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Full Length Research Paper

Comparison of solids in effluent from pulping kenaf stem with formic acid and sodium hydroxide

Chukwudebelu J. A.[1]* and Agunwamba J. C.[2]

[1]Center for Environmental Management and Control, Faculty of Environmental Management and Control, University of Nigeria, Nsukka, Enugu State Nigeria.
[2]Department of Civil Engineering, Faculty of Engineering, University of Nigeria, Nsukka, Enugu State Nigeria.

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The pulp and paper industry is the sixth largest polluter discharging a variety of gaseous, liquid and solid wastes into the environment. This pollution mainly arises due to chemicals used during production, so this study compared these two chemicals to determine the better one for a cleaner production process. A dewatered kenaf stem was cooked in the 20, 60 and 90% concentrations of formic acid and sodium hydroxide at time intervals of 1, 2 and 3 h to compare the solids (total suspended solid, total dissolved solid and total solid) of their effluent for environmental friendliness. After examining the whole concentrations and the time intervals, 60% concentration of the acids at 2 h pulping gave better pulp on physical examination. When the solids of the effluents of the two chemicals were analyzed, formic acid effluent had a TSS of 5768 mg/L, TDS of 54088 mg/L and TS of 59855 mg/L, while that of sodium hydroxide was 6053 mg/L for TSS, 96628 mg/L for TDS and 102680 mg/L for TS. This study showed that pulping of kenaf stem with 60% formic acid for 2 h has effluent that is greener than the use of sodium hydroxide of the same concentration at the same duration.

Key words: Effluent, environmental quality, formic acid, kenaf stem, sodium hydroxide, total solids.

INTRODUCTION

Generally, the pulp and paper industry has been considered to be a major consumer of natural resources (wood, water) and energy (fossil fuels, electricity) and a significant contributor of pollutants discharge to the environment (Hossain and Ismail, 2015). Environmental effects have been attributed to chemicals introduced during the manufacturing process, to natural compounds released from plant material used as mill furnish, to interactions of these compounds with each other and interactions with biota in mill effluent during waste water treatment (Hewitt et al., 2006). Accordingly, in both traditional and emerging paper and pulp producers (Chen et al., 2012) such as United States (Schneider, 2011), China (Zhu et al., 2012) and India (Afroz and Singh, 2014), pulp and paper mills are considered a major source of environmental pollutants. Pulping wood or

*Corresponding author. E-mail: adadebelu@yahoo.com.

agricultural residue using conventional methods releases a range of pollutants, including organic products that cause eutrophication in water, aluminium salts and sometimes, sulphur dioxide to the atmosphere. Polluted river due to pulp and paper effluent discharge has adversely affected the aquatic fauna as well as communities in the surrounding areas who economically depend on this river for fishing and agriculture purposes (Zuby and Ajay, 2014). Effluent quality is commonly judged on the basis of such aggregate characteristics as biochemical oxygen demand, chemical oxygen demand, total suspended solids (TSS), total solids (TS), turbidity, pH, color e.t.c. Total suspended solid (TSS) represents the solid particles mixed in water or effluent. Total dissolved solids (TDS) are measured as the mass of residue remaining when a measured volume of filtered water is evaporated. Total solids (TS) are the amount of solid present in dissolved and suspended form. The significant solid wastes such as lime mud, lime slaker grits, green liquor dregs, boiler and furnace ash, scrubber sludges, wood processing residuals and wastewater treatment sludges are generated from different mills. Disposal of these solid wastes cause environmental problems because of high organic content, partitioning of chlorinated organics, pathogens, ash and trace amount of heavy metal content (Monte et al., 2009).

Pulping procedure consists of a selective extraction of lignin from lignocellulosics like wood and nonwood materials without degradation of cellulose. It can be chemical pulping (e.g., kraft or soda chemical pulping), mechanical pulping, and semichemical pulping. Soda pulp is the original chemical pulp and is produced by cooking chips of (usually) deciduous woods in a solution of caustic soda under pressure. The pulping process affects the strength, appearance and intended use characteristics of the resultant paper product. Pulping processes are the major source of environmental impacts in the pulp and paper industry, each pulping process has its own set of process inputs, outputs and resultant environmental impacts. The story of the Nigerian paper and pulp manufacturing sub-sector of the economy, especially in the last three decades at best, resonates with the familiar take of the comatose operational state of the manufacturing sector in general. The few existing ones have resisted pressure to make their processes environmental benign. Pulp and paper industry is considered as one of the most polluting industry contributing 100 million kg of toxic pollutants that are being released every year in the environment (Dey et al., 2013). The introduction and development of organosolv pulping is aimed to reduce the environment pollution by improved pulping process. Some other organosolv processes include ASAM (Kordsachia and Patt, 1988; Kordsachia et al., 2002), MILOX (Ligero et al., 2010) e.t.c. Previous studies (Preeti, 2008; Ligero et al., 2010) have concentrated on some characteristics of effluent from pulping with formic acid and soda without considering the interaction between the chemical, time, and concentration. Chempolis belongs to Organosolv which is a chemical pulping carried out by using organic solvents and chemicals (Lora and Aziz, 2000; Lonnberg et al., 1987). Chempolis process is based on acidic delignification to remove lignin, a desired part of the hemicelluloses and nutrients. In Chempolis process (Rousu et al., 2002), pulping is carried out with formic acid at slightly elevated temperatures with a conventional liquor-to-straw ratio. Most studies in the field of organic pulping have only focused on the properties of the pulp while the waste is a growing public health concern worldwide. Hence, the goal of this paper is to find out if there exists a possibility for improving the effluent quality by exploring the interactions of the chemicals, concentration, and time which was not favored in prior attempts by previous researchers.

MATERIALS AND METHODS

Kenaf stem was chopped into 1 to 4 cm long, washed with warm water to remove dirt and dust. The washed kenaf was dewatered to a solid content of 40% to 45%. Five grams of kenaf stem was taken in 400ml of pulping mixture in 1000 ml flask at atmospheric pressure and pulped at 20, 60 and 90% concentrations of formic acid and sodium hydroxide, cooking time was varied from 1, 2 h and 3 h at 95°C as shown in Figure.1. At the end of each period, the sample was filtered with a fine mesh sieve of size 0.027 mm to get the effluent used in the analyses. The tests were carried out in triplicate and each value is an average of three samples.

The effluent was analysed using the Standard Method for Examination of Water and Wastewater (APHA, 2005). The parameters determined were TSS, TDS and TS. The ANOVA tables on appendix 2 were used to test the hypothesis which states that duration and concentration of chemicals do not affect waste characterization during pulping.

RESULTS AND DISCUSSION

After 1 h and 20% concentration of acids pulping, the residue was not well pulped. At 2 h and 60% concentration pulping, the residue was well pulped. At 3 h and 90% concentration, some were well pulped while others were over pulped. Table 1 shows the values of TSS, TDS and TS of the effluent when the stem was pulped with 20% concentration of formic acid and sodium hydroxide at 1, 2 and 3 h intervals. With sodium hydroxide (NaOH), the TSS values in the reaction was highest (9903 mg/L) after 1 h but reduced with increase in time with a value of 7385 mg/L at 3 h.

Formic acid had its lowest TSS value (5968 mg/L) at 3 h and highest at 1 h (8178 mg/L). The finding of the present study suggest that value of TSS in effluent from formic acid and sodium hydroxide pulping decrease with increase in pulping time which is in agreement with Preeti (2008) and Pooja et al. (2013). With NaOH, the values of

Kenaf stem Dewatered kenaf stem Pulping of kenaf stem Pulping effluent

Figure 1. Stages of kenaf stem pulping.

Table 1. Effluent from pulping with 20% FA and NaOH.

Time (hour)	Chemicals/parameter	TSS (mg/L)	TDS (mg/L)	TS (mg/L)
1	FA	8178	35912	44089
	NaOH	9903	89338	99240
2	FA	7193	43105	50298
	NaOH	8148	37533	45680
3	FA	5968	45438	51405
	NaOH	7385	8139	15524

Variation of TSS, TDS and TS values with cooking at 1, 2 and 3 h with 20% concentration of FA and NaOH.

Table 2. Effluent from pulping with 60% FA and NaOH.

Time (how)	Chemicals/parameter	TSS (mg/L)	TDS (mg/L)	TS (mg/L)
1	FA	6185	50,863	57048
	NaOH	9060	118885	127945
2	FA	5768	54088	59855
	NaOH	6053	96628	102680
3	FA	5433	54495	59928
	NaOH	4638	68223	72860

Variation of TSS, TDS and TS values with cooking at 1, 2 and 3 h with 60% concentration of FA and NaOH.

TDS reduced with time from 89338 mg/L at 1 h to 8139 mg/L after 3 h while TDS increased from 35912 mg/L at 1 h to 45438 mg/L after 3 h with formic acid. This may be indicative that chemicals and raw materials react differently. This findings showed increase in TS with time in formic acid (44089 to 51405 mg/L) and decrease with time in NaOH (99240 to 15524 mg/L). This suggests that solids in the formic acid solution were not degraded much with time and concentration.

Table 2 provides the values of TSS, TDS and TS of effluent obtained when the stem was pulped with 60% concentration of FA and NaOH. From the data in the table, there is a clear trend of decreasing in the TSS values of FA and NaOH effluent which suggest that more organic matter was degraded with time. As illustrated in Table 2, TDS of effluent from FA pulping increased with increase in time while that from NaOH pulping decreased with increase in time which shows that NaOH was able to digest more organic matter. The TS content of FA pulped effluent showed increment with time while NaOH pulped effluent reduced with time.

Table 3 presents the values of TSS, TDS and TS from

Table 3. Effluent from pulping with 90% FA and NaOH.

Time (hour)	Chemicals/parameters	TSS (mg/L)	TDS (mg/L)	TS (mg/L)
1	FA	5273	55670	60942.5
	NaOH	7353	285988	293340
2	FA	5122	65045.5	70167.5
	NaOH	6105	210405	216510
3	FA	4973	83172	88145
	NaOH	3165	129068	132233

Variation of TSS, TDS and TS values with cooking at 1, 2 and 3 h with 90% concentration of FA and NaOH.

effluent obtained from pulping kenaf stem with 90% concentration of FA and NaOH. As illustrated in Table 1 and 2, TSS from FA and NaOH pulping effluent decreased with time having highest and lowest as 5273/4973 and 7353/3165 mg/L. While the value of TDS from NaOH pulping followed the same pattern, while that from FA increased with increase in time and the same occurred with TS values. The effluent from NaOH pulping showed a high reduction in TS values from 1 to 3 h with 90% concentrations which may be as a result of reduction in the amount of solid particles in the solution with time as can be seen in Pooja et al. (2013).

