Municipalities Network Advocacy on Sanitation in South Asia (MuNASS) Project

Sanitation Situation Report of BHEEMDATT MUNICIPALITY

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Executive Summary

After Nepal has attained Open Defecation Free Status in September 2019, the country is heading towards long term goal of total sanitation. However, before heading ahead, it is important to have understanding of the current sanitation status. At present, 70% of the population in Nepal rely on non-sewered sanitation system, owing to the economical and geological realities of the country. With such a bigger number relying on non-sewered system, it is important to have proper management of the system so as to assure better health and hygiene of people. The "Municipalities Network Advocacy in Sanitation in South Asia (MuNASS)" project believes that the sustainable sanitation to all can be only achieved when the local government are capable for planning, developing and implementing effective sanitation strategies. As a part of capacity development, the study on FSM status was conducted to assist local government making effective planning and implementation for it.

The municipality is extended to an area of 171.63 sq. km with 1,04,599 population. The study aims at understanding the current status of sanitation in the municipality and hence produce evidence-based data and information for effective FSM planning. For the purpose, methodologies such as literature review of secondary data, in-depth questionnaire survey of households and institutions, direct observation and key informant survey on FSM key stakeholders are conducted.

For the major survey such as household survey the application called "KOBOCOLLECT" was used by the volunteers selected by the municipality. As for the institutional survey door to door method was applied. After the fieldwork, all the e-forms submitted in KoBo dashboard were adequately checked for accuracy and completeness before analysis.

Bheemdatt municipality was declared as Open Defecation Free (ODF) on November 2017 and there is no provision of sewerage system. However, it was observed 0.5% of households do not own toilets. An ideal septic tank, consisting of fully lined double chambers and bottom with overflow pipe for discharge of effluent is constructed in 4.5% households. Among these, approximately 60% have connected effluent into either stromwater drain or open environment. The fully lined tank is installed in 37% of households.

Bheemdatt municipality depends on groundwater as its major source for drinking water. In an average 87.5% of households depend on groundwater, 65% have shallow tube well while rest has connected water supply distributed by Bheemdatt Water Supply User's Committee.

For the size of containments, according to the survey the average volume of household containment is 8 m^3 with standard deviation of 4.72. Similarly minimum and maximum volume are 1.0 m^3 and 23 m^3. And for the size of institutional containments, average size of the containment is 11.8 m^3 with minimum and maximum size of 2.3 m^3 and 65 m^3 respectively. Number of the user is one of the major factor determining the size of the containment. The municipality has storm water drain in core urban areas but lacks municipal sewer thus all the households with toilets rely on an onsite sanitation system. A rectangular septic tank with fully lined walls and bottom was preferred in the households located in the urban clusters while tanks with impermeable walls and open bottom have been installed in the households at peri-urban and newly settled areas. Whereas, in rural settlements lined pits with semi-permeable walls and open bottom either twin or single pits were used for storage of the faecal sludge. Both traditional manual scavenging and mechanical emptying practices were observed.

Here emptying is also one of the major components of the sanitation value chain. As from the data we observed that 31% of the containments were emptied once every 6 to 10 year followed by 26% of the containments with the emptying frequency of once every 3 to 5 years. In an average 60% of households which have emptied their containments got service from private desludging service provider. As per data, both the municipality and private entrepreneur have been providing the desludging service in bheemdatt municipality. The major issue and challenges in the business as experienced were lack of designed disposal site, social discrimination for the operators and registration of vehicles in the Department of Transport Management.

Presently, there is no treatment plant in place to treat the faecal sludge in Bheemdatt municipality. The data revealed that only 16.7% of households have emptied their containment at least once since the installation. These containments are emptied after it got filled. Both traditional manual scavenging and mechanical emptying of the containments are practised in the municipality. According to the data, 35.3% of household contact private service provider followed by the 31% household contact municipality for emptying their containments. Whereas 18% perceived self-emptying and disposed into a pit.

Faecal Sludge Treatment Plants (FSTP's) are treatment systems that primarily treat the black and grey water before safely releasing the effluents to the environment. The inputs to FSTP are the faecal sludge (FS) accumulated in different onsite sanitation systems in various types of households. Once the containments are full (in typical scenario), FS is emptied and transported to the FSTP with the help of vehicles like the emptying trucks or by the manual emptier. While achieving treatment of FS, important resources like bio-gas and soil conditioners can be recovered from these treatment plants with necessary arrangements.

The overall sanitation status of the municipality indicates the urgent need for FSM interventions. The higher portion of containment never emptied indicates leakages and unauthorized open emptying practices into an environment possesses potential threat to human health. Both of which are serious issues and hence the municipality should immediately act on to improve FSM for better environment and human health. Some of the initiatives that the municipality could take for improved FSM could be; formulation of standards of containment and upgrading existing containment, data management and effective monitoring, formulation of regulations for emptying service and finally classification of service delivery area and appropriate treatment facilities.

Abbreviations

CBS	Central Bureau of Statistics
ENPHO	Environment and Public Health Organization
FS	Faecal Sludge
FSM	Faecal Sludge Management
MuAN	Municipal Association of Nepal
MuNASS	Municipalities Network Advocacy on Sanitation in South Asia
NSS	Non-Sewered Sanitation System
ODF	Open Defecation Free
PPE	Personal Preventive Equipment
SDG	Sustainable Development Goal
SFD	Shit Flow Diagram
UCLG ASPAC	United Cities Local Government Asia Pacific

Acknowledgment

We offer our sincere acknowledgement to Mr. Surendra Kumar Bist, Mayor and Mrs. Sushila chand Singh, Deputy Mayor of Bheemdatt Municipality, together with all ward chairpersons and staffs of the municipality for continuous support and valuable feedback during the study. We sincerely thanks Mr. Ganesh Kumar Thagunna, a focal person of the MuNASS Project in Bheemdatt Municipality for coordinating and mobilizing volunteers during the study.

