count which could originate from faecal matter from livestock, human, and pet. Whilst flies could have contaminated the drinking water with *Shigella* spp as a transmission vector from polluted faecal waste. The microbial contamination of the drinking water can lead to water related diseases such as dysentery, typhoid and diarrhoea that can lead to disease burden in the communities. The adoption of the community led total sanitation can help reduce contamination of drinking water and incidences of waterborne disease. The study recommends that uunhygienic practices must be stopped and construction of latrines by every household should be encouraged in the open defaecation communities.

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Conflict of interest

There is no conflicting interest amongst authors of this manuscript.

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