All the concentrations with the two chemicals have their maximum TSS after 1 h and minimum after 3 h which gave highest value at 20% for 1 h and lowest at 90% for 3 h (9903 and 3165 mg/L) The finding is consistent with findings of past studies by Preeti (2008) and Pooja et al. (2013), in which there were decreases in the TSS values. The effluent from NaOH pulping showed a high reduction in TS values from 1 to 3 hours in all the concentrations which may be as a result of reduction in the amount of solid particles in the solution as reflects in Pooja et al. (2013). With formic acid, TS value did not decrease rather it showed a minimal increase with time along the concentration lines. This showed that solids in the solution did not degraded much with time and concentration.

In this research, solids in the pulping effluent are considered with respect to environmental quality. High values of solids in effluent are detrimental to the environment. Federal Ministry of Environment has effluent standard for discharge into the environment. The maximum limit for total dissolved solid is 2000 mg/L, total suspended solid is 30 mg/L while total solid is 2030 mg/L (FEPA, 1991). From the two pulping processes, though formic acid effluent has values far above the limit, it is lower than that of sodium hydroxide.

Conclusion

Environmental qualities of solids from soda and formic acid pulping of kenaf stem were compared. This was done by pulping at three different concentrations of the chemicals during three time periods. Based on the information from the bench, it was found that pulping with formic acid and soda at 60% concentration for two hours has better environmental quality. This was selected from other conditions because it gave better pulp on physical examination as well as better environmental qualities on analyses. Though the results do not indicate that this option is the best in all parameters analyzed, it ranked the best in most of the parameters. Turning kenaf waste into resources is not only a good idea but also a proven one; it could have a very positive impact on people and the planet while building a profitable business. However, further research is needed to check other effluent parameters to know whether they toe the same line as the solids.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix 2
ANOVA tables for Hypothesis

TDS

	2hrs	
	FA	**NaOH**
20%	43105	37533
60%	54088	96628
90%	65046	210405

ANOVA

SUMMARY	***Count***	***Sum***	***Average***	***Variance***		
0.2	2	80638	40319	15523592		
0.6	2	150716	75358	9.05E+08		
0.9	2	275451	137725.5	1.06E+10		
FA	3	162239	54079.67	1.2E+08		
NaOH	3	344566	114855.3	7.72E+09		
Anova:						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	9.74E+09	2	4.87E+09	1.637995	0.379076	19
Columns	5.54E+09	1	5.54E+09	1.8641	0.305439	18.51282
Error	5.94E+09	2	2.97E+09			
Total	2.12E+10	5				

From the ANOVA, p > α in both rows and columns which shows that there is no statistical significant difference in chemicals and concentrations. Therefore, the null hypothesis is accepted in both rows and columns.

TSS

	2 hrs	
	FA	**NaOH**
20%	7192.5	8147.5
60%	5767.5	6105
90%	5122	6052.5

ANOVA

SUMMARY	***Count***	***Sum***	***Average***	***Variance***		
0.2	2	15340	7670	456012.5		
0.6	2	11872.5	5936.25	56953.13		
0.9	2	11174.5	5587.25	432915.1		
FA	3	18082	6027.333	1122378		
NaOH	3	20305	6768.333	1427265		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	4977025	2	2488513	40.70878	0.023976	19
Columns	823621.5	1	823621.5	13.47336	0.066862	18.51282
Error	122259.3	2	61129.63			
Total	5922906	5				

From the ANOVA, the p < α on the rows which shows that there is statistical significant difference in the concentrations. P > α on the columns which shows that there is no statistically significant difference in the chemicals. Therefore, the null hypothesis is rejected and the alternative hypothesis accepted for the rows. And the null hypothesis is accepted for the columns.

TS

	2 hrs	
	FA	**NaOH**
20%	50297.5	45680
60%	59855	102680
90%	70167.5	216510

Anova:

SUMMARY	***Count***	***Sum***	***Average***	***Variance***
0.2	2	95977.5	47988.75	10660653
0.6	2	162535	81267.5	9.17E+08
0.9	2	286677.5	143338.8	1.07E+10
FA	3	180320	60106.67	98751727
NaOH	3	364870	121623.3	7.56E+09

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Rows	9.37E+09	2	4.68E+09	1.571999	0.388803	19
Columns	5.68E+09	1	5.68E+09	1.905084	0.301539	18.51282
Error	5.96E+09	2	2.98E+09			
Total	2.1E+10	5				

From the ANOVA, $p > \alpha$ in both rows and columns which shows that there is no statistical significant difference in chemicals and concentrations. Therefore, the null hypothesis is accepted in both rows and columns.

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Full Length Research Paper

Analysis of physiochemical characteristics influencing disposal of pit latrine sludge in Nakuru Municipality, Kenya

Gudda, F. O.[1]*, Moturi, W. N.[1], Omondi, S. O.[3] and Muchiri, E. W.[2]

[1]Department of Environmental Science, Egerton University, Kenya.
[2]Department of Civil and Environmental Engineering, Egerton University, Kenya
[3]Department of Biological Sciences, Egerton University, Kenya.

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On-site sanitation facilities, mostly pit latrines are the main points of human excreta disposal in peri-urban low-income settlements in Kenya. Collection, treatment and final disposal of pit latrine faecal sludge, pose a significant management problem and present public health risks. The choice of appropriate faecal sludge treatment technology depends on precise region based data on the sludge characteristics that are often unavailable. The study analysed physiochemical characteristics of faecal sludge sampled at different depths of pit latrines. Twenty-four samples were collected from six pit latrines along the depth strata at 1-m intervals from the surface to 3 m depth. Samples were analysed for chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonia, total nitrogen and total phosphorus. The mean COD: BOD ratio was 1:5 with a concentration of 112800 and 24600 mg/L, respectively. Concentrations for all parameters were variable and higher in comparison with properties reported in literature. Upper layers had higher concentrations than lower depths. The concentrations of the sludge were 10-100 higher than acceptable limits for in-fluent sludge into municipal wastewater treatment plants. These results show that disposal of pit latrine faecal sludge into the wastewater treatment plants without co-treatment overload the system since treatment plants in use currently have not been designed to handle pit latrine sludge. The properties of faecal sludge analysed indicate that the wastewater treatment plants may not be capable of treating faecal sludge unless co treatment mechanisms are applied. Therefore, influent faecal sludge must be maintained within allowable concentrations; otherwise, the effluents may lead to significant environmental pollution impacts.

Key words: On-site sanitation, depth strata, faecal sludge disposal, low-income settlements.

INTRODUCTION

Despite significant steps and achievements towards meeting the Millennium Development Goals (MDGs) on sanitation, approximately 2.5 billion people did not have access to improved sanitation services as at 2015

*Corresponding author. E-mail: freddgudda@gmail.com.

(WHO/UNICEF, 2015).

Sanitation gaps exist regarding services offered to urban poor and rural communities in developing countries. According to the 2015 Joint Monitoring Program (JMP) progress report, in sub-Saharan Africa, only 30% of the current population have access to improved sanitation facilities. In addition, the region has the greatest share of people practicing open defecation and recorded an increase in open defecation cases, whereas all other regions of the world recorded a decrease since 1990 (WHO/UNICEF, 2015).

In Kenya, approximately 60% of the urban dwellers live in peri-urban low-income settlements characterized by inadequate or no sewerage connections (Nilsson and Nyanchaga, 2008). Therefore, on-site sanitation systems (OSS) mostly pit latrines offer points for faecal sludge (FS) and wastewater disposal. OSS may provide attainable and affordable sanitation services to urban dwellers (Kone, 2010). However, utilization of OSS is viewed as a temporary solution awaiting development of sewer-based sanitation systems but these facilities are always in use for longer periods, they serve as permanent and independent sanitation systems (Strande et al., 2014). Therefore, to ensure public safety and environmental protection, there is a need to develop and implement programs for emptying, transportation, treatment and final disposal of the OSS contents (Thye et al., 2011). The current scenario in most cities in sub-Saharan Africa is characterized by absence of supporting infrastructure leading to most of FS ending up in the environment un-treated (Cofie et al., 2006).

Pit latrines offer essential sanitation services as a main point of FS disposal hence play a significant role in ensuring public health safety. The sanitation provision task does not end at the point of pit latrine construction. There is a need to understand that OSS will eventually reach capacity hence require plans for post fill up management and budget support (Still and Foxon, 2012). Most of the municipal treatment plants are designed with knowledge of wastewater characteristics that are widely known. The OSS presents a second problem after fill up as treatment of their sludge requires significant technological readjustment contrary to traditional wastewater treatment. Co-treatment of FS may not be a sound approach in regions where performance of wastewater treatment plants is failing. “High strength” sludge are characterized by high ammonia presenting a great challenge for low cost treatment technologies (Koné et al., 2004).

Disposal of OSS sludge remains a significant challenge in numerous developing countries (Water Utility Partnership, WUP, 2003; Bongi and Morel, 2005). FS content may end up in open grounds, ditches, roadsides, watercourses and lakes (Strauss et al., 1997). In Kenya, pit latrine emptying is done by registered entities disposing the contents in municipal waste treatment plants. However, Waste Stabilization Ponds (WSPs) are designed for wastewater leading to significant organic loading by faecal sludge. Straus et al. (1997) reported that to achieve effective FS treatment in municipal wastewater plants, two parallel batches-operated settling or thickening tanks should be included in the design. The tanks must have a minimum of 3 h of settling followed by four stabilization ponds in series retaining the content for a minimum of 30 days. The ponds are anaerobic, as facultative conditions do not develop because of the high ammonia concentrations. In the contrary, most municipal treatment plants in use currently have not been designed to handle the treatment OSS sludge. The circumstances are a clear recipe for failure of the WSPs. Source separation would lead to efficient handling of the sludge. In addition, treatment should depend on the end use to enable resource recovery (Rose et al., 2015).

Characteristics of FS vary with location, households and regions (Fernandez et al., 2004). Literature based characterization gives only qualitative information that cannot be used in designing FS treatment facilities. Accurate region based data on characterization of FS is necessary for designing treatment plants and choice of appropriate treatment technologies (Bassan et al., 2013). However, there is limited, variable or unavailable data on pit latrine FS parameters. In addition, understanding the variations of the parameters along the depth strata would provide supplementary information for designing emptying technologies. The objective of this study was to characterize variation of FS across pit latrines and with depth.

MATERIALS AND METHODS

Study area

The study was carried out in Hilton Settlement within Nakuru Municipality, Kenya. The selected pit latrines were in a low-income peri-urban settlement. Nakuru town is one of the fastest growing municipalities in Kenya. It is the fourth largest urban centre with a population of about 307,990 inhabitants (GoK, 2010). The major economic activities of the settlement’s inhabitants are in the informal sector with irregular sources of livelihood. Availability of safe water and proper sanitation present a major problem to the local authorities because most settlements have no water and sewerage connection. Anecdotal information indicates that the study area falls within a fault line of the Eastern Rift Valley. The geology of the area is characterized by volcanic rocks and sediments making digging of deep pit latrine vaults problematic (McCall, 1967). Therefore, a significant number of pit latrines are relatively shallow necessitating frequent emptying cycles.