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1 Introduction

1.1 Background

The "Municipalities Network Advocacy in Sanitation in South Asia (MuNASS)" project, is implemented to enhance capacity, implement national policy and strategy on sanitation particularly focusing on Fecal Sludge Management (FSM) and Non-Sewered Sanitation System (NSS) in line with Sustainable Development Goal (SDG) 6.2. A limited number of functioning sanitation facilities and appropriate sanitation technologies are main constraint towards achieving the goal. It has increased potential threats towards environmental pollution and human health hazard. Thus, it is always better to act on preventive approach rather than curative action.

In Nepal, 70% of the population rely on non-sewered sanitation systems. The system is good option owing to economical and geological realities of Nepal. Thus, proper management of the system could ensure better health hygiene of the people. The project belief sustainable sanitation to all can be only achieved when the local government, a major implementing body at the ground are capable for planning, developing and implementing effective sanitation strategies. As a part of capacity development, the study on situational status of FSM was conducted to assist local government making effective planning and implementation for it.

1.2 Objectives

The main goal of the study is to support local government with decision making and planning for better sanitation facilities and services. The major objectives of the study are

i. To understand the current FSM status of the municipality
ii. To produce evidence based data and information for effective FSM planning, assist in preparing Detail Project Report of FSM, support advocacy and awareness raising initiatives.

1.3 Limitation of the Study

Limitation of are

- The study did not cover sanitation status of the Industries as, there is national provision for industries to manage waste generated in it.
- Assessment of existing policies and institutional set up was not conducted as there is separate activity within the project regarding preparing municipal policy on FSM.

- Also, financial assessment such as cost effective assessment on FSM interventions was not performed as, it is totally nonprofit oriented project and responsibility of government to provide safe sanitation. Besides it, there is limited knowledge on CapEx and OpEx of different FSTPs in the country.

1.4 Study Area

Bheemdatt municipality is located in Kanchanpur District of Sudurpashchim Pradesh, Nepal. The municipality was named Bheemdatt in the honour of the revolutionary farmer leader Bhimdatt Pant after reformation of the country as the Federal Republic of Nepal in 2008. The municipality is divided into 19 wards and cover an area of 171.63 square kilometres. The municipality is surrounded by Bedkot Municipality in the east, Dadeldhura District in the north, Shuklaphanta National Park in the south and Uttarakhand, India in the west.

At the time of the 1991 Nepal Census, it had a population of 62,050. According to census 2001, the population has increased to 80,839. While the population is 1,04,599 after reformation of the municipality in 2015. The indigenous Rana-Tharus and migrated populations from districts like Baitadi, Darchula and Dadeldhura have made a unique combination of ethnic groups within diverse groups. The people in the municipality have diversified their occupation from agriculture to business and trade.

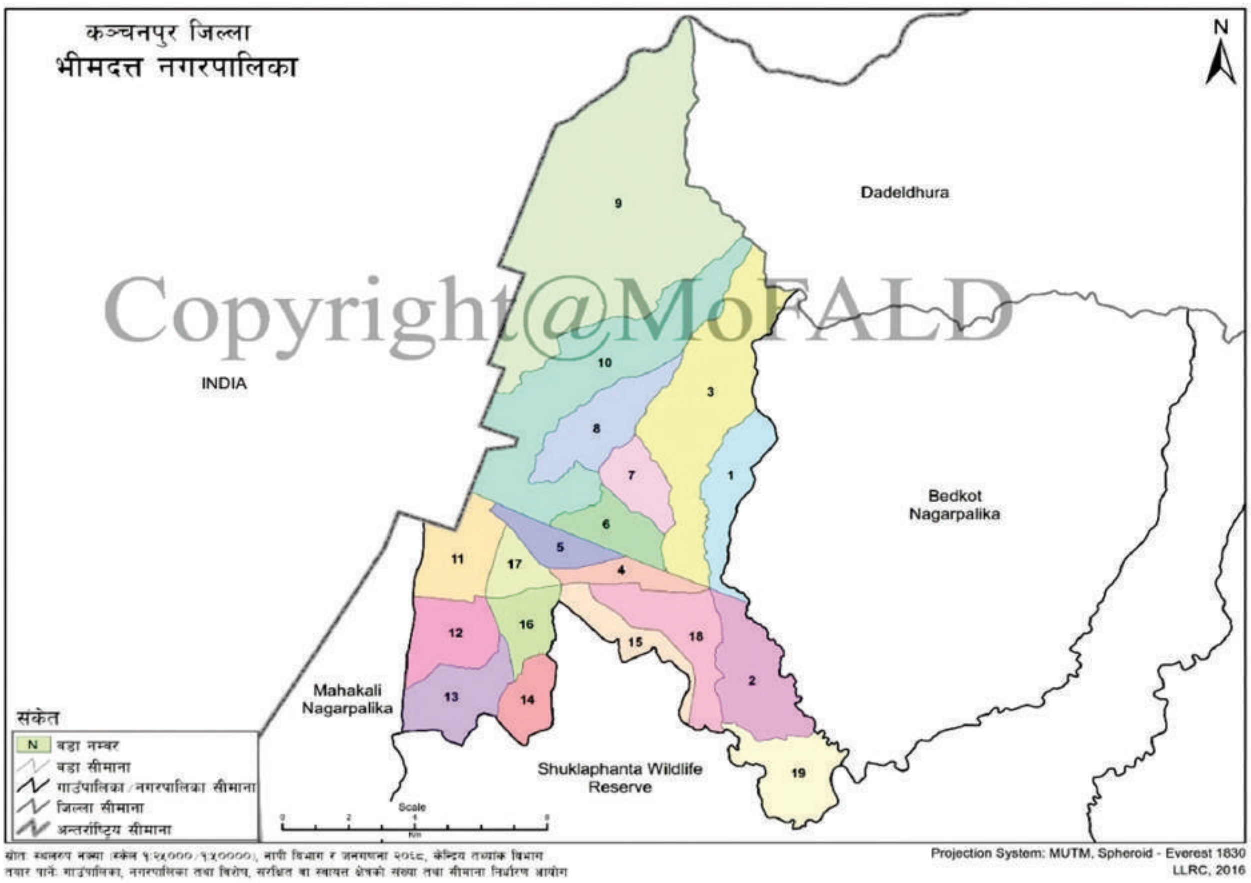

Figure 1: Map of Bheemdatt Municipality with wards boundary

2 Methodology

The methodologies adopted in the study are in literature review of secondary data, depth questionnaire survey at household and institutional level on existing sanitation status. Also, key informant survey on FSM key stakeholders are conducted followed by direct observations of the existing sanitation situation.

2.1 Household Survey

Random household survey was conducted in all wards of the municipality through mobilization of volunteers selected by the municipality. The household survey was conducted using mobile application "KOBOCOLLECT" after orientation. Two days orientation training was conducted to make volunteer understand on objective of the survey, technical terms regarding sanitation, use of mobile application and conducting random sample survey.

2.1.1 Determining Sample Size

The number of households to be sampled in the municipality was determined by using Cochran (1963:75) sample size formula $n_o = \frac{Z^2pq}{e^2}$ and its finite Population Correction for the Proportion $n = \frac{n_0}{1+\frac{(n_0-1)}{N}}$.
Where,

Z^2	1.96	At the confidence level of 95%
p	0.5	Assuming that about 50% of the population should have some sanitation characteristics that need to be studied. (This was set at 50% since this percentage would yield the maximum sample size since the percentage of the population practicing some form of sanitation is not clearly known at the intervention sites)
q	1-p	
e	±5%	Level of precision or sampling error
N		Total number of population (households in the municipality)

This is followed by Proportionate Stratification Random Sampling such that each wards in the municipality is considered as one stratum. The sample sized required in each ward is calculated as

$n_h = \frac{N_h}{N} \times n,$ where, Nh is a total population in each stratum.

Thus a total of 379 households were sampled from 23522 households distributed among 19 wards with proportionate stratification random sampling as shown in table 1.

Table 1: Proportionate Stratified Sample Distribution in each wards

Ward	Households	Sample
1	693	11
2	1507	24
3	1262	20
4	1266	20
5	914	15
6	2017	32
7	1117	18
8	1010	16
9	1585	26
10	2110	34
11	870	14
12	655	11
13	1088	18
14	670	11
15	881	14
16	653	11
17	415	7
18	3825	62
19	984	16
	Total	379

2.1.2 Sampling Procedure

To have a more consistent way of identifying, selecting and interviewing allocated number of households across the each wards, systematic sampling approach was followed and random households are selected for the survey. The steps used are as below:

Steps used:

1. Calculate the ward sampling interval, i.e. total number of households divided by no. of households to be sampled.
2. Select a random start between 1 and sampling interval using excel function RANDBETWEEN (1, sampling interval).
3. The random start identifies the first households to be interviewed, the second household will be number (random start + sampling interval)
4. Repeatedly add sampling interval to select subsequent households.
5. As a rule, for replacement of HHs that are not available or not consent to the interview, first household on left hand side of the absent household was selected

2.2 Institutional Survey

Door to door method was applied for Institutional survey. All institutions within the set criteria for selection was surveyed. The criteria for selection are:

1. Educational and financial institutions operated in either its own building or rented building are selected but operating in single room or flat not selected.
2. All hotels with provision of residential facilities are selected.
3. Health care center with the provisions of bed are selected, i.e. small clinics were not selected.
4. Government/ Non-government Offices are selected.
5. Commercial Buildings are selected.

In total 209 institutions were surveyed and descriptions of surveyed institutions are shown in table 2.

Table 2: Description on total number of institute surveyed

Ward	Financial Institutions	Hotel/ Home Stay	Commercial Buildings	Educational Institutions	Government /Non-government Office	Community Buildings	Health Care Center	Total
1		1		2	1			4
2				6	1	1		8
3		1	2	8	1	1		13
4	10	3		4	6		2	25
5		1		3	1			5
6	1	20	1	15	2			39
7	2			7	1			10
8				3	1			4
9				3				3
10				3	1			4
11				1	2			3
12				7	1			8
13				4	2			6
14				1				1
15				5	3			8
16				2	1		1	4
17	2			1	2		1	6
18	12	6	4	23	1	2	6	54
19				1	2		1	4
Total	27	32	7	99	29	4	11	209

2.3 Key Informant Interview

Key informant interview was conducted to understand existing sanitation policies of the municipalities, planning process for developing sanitation program and on-going programs. Similarly, the interview was focused on existing service delivery mechanism. Mr. Surendra Bista, mayor of Bheemdatt municipality, Mr. Padam Raj Bhatt, Environmental Officer at Regional Urban Development Program and Mr. Puspha Raj Bhatt, Planning Officer at Waste Management Subsection of the municipality were interviewed. Similarly, proprietor of the Mahaendranagar Saffi Sewa was interviewed regarding current desludging practices and business.