Faecal sludge sampling

Sample collection was carried out in January 2015 during the dry season as most pit latrine emptying occur in that period of the year as the ground has low moisture content. Six pit latrines that had never been emptied and shared by more than one family and without connection to water sources were selected purposively.

Samples were obtained directly along the pit latrine depth strata at 4 depths (0.0, 1.0, 2.0 and 3.0 m) using a modified faecal sludge

Table 1. Comparison of variation in faecal sludge characteristics in literature.

Parameter	Source of data			
	Strauss et al. (1997)	**Koné and Strauss (2004)**	**Bassan et al. (2013)**	**Appiah-Effah and Nyark (2014)**
TP	_	-		2088
TN	_	-		4083
NH_3	2000-5000	3300	_	2568
BOD	_	7600	2126	11835
COD	20000-50000	49000	12437	85998
BOD: COD	5.1-9:1	6.4:1	5.8:1	7.3:1

Concentration (mg/L).

sampler. The sampling points were informed by specifications of sampling at intervals of 0.5 depth differences for pit latrines with a depth maximum of about 1.5 m (Buckley et al., 2008). However, in the study area, pit latrines had depths of more than 5 m, necessitating sampling points of at least 1-m difference to enable an analysis of representative sample of the pit content. Faecal sludge sampling protocol was followed strictly to avoid mixing of samples from various layers of the pit latrine content. Twenty-four samples were obtained along the pit latrine strata. Field observation was used to select the type of the OSS (shared, dry pit latrine and never desludged before) and key informant interviews were used to obtain information from the waste treatment plant operator at the municipal sewerage plant. Formal written and oral consent was obtained from the study respondents prior to sample collection and the interview. Sample analysis was done at the municipal water and sewerage laboratory. Ethical consent was obtained from Egerton University ethics committee.

Sample analysis

Sample analysis was done in accordance with the standard methods of analysing water and wastewater (APHA, 2005). Parameters that were analysed included biochemical oxygen demand (BOD), chemical oxygen demand (COD), total nitrogen (TN), total phosphorus (TP) and ammonia (NH_3^+). Samples were stored in cool boxes and transported to the laboratory. The samples were stored at 4°C until analysis. Analysis of BOD and NH_3^+ were done within 12 h after sampling, whereas the analyses of other parameters were done within 24 h of sampling. Samples were homogenized to make representative sample, then a stock solution of 0.05 g/ml prepared and used for analysis. Standard laboratory reagents and apparatus were used to characterize the selected physicochemical parameters of the FS samples.

Data analysis

Descriptive statistics was used to show the average concentration of the various parameters across pit latrines and at different depths. One-way ANOVA was used to establish the differences in concentrations with sampling depths and among the studied pit latrines. Tukey's method of post-hoc analysis showed the points where there are significant differences in concentration between the sampling depths. The analyses were done at 95% confidence intervals using Minitab Version 16 and Excel software.

RESULTS

Characteristics of the faecal sludge

The one-way Anova analysis at 95% CI showed significant variation in FS characteristics within and across pit latrines. The large ranges in average concentrations of COD and BOD show large differences in level of organic content degradation of the sludge among pit latrines (Table 1).

Table 2 shows the mean and standard deviation for the analysed parameters. Average FS concentrations are high because of limited dilution by water, household wastes disposal and low degradation rates associated with anaerobic conditions.

Faecal sludge properties variation with depth

The analysis showed a decrease in concentration of measured parameters with depth of sampling. The average concentrations of the sludge sampled from different depths are compared statistically in Table 3.

Organic loading of the sludge

Chemical oxygen demand represents the total organic loading indicating the extent of degradation of the sludge at different depths. The average COD concentration reduces from the surface layer to 3 m depth (Table 3). There was a 22% change of COD concentration of FS from the surface layer to 3 m depth (Table 3). The reductions of COD with depth indicate increasing stability of FS with depth but the reduction is not statistically significant ($p>0.05$) between the surface layer and 3 m depth. Lower layers of the sludge are relatively stable because of the longer storage duration. However, the concentration at lower depths are lower than the fresh sludge sampled at the surface depths confirming the need for further treatment of sludge obtained at all depths of the pit latrine before reuse or disposal into the environment.

The average BOD concentration and changes from the surface layer to 3 m depth are as reported in Tables 2 and 3. The concentration of BOD was not significantly different across the pit latrines ($p=0.93$) but significantly different with depth ($p<0.05$). Comparison of concentration with depth is significantly different between

Table 2. Average concentration of biochemical properties of pit latrine FS (n=132).

Parameter	Mean	SD	Minimum	Median	Maximum
TN	3232	872	1717	3106	5496
TP	2906	1257	613	2936	4927
NH_3	2895	1037	1300	2663	5100
BOD	24600	9069	11000	22750	39500
COD	112800	29809	72000	108000	176000
BOD: COD	1:4.6	1:3.3	1:6.5	1:4.74	1:4.5

Concentration in mg/L, SD: Standard deviations, n=number of samples analysed.

Table 3. Variations of FS characteristics with depth.

Parameter	0 m Mean±SD	1 m Mean±SD	2 m Mean±SD	3 m Mean±SD	p-value
TN	3615.7±814.8	3575±1102	3226 ± 904	2767± 632	0.415
TP	3723±1121	1649±966	2889±564	4279±485	0.003
NH_3	3154±620	2750±1817	2763± 517	2950± 212	0.913
BOD	36833±2961	22750±3254	21500±3362	16083±3597	<0.0001
COD	133333±24089	116000±40398	92000±8390	104000±11314	0.099
BOD : COD	3.6:1	5:1	4.3:1	6.5:1	

Concentration (mg/L), surface layer (n) = 6, 1 m (n) = 6, 2 m (n) = 6, 3 m (n) = 4, SD; Standard deviation, p<0.05 is significant, p>0.05 is not significant; p-value-comparison of surface layer and 3 m.

the surface layer and the lower depths at 95% CI (Tukey's Method). The significant differences in BOD concentration within a pit latrine indicate variations in the biological degradation of the organic matter from the upper layers to the lower depths. Reductions of the BOD with depth indicate increasing stability of the sludge hence reduction in microbial degradation. This can be justified by increasing COD: BOD ratio with depth (Table 3). When the ratio is greater than 3, then it shows lower biodegradability of the sludge because the biologically degradable component has been broken down. Therefore, based on the ratio reported at 3 m depth (Table 3), the sludge is most stable and could be associated with storage for a long period in an OSS system (Heins et al., 1998).

Nutrients in faecal sludge

The mean nutrient concentrations are higher than data in literature. Concentration of NH_3 was highest at the surface, whereas concentrations of TP and TN were highest at the 3 m depth (Table 3). There was a significant difference in concentration of TP at the surface and at 3 m depth (p=0. 003). However, there was no significant difference in concentration with depth for NH_3 and TN. One-way ANOVA indicated significant differences in concentration of NH_3 (F=13. 95, p=0. 00) and TN (F=12. 29, p=0. 00) across the pit latrines.

DISCUSSION

The characterization showed that the FS has "high strength" properties (Strauss et al., 1997). This property is because samples were from pit latrines without connection to water sources leading to low moisture content of the sludge. Biodegradability of the FS is relatively low as indicated by a BOD : COD ratio greater than 3. Only the surface sludge was highly biodegradable with a BOD : COD ratio of 3.6 and it could be because of freshly deposited faeces that has not undergone degradation (Heinss et al., 1998). Similar findings of low biodegradability of the FS associated with storage for long periods in OSS systems have been reported in previous studies (Heins et al., 1998; Bassan et al., 2013). In addition, low biodegradability could be because of household disposal of solid wastes into the pit latrine vaults increasing its organic load.

The BOD concentrations were in the range reported in Appeadu and Ougodogou as 2126 mg/L by Bassan et al. (2013). However, they were lower s compared to those reported by and Strauss (2004) and Appiah-Effah and Nyarko (2014) who reported values of 7600 and 11835 mg/L, respectively. The differences could be because of the depths of sampling and age of sampled FS. Fresh FS at higher depths had higher concentrations of BOD in comparison with older ones in deeper layers that have undergone significant degradation.

The concentrations of COD were two times higher than those reported by SANDEC as 49000 mg/L (Koné and Strauss, 2004). However, they were in the range of values reported as 85,998 mg/L in peri-urban areas of Ashanti region in Ghana (Appiah-Effah and Nyarko, 2014). The higher COD concentration is an indication of presence of resistant organic matter in the sampled FS. This will necessitate higher consumption of oxygen by microorganisms to degrade the faecal sludge (Sawyer and McCarty, 1978). High COD concentrations show the presence of resistant organic materials in the FS leading to slow degradation. The materials may result from disposal of household wastes like food remains and papers. In addition, the organic loading of materials used in anal cleansing like tissue paper, corncobs, rags and leaves may contribute to higher COD concentration (Tilley et al., 2008). High concentrations of COD would require longer treatment time and higher oxygen consumption for breakdown of the high organic matter.

High TP concentration at the surface could be because of disposal of wastewater having detergents or presence of detergents. Lower concentrations that are significant are because phosphorous is consumed by microorganisms in faecal sludge for growth. However, the absence of significant differences in concentration of NH_3 and TN with depth can be associated with dilution of faecal sludge within a pit latrine. In addition, significant differences across pit latrines are because of the differences in household characteristics. Decreasing concentrations of TN with depth could be because of the higher mineralization of organic nitrogen over time. Surface concentrations were higher because of addition of fresh faecal materials. The differences in ammonia concentration with depth and among the pit latrines are an indication of differences of organic nitrogen breakdown. Higher concentrations of ammonia at the surface indicate higher microbial activity associated with sludge degradation, and because of the mineralization of organic nitrogen in FS (Epstein, 2002).

Total phosphorous concentrations documented were relatively high and it could be attributed to detergents used in unit washing and disposal of grey water into the pit latrines and diets of pit latrine users. Similar findings were reported in the study on public pit latrines in Kumasi (Awuah et al., 2014). High TP concentration in the sludge sourced from detergents may affect decomposition because they have a negative impact on microbial activities with some of these detergents being biocides; hence inhibiting microbial activities in the FS which may be beneficial to the degradation processes (Block et al., 2001; Kawasaki et al., 2002). Phosphorous immobilizes other chemicals like zinc and copper that are essential for microbial life, making the reported concentrations a cause of concern to the beneficial microorganisms for faecal sludge degradation (Chang et al., 1983). The documented TP concentrations justify the need for further treatment of the FS as the current concentration would lead to algal growth, odour and oxygen depletion if the sludge is disposed into water bodies.