2.4 Data Collection Process

The data was collected by using KoBo Collect application, which was uploaded into mobile phones through mobilization of the local enumerators. ENPHO engaged its own staff as supervisors to undertake this survey. The supervisors engaged local enumerators to conduct the household and institutional survey. Enumerators were trained on questionnaire survey and using KOBO COLLECT. During the training, enumerators were familiarized themselves with questionnaire contents, flow of questions, mobile data collection devices, and test run all the devices.

2.5 Data Processing and Analysis

After the fieldwork, all the e-forms submitted in the KOBOdashboard were adequately checked for accuracy and completeness before analysis. The data was cleaned and verified for inconsistency, missing values and errors. After data cleaning, the second step of analysis involved generation of syntax commands to ensure that variables are transformed appropriately for ease of analysis.

The data processing and analysis entailed the following steps:

- Downloading the data from the KOBO COLLECT in excel and Performing exploratory analysis to check for accuracy, completeness, relevance and consistency of the critical data elements;
- Performing data cleaning using a set of manipulation commands to ensure that data are aligned to the data analysis plan and the agreed reporting template;
- Descriptive analysis entailed computing frequency distributions; means and cross tabulations

Data cleaning process is one of the important steps in data processing before its analysis. Data cleaning entails a set of procedures aimed at assessing the sampling protocol adherence, completeness of collected data, accuracy, consistency and relevance of each of the data elements under consideration as well as actual correction of the data with errors for improved data quality.

The process of data cleaning ensures that the errors in data arising from missing data, outliers and other out of range issues are handled in time for better quality results. Following the completion of data collection, the data was cleaned and verified before analysis and interpretation of data.

3 Sanitation Status

The municipality was declared Open Defecation Free Zone on November 2017. Almost 50% of the toilets were constructed during the ODF Campaign. However, 0.5% of households do not have toilet. The municipality has stormwater drain in core urban areas but lacks municipal sewer network thus all the households depend upon onsite sanitation system. The following section highlights existing sanitation situation in both household and institutional level.

household with septic tank

3.1 Types of Containment

An ideal septic tank, consisting of fully lined double chambers and bottom with overflow pipe for discharge of effluent is constructed in 4.5% households. Among these, approximately 60% have connected effluent into either stromwater drain or open environment. The fully lined tank is installed in 37% of households. Similarly, tanks with impermeable walls and open bottom are installed in 41.5% of households at peri-urban and newly settled areas. Whereas, in rural settlement lined pits with semipermeable walls and open bottom either twin or single pits are used to store the faecal sludge. However, installation of twin pits are technically inappropriate as an inlet pipe from a toilet is connected in series to both pits. Remarkably, anaerobic biogas digester, designed for the integrated treatment of human faeces, animal manure and organic waste at household have been installed in certain clusters. Unfortunately, in some households containment or toilet have been damaged as shown in figure 2.