The documented high nutrient concentration in FS is a cause of concern regarding treatment method, reuse and final disposal. The relatively high nutrient concentrations in faecal sludge are an important justification for use as farm manure (Awuah et al, 2014). However, within the study area, there is limited or no use of pit latrine sludge in farms, hence the material is discarded as wastes. Similar findings on non-reuse of pit latrine sludge were reported in previous studies (Chaggu et al., 2002; Strande et al., 2014). However, there have been reported beneficial uses of the FS in agriculture that can be adopted in the current context to minimize environmental impacts of disposal into the environment (Koottatep et al., 2001; Keraita et al., 2003; Scott et al., 2004; Cofie et al., 2005).

The FS collected from pit latrines in the area are disposed into the municipal WWTPs without any co treatments. The disposal is majorly into manholes connecting to main sewerage lines or direct into the ponds. The municipal authority has programs for controlling the number of emptying lorries draining their content but no programs for pre-treating the FS. There are organizations collaborating with private companies and the municipal council in beneficiation programs. The programs focus on solid FS from pit latrines that are dried for reuse in small scale. However, the process has not been rolled out comprehensively and is in the initial stages of implementation. Municipal WWTPs are not designed for treatment of sludge from OSS facilities because of the high organic load and solids in the FS. However, with co-treatment, the facilities can treat the FS under close monitoring (Straus et al., 2000; Chaggu, 2004). Problems and technical difficulties may arise in treating FS in WWTPs but there are guidelines on using the system to treat FS. Disposal of FS in its state without quantitative monitoring has a causal effect on the poor functioning of the WWTP (Lopez-Vazquez et al., 2004).

All the documented characteristics of the sludge are above the minimal standard concentrations recommended for in-fluent sludge by the National Environmental Management Authority (EMCA, 1999). Ammonia concentration is 29 times higher than the recommended standard of 100 mg/L. The WWTP system is facultative therefore high ammonia concentration would affect aerobic conditions necessary for sludge degradation (Zimmo et al., 2003). Ammonia concentrations above the range of 40 to 50 mg/L have toxicity to algal growth, which is essential for the WWTP functioning (Koné and Strauss, 2004). For COD and BOD concentration in the sludge, pre-treatment to a concentration of 650 and 150mg/L respectively, would make the concentration to be in the same range with parameters of urban wastewater that can be treated in WSP (Inganiella et al., 2000**)**. However, the BOD and COD documented in this study were 164 and 173 times the recommendations for characteristics capable of treatment in WWTPs. Total phosphorous and total nitrogen characteristics are equally high, hence would encourage eutrophication of the WWTPs reducing efficiency of the treatment plants. Disposal of the FS into water bodies would also lead to massive algal growth and oxygen depletion. Therefore, based on FS characteristics documented above, there is a need for better treatment prior to disposal into the environment to reduce potential for pollution. Appropriate treatment of FS would significantly contribute to the achieving Sustainable Development Goals target on sanitation provision for all developed by the United Nations General Assembly in 2015.

CONCLUSION AND RECOMMENDATIONS

The results show variation of faecal sludge properties within and across pit latrines. Documented characteristics of COD, BOD, TN, NH_3 and TP indicate higher concentrations as compared to those reported in literature necessitating region based analysis to inform development of appropriate FS treatment technologies. The COD concentration that infer on the extent of degradation showed a reduction in concentration by 22% from surface to 3 m depth but with no significant differences between surface concentration and lower depths. This indicates that there is need for further decomposing of the FS though there were reductions in organic loading with depth.

The BOD concentrations at 3 m were significantly lower than those at the surface, indicating the presence of biological degradation of FS but the average concentration at the lower depth were higher than those safe for treatment in WWTPs. In addition, the mean BOD : COD ratio was five indicating that the sampled FS had low degradability. The sludge characteristics show that the current disposal method of OSS sludge present organic loading on the WWTPs which may lead to treatment failure. Nutrients concentrations are important in WWTPs functioning as the system is dependent on algae and aerations balance for optimal performance. However, the documented characteristics are up to 100 times higher than the recommended maximum concentrations of FS permissible for treatment in municipal treatment plants.

The resulting effect of disposing these FS in WWTPs would lead to significant pollution, as the wastewater would be released into the ecosystem before complete degradation because the system cannot sufficiently treat the influent waste. The study recommends that it is necessary to implement a mechanism for co-treatment of FS with focus on maintaining allowable volumes to be processed. Moreover, the design of the treatment technology should be based on FS characteristics of the local context. There is a need for further studies to understand FS characteristics in peri-urban settlements to inform appropriate treatment options. Moreover, there is need to find out how FS can be made safe and acceptable for use as manure.

CONFLICT OF INTERESTS

The authors have not declared any conflicts of interests.

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Determination of heavy metals concentrations within the ever growing Lake Baseka, Ethiopia using spectrophotometric technique

Fuad Abduro[1,2*] and Gelaneh W/michael[2]

[1]Department of Chemistry, College of Natural Science, Jimma University, P.O. box 378, Jimma, Ethiopia.
[2]Department of Chemistry, School of Applied Science, Adama Science and Technology University, P.O. box 1888, Adama, Ethiopia.

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The ever growing saline lake Beseka is located at the northern end of Main Ethiopia Rift; MER. The levels of some selected heavy metals (Pb, Cr, Cd, Fe, As and Mn) were determined in water sample collected from 5 sites of the ever growing Lake Beseka by systematic random sampling methods and analyzed spectrophotometrically for its suitability for drinking, irrigation and other domestic purpose. The results of the heavy metals concentration revealed the following: Pb (0.434−0.916 mg/L), Cd (0.031−0.103 mg/L), As (0.043−0.067 mg/L), Fe (0.163−0.247 mg/L) Cr (BDL) and Mn (0.061−0.092 mg/L). The result obtained revealed that the heavy metals show variation among sampling points. Pb, Cd, As and Fe recorded concentrations above the WHO guideline limits of 0.02, 0.003, 0.01 and 0.04 mg/L, respectively but they are below the ANZECC and ARMCANZ standard guide line limit for irrigation A and Cr were below their respective detection limits. The main causes of deterioration of water quality are disposal of effluent from municipal of MER, agrochemical runoff and effluent discharged from industries without treatment. The results suggest that the use of such waters for drinking and domestic purposes pose a serious threat to the health of the users and calls for the intervention of government agencies.

Key words: Heavy metal, atomic absorption spectrophotometer (AAS), main Ethiopia rift (MER), determination, analysis.

INTRODUCTION

The saline Lake Beseka is found within the volcanically active rift floor of the main Ethiopia rift (MER). Lake Beseka water quality deteriorated due to anthropogenic activities like discharge of effluents from municipals of MER, agrochemical run off, effluents discharged nearby MER factories without treatment and poor sanitation which make community to depend on unsafe and poor water consumption. Beside this, the contaminated lake

*Corresponding author. E-mail: fuadabduro8@gmail.com. Tel: +251913569913 or +251913356548.

Table 1. Surface sampling points and the corresponding locations.

Surface sampling sites/ points	Altitude (m)	GPS coordinates	
		Northing	Easting
Lake BesekaPoint1 (LBP1)	3179	8-54-22.10	39-53-01.25
Lake BesekaPoint2 (LBP2)	3158	8-53-31.62	39-51-27.98
Lake BesekaPoint3 (LBP3)	3139	8-52-21.14	39-52-25.05
Lake BesekaPoint4 (LBP4)	3554	8-53-24.62	39-54-30.70
Lake BesekaPoint5 (LBP5)	3139	8-49-46.15	39-50-35.66

water are strongly linked with Awash River that is used for domestic consumption and irrigation. The inflow of Lake Water mixes with ground water of the Awash River affects large number of physical and chemical processes that may have influence on the water quality like change the natural color of the water due to the presence of trace metal (APHA, 1992).

In addition to the anthropogenic activities, the Lake Beseka water quality also deteriorated by the natural processes like precipitation inputs, erosion, weathering of crustal materials (Fernandez and Olalla, 2000), determine the quality of ground water in MER. The main sources of heavy metals pollutions in Main Ethiopia Rift are the industrial influents discharged from various processing industries (Tole and Shitsama, 2001). The impacts of both natural and anthropogenic activities deteriorate the quality of lake water.

In recent times, the saline Lake Beseka is used for the purpose of washing vehicles that discharges heavy metals and disposal of effluents from municipals of MER, garages, agrochemical run off and effluents from nearby industries increases the concentration of heavy metals (Biney, 1994) which deteriorate the quality of the water. In this study, the concentration of As, Pb, Cr, Fe, Mn and Cd in the water of Beseka saline Lake of northern part of (MER) are investigated. The results of this study can be used by authorities for directing environmental monitoring, management, and remediation programs.

MATERIALS AND METHODS

Sampling

In January 15, 2016, five water samples were collected from saline lake Beseka by systematic random sampling method from the surface of Lake water of different directions in poly ethylene plastic bottle (PEPB) which was washed by grade reagents of 68-72% HNO_3, and followed by deionized water and sterilized by autoclave at 121°C for 20 min. The sample was collected from each point on three occasions (day break, afternoon and evening) from lake water in 1 L of PEPB. The water samples were then kept in an icebox before being prepared for analysis. The exact coordinates of the locations of the sampling points were marked with a Global Positioning System (GPS) (Garmin 12 Channel GPS, USA) (Table 1) and the coordinates were exactly overlaid on the map of Lake Beseka by using ArcGIS 9.0 Software.

Sample preparation and analysis

Water samples were filtered using a vacuum pump and 0.45 μm pore-size filter papers in order to separate particulate matter. The filtered samples were acidified with HNO_3 for target analyte measurement. The samples were kept at 4°C prior to analysis. Heavy metals of lead, cadmium and chromium concentrations were analyzed by FAAS (Buck Scientific model 210VGP, east Norwalk, USA) using APHA (1998) standard methods while iron, manganese and arsenic was analyzed by DR-2800 spectrophotometer using EPA, (1999) standard methods.

RESULTS AND DISCUSSION

Calibration curves

Calibration curve was used to calculate the concentration of the heavy metals known in each water sample. The calibration curves for each metal were drawn by preparing four concentrations of known solution versus its corresponding absorbance measured as shown in Table 2.

The correlation coefficients of all the calibration curves were > 0.99 and these correlation coefficients indicate very good correlation (positive correlation) between concentration of heavy metals and their absorbance.

Recovery test

The percentage recovery ranged between 98.32 and 100.12% for AAS as described in Table 3 and 99.55 to 100.1% for spectrophotometer. This implies that, the measured results are within the acceptable range of 75 to 110% and the result also agrees with the findings of Fong et al. (2006). Thus, the digestion of water samples procedure for chemical analysis in the water sample was validating.

The heavy metals data of the water sample collected in the January 15, 2016 are presented in Table 4. The results of the samples vary among the samples because of the anthropogenic factors like disposal of effluent from the municipals, industries, garages, hospitals and natural processes such as precipitation inputs, erosion, weathering of crustal materials, dilutions of rocks by hot

Table 2. Instrumental method of detection limits for the analysis water samples by FAAS.