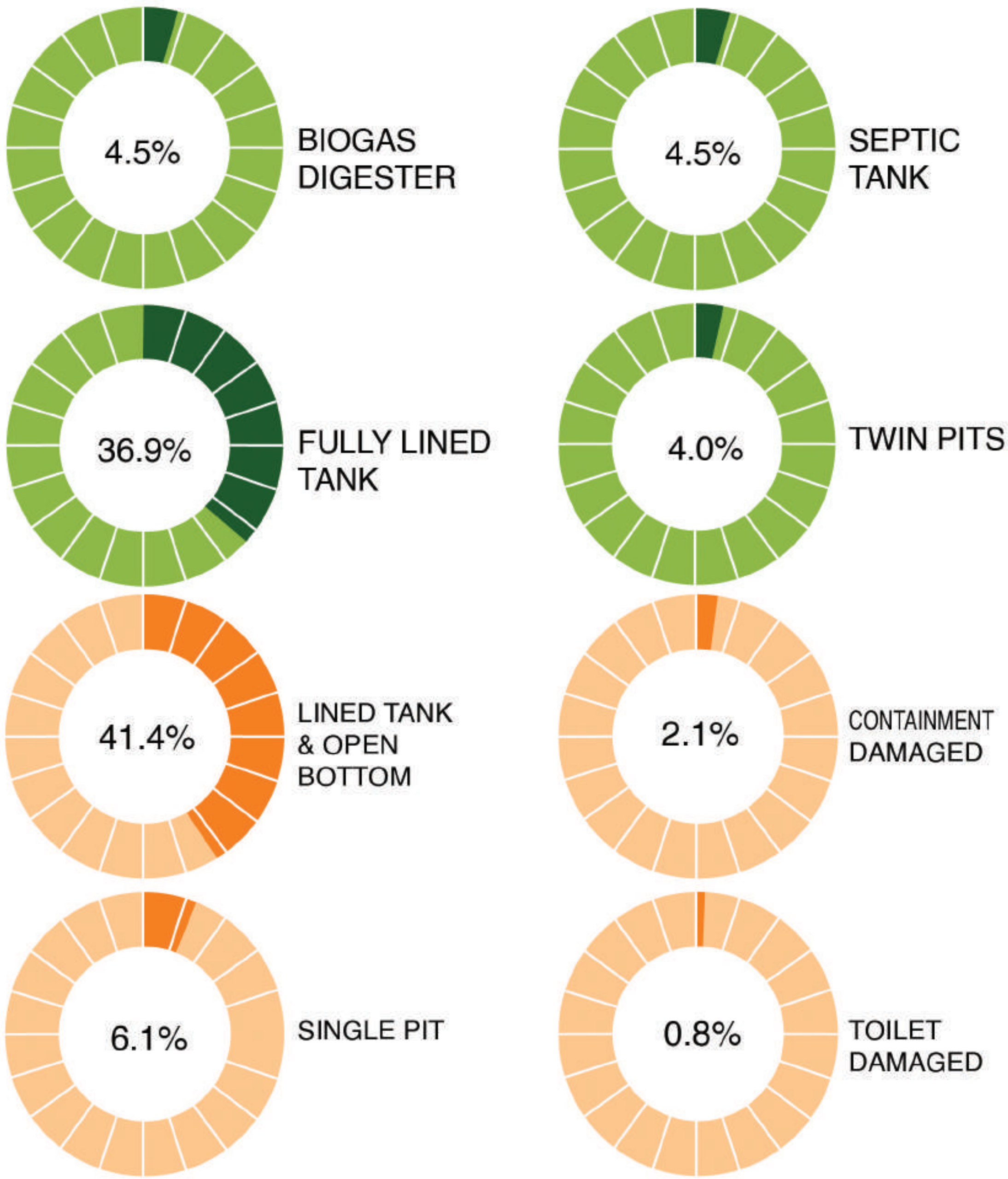

Figure 2: Types of Household containment in Beemdatt Municipality

Figure 3 shows types of containments in institutions. Fully lined tanks and lined tanks with impermeable walls and open bottoms were mostly used. Anaerobic biogas digester and twin pits are not installed.

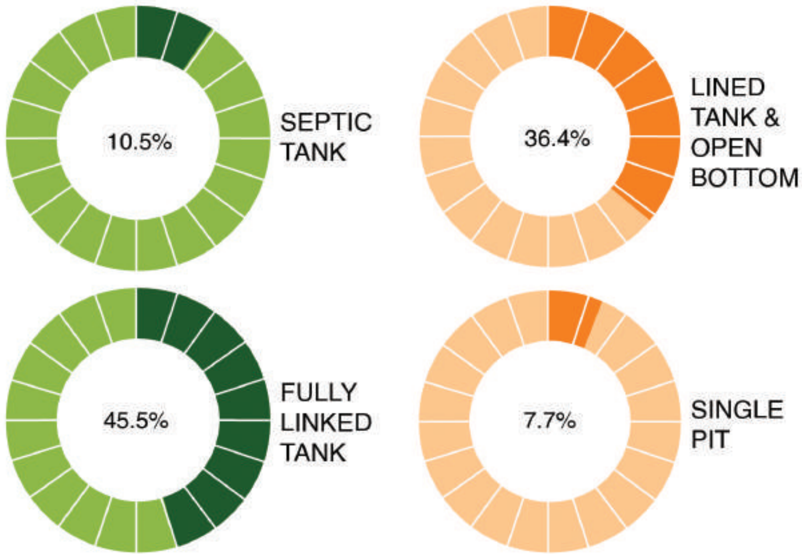

Figure 3: Types of Institutional containment in Bheemdatt Municipality

3.1.1 Distance between source of water and containment

Groundwater is major source of drinking water in the municipality. In an average 87.5% of households depend on groundwater. Among them, 65% have shallow tube well while rest has connected pipe water supply distributed by Bheemdatt Water Supply User's Committee. Similarly, 12% depends upon surface source of drinking water out of which 40% have pipe water supply distributed by water supply user's committee. Generally, septic tank, fully lined tank and anaerobic biogas digester possess lower risk towards groundwater contamination. While lined tank or pits with impermeable or semipermeable walls and open bottoms possess higher risk. 41% of households with lined tank with impermeable walls and open bottoms have shallow tube well or dug well as source of drinking water. As shown in figure 4, the majority of these water points are within the horizontal distance of less than 25 feet from the containment. Also, vertical depth of these water points are less than 80 feet.

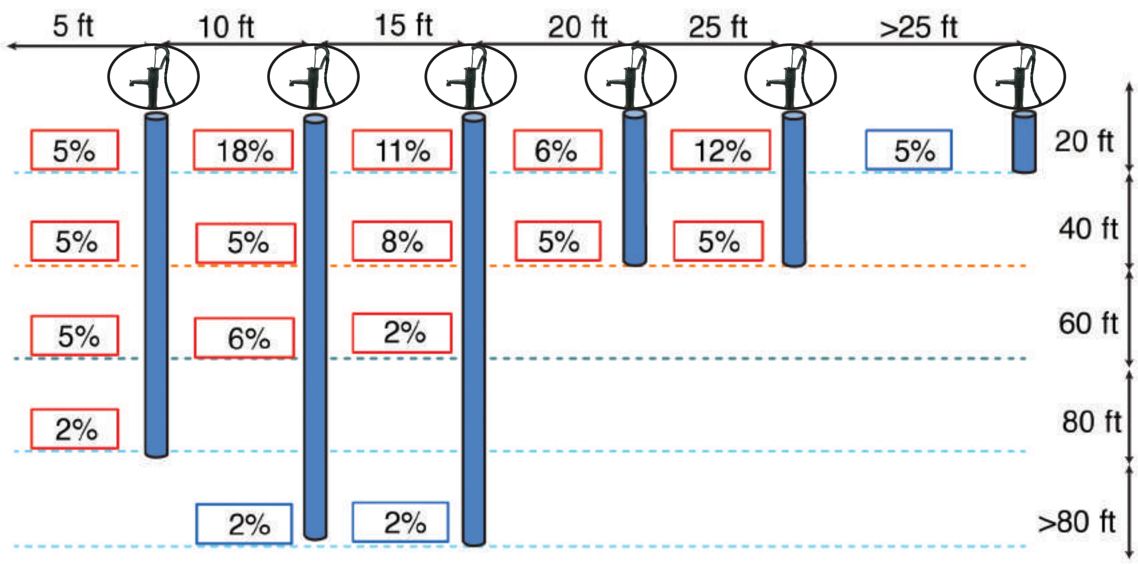

Figure 4: Description on Household having lined tank and open bottom containment with Groundwater as Major source of Drinking water

Similarly, 21% of households with either twin or single pits depends on shallow tube or dug well for drinking water. All these water points were bore at the depth of less than 50 feet and 50% are within the horizontal distance of 25 feet from the containment.

3.1.2 Size of Household Containment

Size of containments are highly variable except with anaerobic biogas digester. Anaerobic biogas digester have been subsidized according to guideline of Government of Nepal. Thus the size was either 6 m^3 or 8 m^3. Figure 5 shows the histogram of volume of the sampled containments which is slightly skewed towards the right hand side at skewness value of 0.77. The average volume is 8 m^3 with standard deviation of 4.72. Similarly, the minimum and maximum volumes are 1.0 m^3 and 23 m^3 respectively which indicates disintegrated data on types of containments is essential to minimize errors.

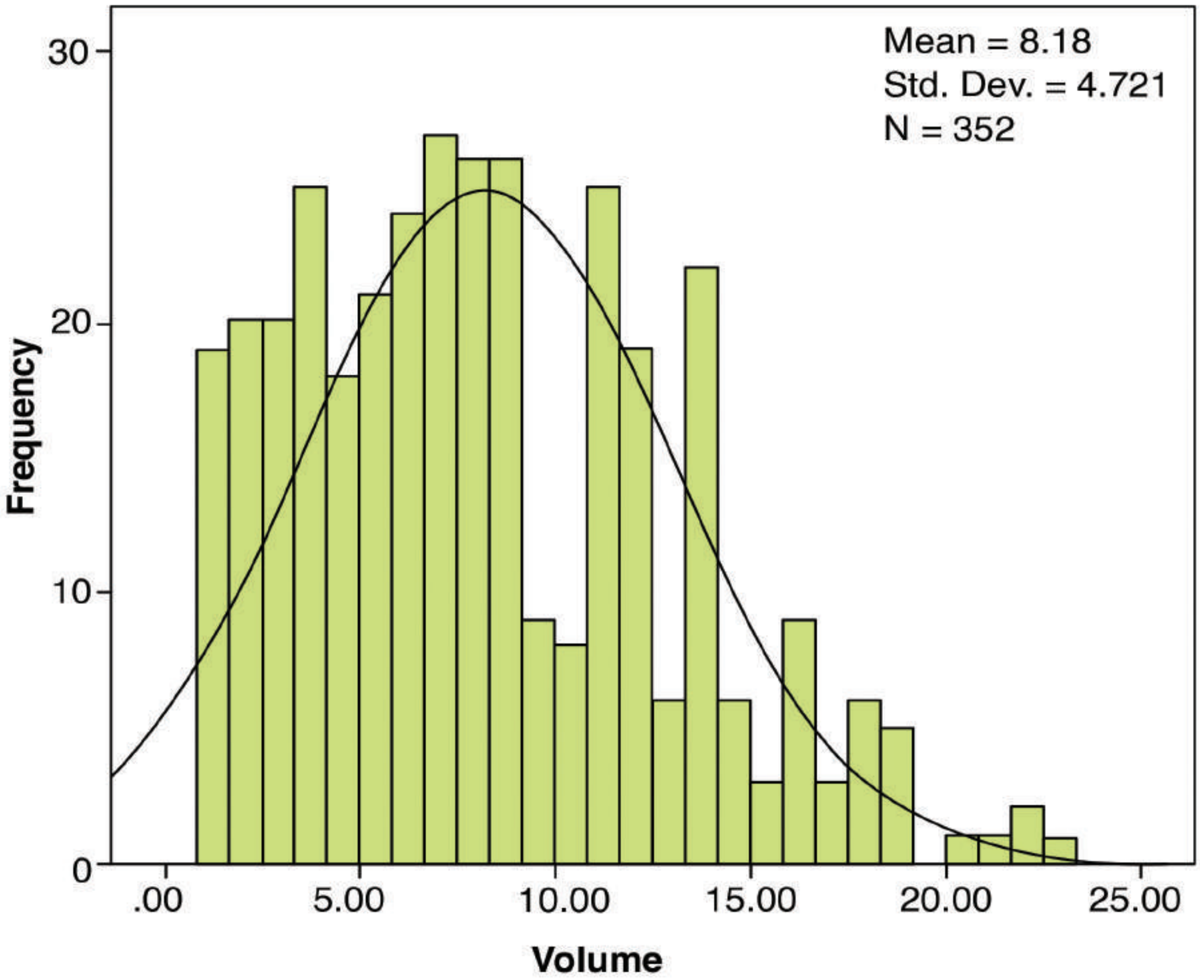

Figure 5: Histogram of Volume of containments

3.1.2.1 Size of Rectangular Containments

Figure 6 shows almost normally distributed histogram of the volume of rectangular containments. Septic tank, fully lined tank and lined tank with impermeable walls and open bottoms are considered as rectangular containment. The average volume of the containments is 9 m^3 at with standard deviation of 4.463. Also, minimum and maximum volume are 2 m^3 and 22 m^3 respectively.