Heavy metal	Detection limits mg/L	Concentration mg/L.	Absorbance.	Correlation coefficient (R^2)	Regression equation
Pb	0.05	0.00	0.0011	0.9962	Y= 0.01x + 0.0008
		0.25	0.0032		
		0.50	0.0063		
		0.75	0.0094		
Cr	0.05	0.00	0.0003	1	Y= 0.17x + 0.0002
		0.25	0.0438		
		0.50	0.0875		
		0.75	0.1313		
Cd	0.002	0.0	0.0001	0.9999	Y= 0.02x + 0.0001
		0.1	0.0021		
		0.2	0.0042		
		0.3	0.0063		

Table 3. Recovery test results for the mean concentration of heavy metals analyzed by AAS.

Heavy metals	Concentration (mg/L)			Recovery (%)
	Un-spiked blank	Amount added	Spiked blank	
Pb	0.0001	0.25	0.2459	98.32
Cd	0.0001	0.075	0.0748	99.6
Cr	0.0000	0.25	0.2503	100.12

Table 4. Recovery test results for the mean concentration of chemical parameters analyzed by spectrophotometers.

Chemical parameters	Concentration (mg/L)			Recovery (%)	
	Un-spiked sample	Amount added	Spiked sample	Experimental	Calculation
As	0.053	0.990	1.039	99.98	99.596
Fe	0.183	0.196	0.379	100.02	100
Mn	0.072	0.099	0.172	100.00	101.01

ground waters, etc. Naturally, the quality of ground water in MER influenced by complex geological activities which increase the concentration of the chemical constituents in water by transfer of deep ground water in thermal spring (Tamiru, 2005).

Heavy metals analysis of the lake water sample includes lead, arsenic, manganese, iron, chromium and cadmium from the ever growing lake Beseka is shown in Table 5.

Lead

The average value for lead concentration of lake Beseka ranges between 0.434 and 0.916 mg/L with an average value of 0.631 mg/L, which was above the maximum allowable WHO standards level, that is, 0.01 mg/L for drinking purpose. The increase in the lead concentration levels indicates discharges of effluents such as human and animal excreta, agricultural run-off containing phosphatic fertilizers, effluent discharges from nearby industries of MER, household sewages and mechanic workshops especially battery chargers.

Arsenic

The total amount of arsenic over the surface of the lake

Table 5. Results of heavy metals analyzed spectrophotometrically.

Chemical species	Sample of points					Mean
	LBP-1	LBP-2	LBP-3	LBP-4	LBP-5	
Heavy Metals analyzed by FAAS						
Lead	0.916±0.001	0.654±0.001	0.611±0.001	0.541±0.001	0.434±0.001	0.631± 0.001
Cadmium	0.103 ±0.01	0.065 ± 0.00	0.031 ± 0.01	0.035 ± 0.00	0.037 ± 0.00	0.054 ± 0.004
Chromium	BDL	BDL	BDL	BDL	BDL	
Heavy metals analyzed by DR-2800 spectrophotometer						
Arsenic	0.043± 0.01	0.067± 0.01	0.06± 0.01	0.067± 0.01	0.057± 0.01	0.059 ± 0.007
Iron	0.167± 0.01	0.163± 0.00	0.187± 0.02	0.247± 0.00	0.187± 0.02	0.19± 0.012
Manganese	0.064± 0.02	0.061 ± 0.03	0.073± 0.02	0.092 ± 0.00	0.086± 0.01	0.075 ± 0.016

BDL: Below detection limit.

water varies between 0.043 and 0.067 mg/L with mean value of 0.059 mg/L. It is usually present in natural waters at concentrations less than 1 to 2 mg/LWHO. The finding indicates that the mean values of arsenic are above the WHO (2008) acceptable limit for drinking water quality. According to WHO, the lake water is toxic and it causes bladder and lung cancer. The high concentration of arsenic due to high temperature water rock interaction was believed to be the main driving force behind the existence of trace metals in the hot springs, rivers and lakes in the main Ethiopian rift valley (Tamiru, 2005).

Iron

The total amount of iron species over the surface of lake water varies between 0.163 and 0.247 mg/L with mean value of 0.19 mg/L. The research finding indicates that the amounts of iron within the lake increase from previous studies. MoWR (1999) has also reported the concentration range of total iron in the Lake Beseka ranging between 0.163 and 0.247 mg/L among a large number of different samples taken from different sampling locations over the surface of the lake. The difference is due to high temperature water rock interaction believed to be the main driving force behind the existence of trace metals in the hot springs, rivers and lakes in the main Ethiopian rift valley (Tamiru, 2005).

Chromium

Laboatory analysis indicates that chromium concentration within the lake Beseka were below the detection limit of the instruments.

Cadmium

The total amount of cadmium over the surface of lake water varies between 0.031 and 0.103 mg/L with arithmetic average of 0.054 mg/L. The important releases of cadmium to the water pollutions is due to natural mobilization of cadmium from the Earth's crust and mantle, such as volcanic activity including hydrothermal vents and weathering of rocks; current anthropogenic releases from the mobilization of cadmium impurities in raw materials such as phosphate minerals, fossil fuels and other extracted, treated and recycled materials - particularly zinc and copper industries in the MER. The arithmetic average concentration of cadmium obtained from lake is 0.054 mg/L which was above the allowable limits of WHO and drafts of Ethiopian standards (0.003 mg/L) for drinking purpose. High concentrations of cadmium are toxic to beans, beets and turnips at concentrations of 0.1 mg/L in nutrient solution. Conservative limits are recommended. The arithmetic average concentration of cadmium was above the allowable limits for long and short term irrigation as well as livestock (Australia and New Zealand, 2011; BIS, 2009) which was 0.01 mg/L.

Manganese

The total amount of manganese over the surface of lake water varies between 0.061 and 0.092 mg/L with arithmetic averages of 0.075 mg/L as indicated in the appendix. The increments in the concentration was due to high temperature water rock interaction believed to be the main driving force behind the existence of trace metals in the hot springs, rivers and lakes in the main Ethiopian rift valley (Tamiru, 2005). This implies the effects of natural and human activities are diluted by hot springs bulk waters (Chapman, 1992). The arithmetic average concentration of manganese obtained from Lake was 0.074 mg/L which is below the allowable limits of WHO and drafts of Ethiopian standards (0.1 mg/L) for drinking purpose. Beyond 0.3 mg/L limit manganese and iron affects taste/appearance of water, has adverse effect on domestic uses and water supply structures. Presence of manganese in water may be toxic to a number of crops at a few-tenths, it's above allowable limit was 0.2 mg/L for long term irrigation as well as available for livestock (Australia, New Zealand, 2011; BIS, 2009).

CONCLUSION

The bio-accumulation of heavy metals in the biological system transfers the toxic elements from the producer to consumer level which can be a future health hazard (Aniruddhe, 2000). Heavy metals are important environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary and environmental reasons (Das et al., 2012). The heavy metal load in the reservoir indicates the heavy metal toxicity which varies at different sampling points. Most of the heavy metals, if present beyond permissible limits in water are toxic to children (Das et al., 2012; Elsner et al., 2005; Finley et al., 1999).

According to finding of this study, lead, arsenic, iron and cadmium are present relatively with higher concentrations as compared to their permissible limits set by WHO while manganese is in permissible range and cadmium is BDL. Beseka Lake is also used for fishing, recreation and irrigation purposes, it is quite evident that this heavy metal may enter the food chain, and thus through bio magnifications enter the human body and can cause serious problems to human health, habitats of lake and in the plant growth. Except Mn within permissible range and Cd which is BDL all other target analytes are above the allowable limits for long and short term irrigation (Australia and New Zealand, 2011) as well as for the livestock (BIS, 2009).

Conflict of interests

The author has not declared any conflict of interests.

RECOMMENDATION

The water qualities of the ever growing Lake Beseka were deteriorated as the town grow due to investment activities and discharges of effluents from industries without treatment. The increasing value of heavy metals contaminants indicates the lake water near the two towns is not safe and should not be used for domestic purposes. Therefore, all stake holders (federal, regional and zonal) water resources and environmental department should set up periodical monitoring of the water quality which is thus required to assess the condition of water body and immediate steps should be taken to check the anthropogenic activity around the lake. This will be helpful in saving the lake from heavy metal pollution (Paustenbatch et al., 2003; Ram et al., 2011).

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Latrine utilization and associated factors among kebeles implementing and non implementing Urban Community Led Total Sanitation and Hygiene in Hawassa town, Ethiopia

Lemma Tulu[1], Abera Kumie[2], Sintayehu Bedada Hawas[3], Hailu Fekadu Demissie[4] and Mesfin Tafa Segni[4]*

[1]JSI/SEUHP, Ethiopia.
[2]Public Health at School of Public Health Addis Ababa University, Addis Ababa, Ethiopia.
[3]Arsi Zonal Health Department, Assela, Ethiopia.
[4]Department of Public Health, Arsi University, Assela, Ethiopia.

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A major public health problem in developing countries including Ethiopia is related with poor sanitation and hygiene. Globally, over 2.5 billion people are still without access to improved sanitation. In 2010, 15% of the population still practice open defecation. The main objective of this study was to compare the latrine utilization rate and identify determinant factors among kebeles implementing and not implementing Urban Community Led Total Sanitation and Hygiene (UCLTSH) in Hawassa town. Comparative cross sectional study design was carried out in Hawassa town in 704 households in 3 kebeles undertaken UCLTSH and in randomly selected comparison 3 kebeles where UCLTSH was not implemented. Data entry and cleaning was undertaken by using EPI-info version 3.5.3 and analyzed using SPSS version 20. Multivariate logistic regression was used for independent variables with statistical significant association in bi-variate analysis. In this study, majority of the households 318 (90.3%) of UCLTSH implementers and 299 (85.4%) of non-implementers utilized latrines. The odds of latrine utilization were 1.59 times among households implementing UCLTSH compared with that among non UCLTSH [OR 1.59, 95% CI (1.00, 2.53)]. In relation to functional latrine, it was one of the factors affecting latrine utilization [AOR 28.26, 95% CI (13.03, 61.27)]. This study shows communities implementing urban community led total sanitation and hygiene was better in latrine utilization and having latrine facility than non-implementers. It is recommended that the town health office and municipality should expand the UCLTSH to other kebeles of the town.

Key words: Latrine utilization, urban community led total sanitation and hygiene, Hawassa town, Ethiopia.

INTRODUCTION

Globally, lack of sanitation is a serious health problem, affecting billions of people around the world, predominantly the third world country [1, 2]. Sanitation is essential for life health and human dignity. When human beings do not have access to sanitation facilities, they suffer a lot in the overall socio-economic and environmental existence. The main health problems, especially in developing countries like Ethiopia, are results of poor access of potable water, poor hygiene and sanitation practices. In these cases, sanitation is a basic necessity that affects everyone’s life. Proper disposal of household waste is of critical important to prevent feco-oral and vector borne diseases (Cairncross, 2003).