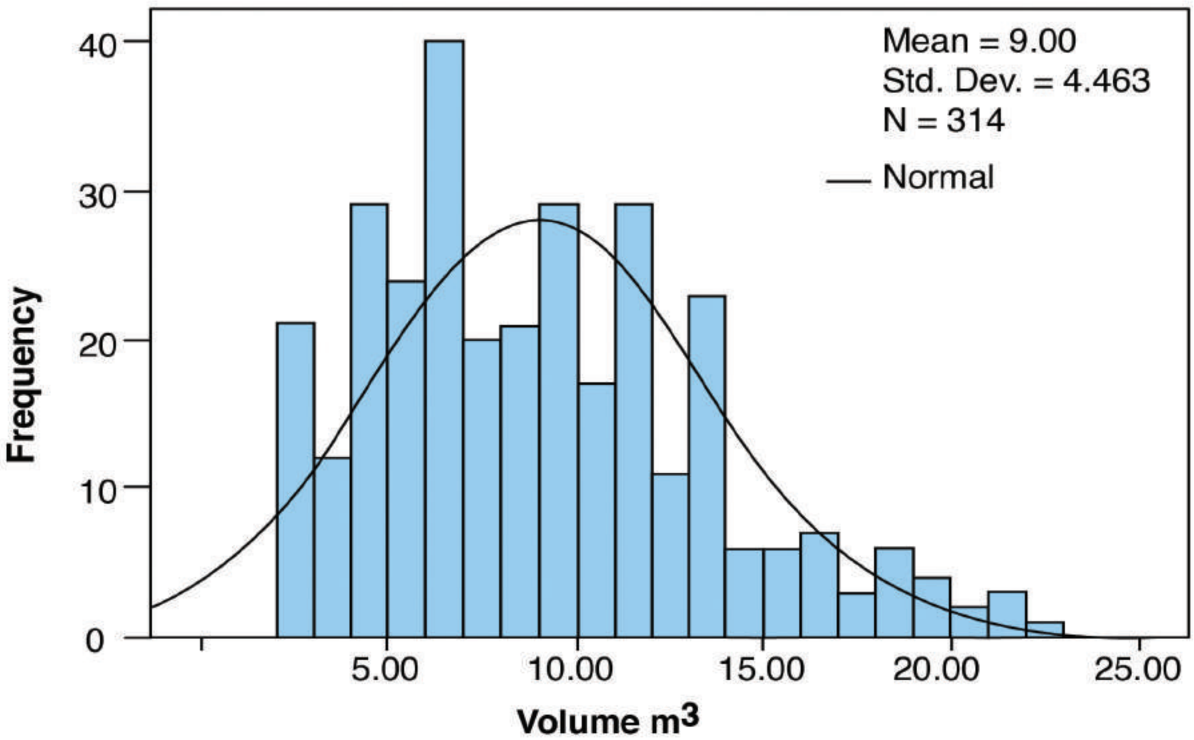

Figure 6: Histogram of Size of Rectangular Containment

3.1.2.2 Size of Circular Containments

Figure 7 shows a histogram of volume of circular containments (twin and single pits) which is almost normally distributed. The average volume of the circular containment is 1.97 m^3 with standard deviation of 0.809 Also, minimum and maximum volume are $1m^3$ and 3.6 m^3 respectively.

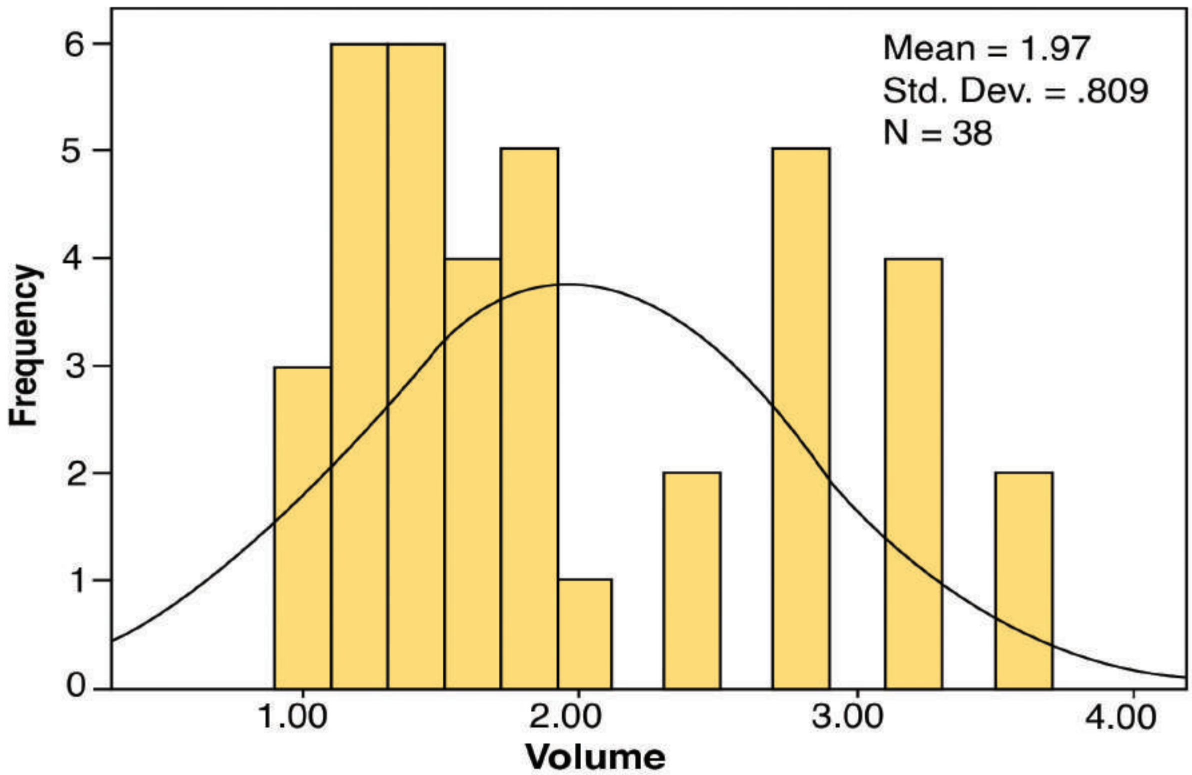

Figure 7: Histogram of Size of Circular Containment

3.1.3 Size of Institutional Containment

The average size of the containment is 11.8 m^3 with minimum and maximum size of 2.3 m^3 and 65 m^3 respectively. The standard deviation is 9.7. Figure 8 shows the histogram of size of containments with normal distribution curve.