Globally, over 2.5 billion people are still without access to improved sanitation. In 2010, 15% of the population still practice open defecation (Ammar, 2010). Bangladesh is one of the poorest countries in the world with a large number of people still living without improved sanitation (Kar and Pasteur, 2005).

The Ethiopian Hygiene and Sanitation Strategy aggressively calls for all households to have access to and use a sanitary latrine; as the country yet swing at lowest status where 84.5% of the population still uses substandard sanitation and hygiene facilities; even where toilets exist, many are not used and open defecation is common. Most of toilets of urban households are fixed point open defecation places (Plan international Ethiopia, 2014).

Community-Led Total Sanitation (CLTS) is an integrated approach to achieving and sustaining open defecation free (ODF) status. CLTS processes can precede and lead on to, or occur simultaneously with, improvement of latrine design, the adoption and improvement of hygienic practices, solid waste management, waste water disposal, care, protection and maintenance of drinking water sources, and other environmental measures. In many cases, CLTS initiates a series of new collective local development actions by the ODF communities (Kar and Chambers, 2008).

For plan international undertaking CLTS activities in Africa (Singeling, 2012; Ammar, 2010), the approach was first introduced in Ethiopia in October 2004 when DrkamalKar visited Arba Minch, in Ethiopia, to conduct training activities for the staff of an Irish NGO, engaged in integrated rural development (Kar and Milward, 2011). Community led total sanitation and hygiene is effective in many countries, the plan project in Ethiopia is really getting successful. In 2010, only 10 kebeles (smallest administrative unit) were triggered. By the end of 2011, 46 kebeles with 47,846 households have gained access to safe sanitation and hygiene services by reaching ODF (Singeling, 2012).

Currently, CLTSH implementation is one of the approaches used to improve hygiene and sanitation status of the people, and its implementation in rural set up in many parts of Ethiopia. The focus of rural CLTSH is to trigger the community and announcing of free open defecation. Its main objective is to focus on open defecation, open urination, open waste disposal and poor waste handling and sanitation practice. However, in urban set up, its effectiveness is not well studied so far, CLTSH practice in urban context is not familiar. Hawassa town is the pioneer town that started to implement urban community led total sanitation and hygiene. So, this study was to help compare the latrine utilization among communities implementing and non-implementing Urban Community led Sanitation and Hygiene (UCLTSH) in Hawassa town.

This study contributes in identifying current status of hygiene and sanitation in UCLTSH and non CLTSH communities of Hawassa town and compare about latrine utilization among UCLTSH implementing and in non UCLTSH implementing and also identify other contributing factors for latrine utilization. The study is important for policy makers, implementing partners and community to resolve the problems related to sanitation, in planning and to take remedial action and modification on implementation of urban community led total sanitation and hygiene. It will also offer base line information for further similar studies.

METHODOLOGY

Study setting

The study was conducted in Hawassa town Southern Nations and Nationality People Region (SNNPR) from December 30, 2014 to January 5, 2015. The town is situated 275 km to south of Addis Ababa. Hawassa town is divided into 7 urban sub cities containing 32 kebeles and one rural sub city having 12 kebeles. The total population of Hawassa town is 356,288 from this 51.7% were male the remaining 48.3 were female and the total households of the town were estimated to be 79,175 (Hawassa Town Health office, 2013). Plan International Ethiopia piloted well designed Urban CLTSH in three kebeles in the urban slum villages/units in Hawassa town as of August, 2013.

Study design

Comparative cross sectional study design was conducted in six kebeles of which three kebeles were from UCLTSH implemented and three kebeles from non UCLTSH.

Study population

The study populations were all randomly selected households from each selected kebeles of Hawassa town (Piyasa, Harari, Nigatkokobe, Wukero, Hoganewacho and Gebeyadarkebeles).

*Corresponding author. E-mail: mesfintafa2011@gmail.com

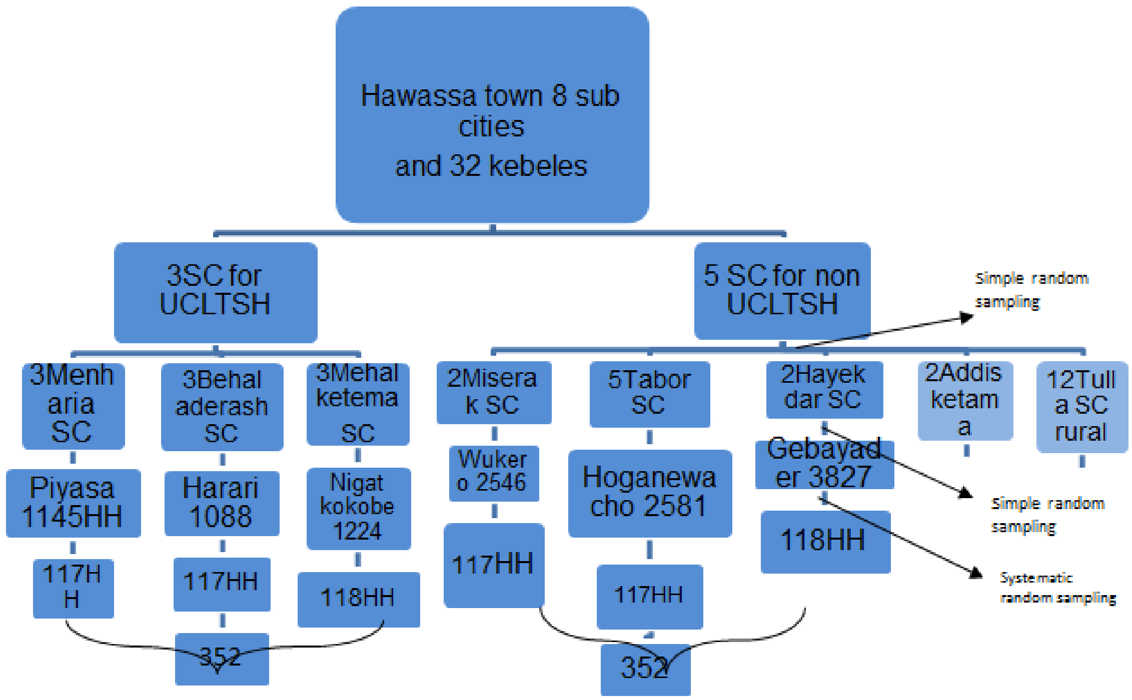

Figure 1. Diagrammatic presentation of sampling procedure.

Inclusion criteria

All selected households head or member of household >18 years and stay in the area for at least 6 months before data collection date.

Exclusion criteria

Households those who were unable to respond due to mental disorder or other health problem were excluded from the study.

Sample size determination

The sample size was calculated using a two proportion sample size calculation equation in Epi Info Version 3.5.1. With the following assumptions; $Z\alpha/2$=1.96 at 95%CI, $Z\beta$= power of detection (80%), P1:P2=1:1. Assuming the proportion of latrine utilization among the general urban population is 62% (P1) among those who have accessed latrine (Awoke and Muche, 2013), and assuming to detect a difference of 10% between latrine utilization among the two population (Exposed to CLTSH and not exposed to CLTSH), the sample size was 320 (n1=160+ n2= 160). The total with 2.0 design effect and 10% contingency is 704 (352 each).

Sampling procedures

Multi stage sampling technique was used. Hawassa town was selected purposively. From the 7 urban sub cities, three kebeles in 3 sub city which has already undertaken UCLTSH starting from August 2013 were considered purposively. Concerning non UCLTSH from the remaining four (Ammar, 2010) urban sub cities, 3 sub cities were selected randomly and one kebeles from each selected sub city not implementing UCLTSH was selected in the same way as sub city. Finally, households were selected using systematic random sampling from each 6 kebeles (Figure 1).

Data collection procedures

The questionnaire was adapted from previous literature on sanitation based study. This questionnaire was translated from English language to Amharic for easy understanding of data collectors and respondents. Data was collected through interview by using structured questionnaire and observation of latrine followed after interview. Ten college graduated students that have previous experience on data collection were recruited as data collector and 2 supervisors with environmental health back ground were participated during data collection.

Data quality assurance

Training was provided for data collectors and supervisors before actual data collection took place. The training was focused on how to fill the questionnaire and how to approach the respondents. A pretest was undertaken on 32 households which were not included in the study a week before actual data collection period. The aim was to figure out any difficulty in filling the questionnaire, challenges in interviewing and to check if there is miss understanding of the questions by enumerators. The pre-test also helped to check consistency and the same understanding. The supervisors were collecting completed questionnaires from each enumerator in daily bases and checking the consistency and the completeness at the spot.

Data analysis procedures

The collected data was coded, cleaned and entered to computer by using EPI-info version 3.5.3 and data were entered double by principal investigator and other experienced personnel to cross check and ensure the consistency of data and transformed to SPSS version 20 for detail analysis.

Descriptive statistics, such as proportion describing the study population in relation to variables and latrine utilization was used to address objective one (latrine utilization). Odds ratio with 95% confidence interval was calculated for objective two. Bi-variate analysis was conducted and these variables significant in a bi-variate analysis were further analyzed in multi-variate analysis in order to control confounders that may affect the association of outcome and exposure variables. Some selected variables that are significantly associated with dependent variable at bi-variate analysis were further analyzed in the multi-variate to identify their related effects among communities implement UCLTSH and non-implementers.

Finally, multivariate logistic regression was used for independent variables with statistical significant association in bi-variate analysis at P-value <0.05 to control confounders. P-value less than 0.05 were taken as significant. The result of the study was also displayed by percentage and tables on findings of the study.

Operational definitions

Community-Led Total Sanitation and Hygiene (CLTSH): Emphasizes changing sanitation and hygiene behavior of communities towards open defecation free environment, hand washing practice and keeping drinking water safe (Kar and Chambers, 2008).

Functional latrine: It is a latrine usable at the time of data collection.

Proper latrine utilization: Is an household having functional latrines, safe disposal of child faeces, no observable faeces in the compound and show at least one sign of use (foot path to the latrine not covered by grass, the latrine is smelly, presence of anal cleansing material, fresh faeces in the squatting hole, and the slab is wet).

Utilization of latrine: When all members of family are using the latrine.

Safe disposal of child faeces: Use toilets and do not dispose children's faeces in the open.

Open defecation: Is defecating in the open and leaving the stuff exposed (FMOH, 2012; HawassaTown Health office, 2013).

Open defecation free: It describes a state in which all community members practice use of latrine at all times and a situation wherein no open defecation is practiced at all (Kar and Chambers, 2008).

Knowledge: Is a result of meaningful learning, information or understanding acquired. Good knowledge if≥75%, the overall knowledge questions (Q301-306) answered.

Attitude: Refers to evaluation of concept and there is a mediating evaluation response to every stimulus, towards all objects, which may be positive or negative or neutral. Good (positive attitude toward over all scores of ≥ 70% to attitude questions) (Q401-406).

Ethical consideration

Ethical clearance was obtained from Addis Continental Institute of Public Health and official letter was written from Adama Science and Technology University to SNNP regional health bureau and to respective offices to get permission to proceed the study. Verbal consent was obtained after explaining the purpose of the study. The confidentiality of the data was also informed before interview was started, any information forwarded was kept private and his/her name was not specified. Each household was asked at least for oral consent and those households that did not volunteer for the consent was not obligated. Only household's willing to take part in the study was interviewed. The question was asked by simple and local language.

RESULTS

Socio demographic characteristics of respondents

In this study, a total of 702 households participated, among these 339 (48.3%) were male and 363 (51.7%) were female respondents. Two hundred eight (64.5%) and 238 (79.6) of the head of the household were husband among UCLTSH implementers and non-implementers, respectively. One hundred thirty one (41.2%) of the respondents among UCLTSH implementer were of age between 30 and 44 and 163 (54.5%) of non CLTSH implementer were above the age of 45. The mean age of the respondents was 44.9 SD, that is, 44.9 (15.2). The educational status of the UCLTSH implementer were 280 (88.1%) and 238 (79.6%) were literate, respectively. In respect to family size, unfortunately the majority range between 4 and 6 family members for both groups, that is, 164 (51.6%) and 140 (46.8%) for UCLTSH implementers and non-implementers, respectively. The mean family size was 5.7 SD, that is, 5.7 (2.9).

Concerning the marital status, majority were married 199 (62.6%) and 203 (67.9%) for UCLTSH implementer and non-implementers, respectively. Two hundred two (63.6%) of UCLTSH implementers were orthodox religion followers, while 135 (45.2%) of non UCLTSH implementers were protestant religion followers. Regarding the ethnic origin of the respondents, majority were Walita in both group 94 (29.6%) and 88 (29.4%) among UCLTSH and non UCLTSH, respectively and followed by Sidama.

Concerning the occupation of the head of house hold, 91 (28.6%) of them engaged in private, government and NGOs as employee among UCLTSH implementers and 101 (33.8) were engaged in merchant among non UCLTSH implementers. Majority of the income of the households were below 1000 Ethiopian birr in both groups. There was no statistical difference in some variables like number family size P-value (0.25), age of the respondents P-value (0.66), occupation of the head of the house hold P-value (0.74) and average monthly income P-value (0.16). On other hand, there were statistical difference observed between implementers and non-implementers of UCLTSH in educational status of the head of the house hold P-value (0.05) (Table 1).

Latrine facility

Majority of the households 346 (98.3%) and 330 (94.3%) among UCLTSH implementers and non-implementer have latrine facility, respectively, however, 28 latrines from implementers and 31 from non-implementers have no any super structure. Type of latrine facility owned, 99 (31.1%) of UCLTSH implementers have pit latrine with concrete slab, while 128 (42.8%) of non-implementers owned ventilated improved latrine. In relation to pour flush latrine 44 (13.8%) and 18 (6%) among UCLTSH implementers and non-implementers, respectively.

Two hundred and six (64.8%) among UCLTSH implementers and one hundred forty nine (49.8%) among non-implementer's latrine facilities were constructed before three years. Majority of the respondents, 314 (98.7%) among UCLTSH implementers and 293 (98.0%) among non-implementer have functional latrine.

One hundred and thirteen (35.5%) of UCLTSH implementers and ninety-four (31.4%) of non-implementers covered their latrine holes. Reason for not having any type of latrine facility 15 (57.7%) were due to shortage of money and 11 (42.3%) due to lack of space. Concerning the distance of latrine from home, the highest 112 (35.2%) among UCLTSH implementers ranged from 6 to 11 m, while 143 (47.8%) among non-implementers is above 11 m.

There was no statistical difference in relation to distance of latrine from house, functional latrine and latrine with covered hole with a P-value of 0.24, 0.46 and 0.28, respectively between the two comparisons groups. On the other hand, there were statistical difference observed between implementers and non-implementers of UCLTSH in availability of latrine, type of latrine owned and year since latrine constructed (Table 2).

Behavioral factors

Two hundred thirty three (73.3%) among UCLTSH implementers and one hundred fifty six (52.2%) of non CLTSH implementers were self-initiated to construct latrine. Result indicates that in both groups, majority of the decision to construct latrine was made by family member's initiation, which is 275 (86.5%) among UCLTSH implementers and 187 (62.5%) among non-implementers.

Concerning utilization of latrine, majority of the respondents, that is, 318 (90.3%) of UCLTSH implementers and 299 (85.4%) of non-implementers utilized their latrine facility. Among those exercising open defecation, majority were children in both groups, 27 (96.2%) among UCLTSH implementers and 25 (80.6%) among non-implementers. Concerning adult, 3.8 and 19.4% among UCLTSH implementers and non-implementer's exercise open defecation, respectively.

One hundred and fifty-two (47.8%) of CLTSH implementers and one hundred and ninety-three (64.5%) of non-implementers can prohibit passerby if they exercise open defecation. Two hundred and thirty-eight (74.9%) of UCLTSH implementers and 229 (76.6%) of non-implementers refuse to defecate open when they are out of their house and when urgent. Almost one third of both groups feel ashamed if they defecate open.

Twenty-six (8.2%) among UCLTSH implementers and 9 (3.0) among non-implementers have beliefs or taboos with location/sharing of latrines. Concerning benefits of latrine, 180 (56.6%) among UCLTSH groups and 215 (71.9%) on non-UCLTSH group, perceived that it prevent or reduce flies. Knowledge about using toilet preventing disease, the majority of respondents (98.8%) among UCLTSH implementers and 98.9% among non-implementers agree or have better knowledge.

Two hundred and sixty-two (82.4%) of UCLTSH implementers and one hundred eighty (60.2%) of non-UCLTSH implementers reason for construction of latrine was health purpose. The perceived de-motivating factors towards the adoption of safe hygienic practices 155 (48.7%) among UCLTSH implementers were due to poor living condition, while 136 (45.5%) among non-UCLTSH implementers were due to low literacy (education) level.

There were no statistical differences in some variables like source of information or who initiate you to construct latrine P-value (0.21), what will you do when passersby practice open defecation P-value (0.65), what would you do when you are out of the house and in urgency P-value (0.6), what you feel if defecating openly P-value (0.24), benefits of latrine P-value (0.65), who open defecate p-value (0.06) and what are the perceived de-motivating factors towards the adoption of safe hygienic practices P-value (0.43). On the other hand, there were statistical difference observed between implementers and non-implementers of UCLTSH in latrine utilization, who decided to construct latrine and belief/taboos with location/sharing use of latrines (Table 3).

Institution/Infrastructure related factors

In this study, among 352 households implementing UCLTSH, only 168 (47.7%) were declared open defecation free. One hundred fifty (47.2%) of the respondents among UCLTSH implementers and 232

Table 1. Socio-demographic characteristics of the respondents in Hawassa town January, 2015 (n=702).

Characteristics	UCLTSH utilized latrine (N=352)		Non UCLTSH utilized latrine (N=350)		P-value
	Number	%	Number	%	
Head of the household					
Husband	208	64.5	238	79.6	
Wife	81	25.0	52	17.4	0.52
Others*	29	10.5	9	3.1	
Educational status of head of HH					
Illiterate	38	11.9	61	20.4	0.05
Literate	280	88.1	238	79.6	
Family size					
≤3	59	18.6	53	17.7	
4-6	164	51.6	140	46.8	0.25
>7	95	29.8	106	35.5	
Marital status					
Married	199	62.6	203	67.9	
Single	30	9.4	12	4.0	0.92
Widowed	68	21.4	63	21.1	
Divorced	21	6.6	21	7.0	
Religion					
Protestant	104	32.7	135	45.2	
Orthodox	202	63.6	107	35.8	0.03
Muslim	10	3.1	25	8.4	
Catholic	2	0.6	32	10.6	
Ethnicity					
Sidama	35	11.0	71	23.7	
Amahra	86	27.0	44	14.7	
Oromo	43	13.6	34	11.4	
Waliyta	94	29.6	88	29.4	0.65
Gurage	30	9.4	38	12.7	
others**	30	9.4	24	8.1	
Age of Respondent					
18-29	65	20.4	30	10.0	
30-44	131	41.2	106	35.5	0.66
>45	122	38.4	163	54.5	
Occupation of the head of HH					
Merchant	70	22.0	101	33.8	
GO/NGO/Private employee	91	28.6	91	30.4	
House wife	78	24.6	53	17.7	0.74
Daily laborer	42	13.2	22	7.4	
Others***	37	11.6	32	10.7	
Average monthly income					
≤500	91	28.6	49	16.4	0.16

Table 1. Cont.

501-1000	95	29.9	97	32.4
1001-2000	75	23.6	80	26.8
2001-5000	57	17.9	73	24.4

*Relatives; **Tigre, selite, kambata, Hadiya; ***student, retired people.

Table 2. Latrine facility distribution of respondents of Hawassa town Jan, 2015 (n=702).

Characteristics	UCLTSH utilized latrine (352)		Non-UCLTSH utilized latrine (350)		X^2 test	P value
	Number	%	Number	%		
Availability of latrine facility						
Yes	346	98.3	330	94.3	7.91	0.005
No	6	1.7	20	5.7		
Type of latrine owned						
Pour flush	44	13.8	18	6.0	59.4	0.0001
VIP	81	25.5	128	42.8		
Pit latrine with slab	99	31.1	101	31.8		
Composting latrine	94	29.6	52	17.4		
Year since Latrine constructed						
Less than 1 year	24	7.5	22	7.4	58.55	0.0001
1-2 years	32	10.1	38	12.7		
2-3 years	56	17.6	90	30.1		
Greater than 3 years	206	64.8	149	49.8		
Functional latrine						
Yes	342	97.2	323	92.3	8.34	0.003
No	10	2.8	27	7.7		
Latrine covered hole						
Yes	113	35.5	94	31.4	1.16	0.28
No	205	64.5	205	68.6		
Distance of latrine from house						
<6 m	97	30.5	60	20.1	2.85	0.24
6-11 m	112	35.2	96	32.1		
>11 m	109	34.3	143	47.8		
Design of latrine meeting all family interest						
Yes	215	61.0	178	50.9	7.44	0.006
No	137	39.0	172	49.1		

(77.6%) among non-UCLTSH implementers said that the poorest of poor helped to have latrine by NGOs or government. In this study, 82 (11.7%) of the households construct their latrine through financial and material subsidiary support from NGOs.

One hundred and thirty-five (42.5%) of declared ODF among UCLTSH implementer's practice was followed by the team after certification. Concerning the leader of

Table 3. Knowledge and behavioral factors of study population in Hawassa town January, 2015 (n=702).

Characteristics		UCLTSH (352)		Non-UCLTSH (350)		X^2 test	P value
		Number	%	Number	%		
Source of information to construct latrine							
Health workers	554	73	22.9	134	44.8		
Self-initiation	79.7	233	73.3	156	52.2	3.04	0.21
Imposition from others	129	12	3.8	9	3.0		
Who decided to construct latrine							
Family members		275	86.5	187	62.5		
Health professionals		14	4.4	106	35.5	58.94	0.0001
Implementing agency		9	2.8	3	1.0		
Kebele leaders		20	6.3	3	1.0		
Utilization of latrine (by all family members)							
Yes		318	90.3	299	85.4	3.97	0.04
No		34	9.7	51	14.6		
Who open defecate							
Adults		1	3.8	6	19.4	3.50	0.06
Children		27	96.2	25	80.6		
What will you do when passersby practice open defecation							
Nothing		70	22.0	31	10.5		
Prohibit him		152	47.8	193	64.5	1.62	0.65
Inform to committee		96	30.2	75	25.0		
What would you do when you are out of the house and in urgency							
Resist to defecate openly		238	74.9	229	76.6		
Defecate but burry it		37	11.6	47	15.7	1.83	0.6
Others*		43	13.5	23	7.7		
What you feel if defecating openly?							
Nothing		7	2.2	12	4.0		
Fear		75	23.6	69	23.1	2.8	0.24
Shame		236	74.2	218	72.9		
Belief /taboos with location/sharing use of latrines							
Yes		26	8.2	9	3.0		
No		292	91.8	290	97.0	7.6	0.005
What are the taboo in sharing and use							
Throwing the faces as far as away from is good		22	84.6	8	88.9	0.06	0.8
Collecting feces in one place is not good		4	15.4	1	11.1		
Benefits of latrine							
Reduce flies		180	56.6	215	71.9		
Reduction of bad smell		105	33.1	53	17.7	1.6	0.65
Prevention of disease		30	9.4	15	5.1		

Table 3. Cont.

Built latrine for privacy and conveniences	3	0.9	16	5.3		
Reason for construction of latrine						
Health	262	82.4	180	60.2		
Privacy	27	8.4	97	32.4	3.04	0.21
Accessibility	29	9.2	22	7.4		
What are the perceived de-motivating factors towards the adoption of safe hygienic practices						
Unemployment	21	6.6	35	11.7		
Low income	35	11.0	34	11.4		
Poor living condition	155	48.7	89	29.8	3.79	0.43
Low literacy level	96	30.2	136	45.5		
Lack of recreational facility	11	3.5	5	1.6		
Using toilet preventing disease						
Agree	314	98.8	296	98.9		
Disagree	2	0.6	1	0.3	0.43	0.80
Neutral	2	0.6	2	0.7		
Discussion the idea of latrine						
Yes	193	54.8	155	44.3	7.8	0.005
No	159	45.2	195	55.7		

Others*Defecate in neighbor toilet

ODF, 42.9, 21.4, 19.6, 13.6 and 2.6% were led by communities, government, health expert (health extension professionals), NGOs and others like community based and faith based organizations, respectively (Table 4).

Predictors for latrine utilization

Some selected variables that are significantly associated with dependent variable at bi-variate analysis were further analyzed in the multi-variate analysis to identify their related effects in latrine utilization. The extent of latrine utilization is better among households implementing UCLTSH with [OR 1.59, 95% CI (1.00, 2.53)]. In relation to functional latrine, it was one of a factor affecting latrine utilization with [OR 28.26, 95%CI (13.03, 61.27)]. Other factors affecting latrine utilization were latrine with hole cover [OR 2.02, 95% CI (1.16, 3.53)], presence of human excreta in the compound [OR 0.21, 95% CI (0.13, 0.33)], discussion if the idea of latrine [OR 2.42, 95% CI (1.49, 3.93)] and design of latrine meeting interest of all family members [OR 3.9, 95% CI (2.21, 6.87)].

UCLTSH status in latrine utilization AOR 1.45 95% CI (0.85, 2.46), latrine with hole cover [AOR 1.13, 95% CI (0.61, 2.12)] and discuss the idea of latrine [AOR 0.88, 95% CI (0.49, 1.57)] were not significant in multivariate analysis. Functional latrine AOR 0.06 95% CI (0.03, 0.15), presence of human excreta in the compound [AOR 2.39, 95% CI (1.33, 4.28)], the design of latrine meeting the interest of all family AOR 0.41 95% CI (0.21, 0.8) was significant in multivariate analysis (Table 5).

DISCUSSION

This study showed that majority of the respondents, 90.3% of UCLTSH implementers and 85.4% non-UCLTSH implementers utilize their latrine facility. Similarly, a study done at Denbia district, Northwest Ethiopia, 86.8% of the respondents were using latrines (Yimam et al., 2014), this is almost the same with non-CLTSH communities of this study. However, the UCLTSH implementers are still better in latrine utilization compared to Denbia district.

Concerning latrine availability, 346 (98.3%) and 330 (94.3%) of the households among implementing and non-implementing UCLTSH, respectively have latrine facility. Study in Bahir Dar Zuria shows 355 (58.4%) of the households have latrine facility (Awoke and Muche, 2013)

Table 4. Institutional/infrastructure related factors of study group in Hawassa town January, 2015 (n=702).

Characteristics	UCLTSH (352)		Non-UCLTSH (350)		X^2 test	P value
	Number	%	Number	%		
Who helped the poorest of the poor to have latrine						
Neighbors'	7	2.2	8	2.7		
Kebele dwellers	22	6.9	19	6.4		
GO/NGO	150	47.2	232	77.6	11.23	0.02
They have no latrine	6	1.9	3	1.0		
Others*	133	41.8	37	12.4		
Follow up by the verification team						
Yes	135	42.5	-	-	-	-
No	183	57.5	-	-		
Leaders on ODF						
Communities	66	42.9	-	-		
Health expert	30	19.5	-	-		
NGO	21	13.6	-	-	-	-
GO	33	21.4	-	-		
Others**	4	2.6	-	-		

Others* community members **community based, faith based organization and volunteer youth.

Table 5. Results of logistic regressing on utilization of latrine on explanatory variable in Hawassa town January, 2015 (n=702).

Variable	Latrine utilization		COR (95% CI)	AOR (95% CI)
	Yes	No		
UCLTSH Status				
Implement	318	34	1.59 (1.00,2.53) *	1.45 (0.85,2.46)
Non Implement	299	51	1.0	1.0
Functional latrine				
Yes	607	58	28.26 (13.03,61.27) **	0.06 (0.03, 0.15) **
No	10	27	1.0	1.0
Latrine with hole cover				
Yes	207	17	2.02 (1.16,3.53) *	1.13 (0.61,2.12)
No	410	68	1.0	1.0
Presence of human excreta in the compound				
Yes	104	42	0.21 (0.13,0.33) **	2.39 (1.33,4.28)**
No	513	43	1.0	1.0
Discussion the idea of latrine				
Yes	327	27	2.42 (1.49,3.93) **	0.88 (0.49,1.57)
No	290	58	1.0	1.0
Design of latrine meeting interest of all family				
Yes	293	16	3.9 (2.21,6.87) **	0.41 (0.21,0.8) **
No	324	69	1.0	1.0

*Significant at P<0.05; **Significant at P<0.005. AOR: Adjusted odds ratio; COR: crude odds ratio; CI: confidence interval.

and study in Nekemet town shows 423 (91.8%) have the latrine facility (Regassa et al., 2008). This finding is higher compared to other previous studies in the country like in Bahirdar and Nekemte towns (Awoke and Muche, 2013; Regassa et al., 2008).

With respect to functional latrine, majority of the respondents that is three hundred forty two (97.2%) among UCLTSH implementers and three hundred twenty three (92.3%) among non-implementers have functional latrine. Study in Hulet Ejju Enessie district showed 714 (86.7%) latrines were functional (Andualem, 2010) and the sudy in Bahir Dar Zuria shows 220 (62.0%) of the households latrines were functional (Awoke and Muche, 2013). The finding is higher in relation to functional latrine than both Hulet Ejju Enessie and bahir Dar Zuria woredas, this may be Hawassa town is urban and the two woredas are rural and the study time is also different.

In this study, among 676 households having latrine, majority of the latrine does not have a covered hole that is among UCLTSH implementers and non-CLTSH 64.2 and 69.4, respectively. Study in Nekemet town shows out of 423 households with latrine facility, the majority observed that the pit hole do not have a cover 272 (64.3%) (Regassa et al., 2008), so the two studies are similar in relation to latrine not having a covered hole.

In relation to open defecation among 702 households, 59 (8.4%) of the households member exercise open defecation. Among different studies, households in India shows that with a functioning latrine (n = 71) on average 27% of the members openly defecated at least once a day (Marion et al., 2014). Ethiopian Welfare Monitoring Survey 2011 Summary report shows open defecation or field/forest was 12.5%. So this study group is better than that of the study groups in India and the national welfare monitoring survey.

In the study from 676 having latrine, 25.5% shared latrine. Ethiopian Welfare Monitoring survey 2011 summary report shows shared facility was 10%. Therefore, the national data is better than Hawassa town households in relation to shared latrine.

In relation to different factors affecting the comparison groups, UCLTSH status utilizes latrine, functional latrine, availability of hand washing facility, availability of water in hand washing facility, and discuss the idea of latrine were not significant in multivariate analysis. Design of latrine meeting interest of all family was significant in multivariate analysis.

Urban Community Led Total Sanitation and Hygiene is not familiar in our country, the pilot project implemented in Hawassa town shows how it has impact in improving sanitation status of urban community.

This study indicates latrine utilization of those households implementing UCLTSH with OR 1.59, 95% CI (1.00, 2.53); this indicates that the odd of latrine utilization among UCLTSH implementer's households is1.59 times that among non UCLTSH implementers.

In relation to factors affecting latrine utilization, latrine with hole cover [AOR 1.13, 95%CI (0.61, 2.12)] and discussion of the idea of latrine [AOR 0.88 95% CI (0.49, 1.57)] were not significant in multivariate analysis. For functional latrine [AOR 0.06 95%CI (0.03, 0.15)], the presence of human excreta in the compound [AOR 2.39, 95%CI (1.33, 4.28)] and the design of latrine meeting the interest of all family [AOR 0.41 95% CI (0.21, 0.8)] were significant. The limitation of this study was not considering data from rural communities (kebeles).

Conclusion

Utilizations of latrine were high among UCLTSH implementers compared to non-implementers. The study also identified functional latrine, latrine with hole cover, presence of human excreta in the compound, discussion of the idea of latrine and design of latrine meeting interest of all family as major factors that affect latrine utilization. It is recommended that the town health office and municipality should expand cooperatively the UCLTSH to other kebeles of the town. The Urban Health Extension Programs should initiate technical support to those households that do not have latrine to make the town open defecation free.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

Abbreviations

AOR, Adjusted odds ratio; **COR,** crude odds ratio; **ODF,** open defecation free; **UCLTSH,** urban community led total sanitation and hygiene.

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