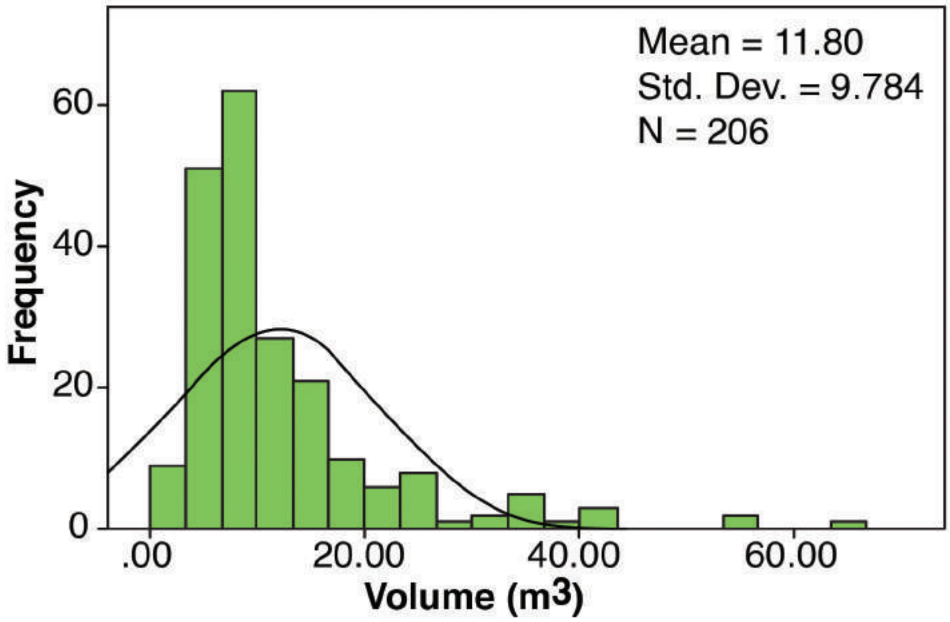

Figure 8: Histogram of size of Institutional Containment

3.1.4 Relation between size of household containment and user

Number of the user is one of the major factor determining the size of the containment. Generally, higher the number of user larger the size of the containment is constructed. In Bheemdatt municipality, as shown in figure 9, the coefficient of correlation between this factors is 0.245 with coefficient of determination 0.004. Thus, there exists moderate relation between number of users and size of containments.

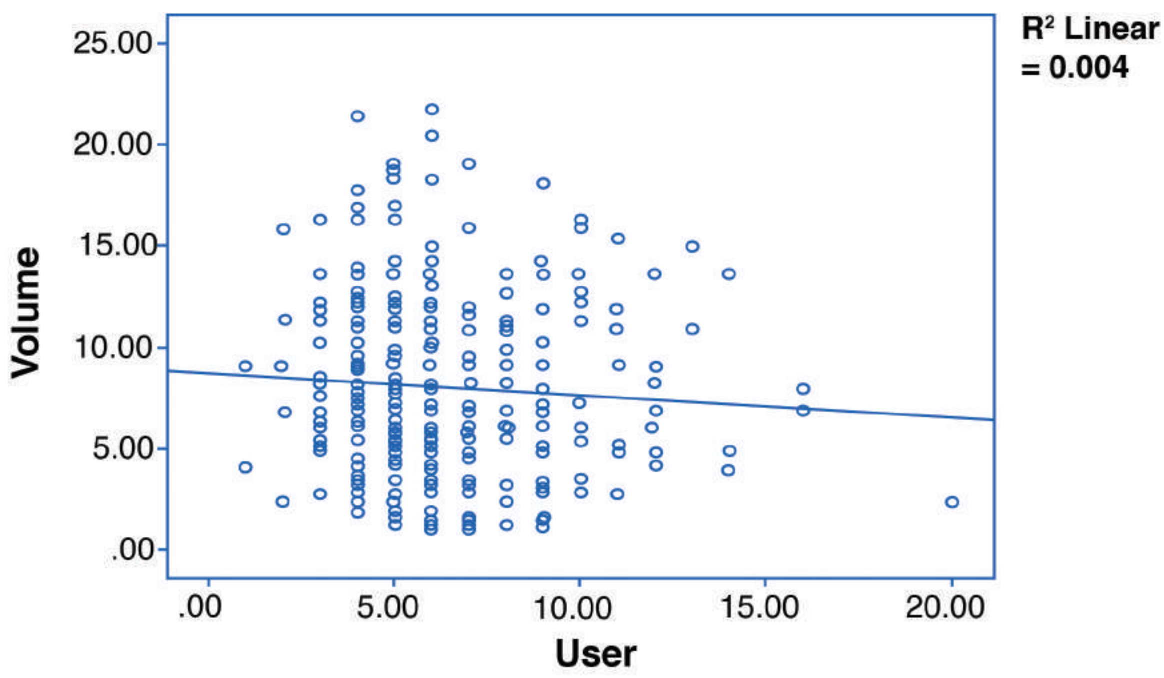

Figure 9: Relation between users and size of containment

3.1.5 Relation between Size of the Institutional Containment and User

The coefficient of correlation between size of institutional containment and user is 0.022 with coefficient of determination 0.025. It shows that there is no strong relation between the factors. Figure 10 shows plot of size of the containment and user.

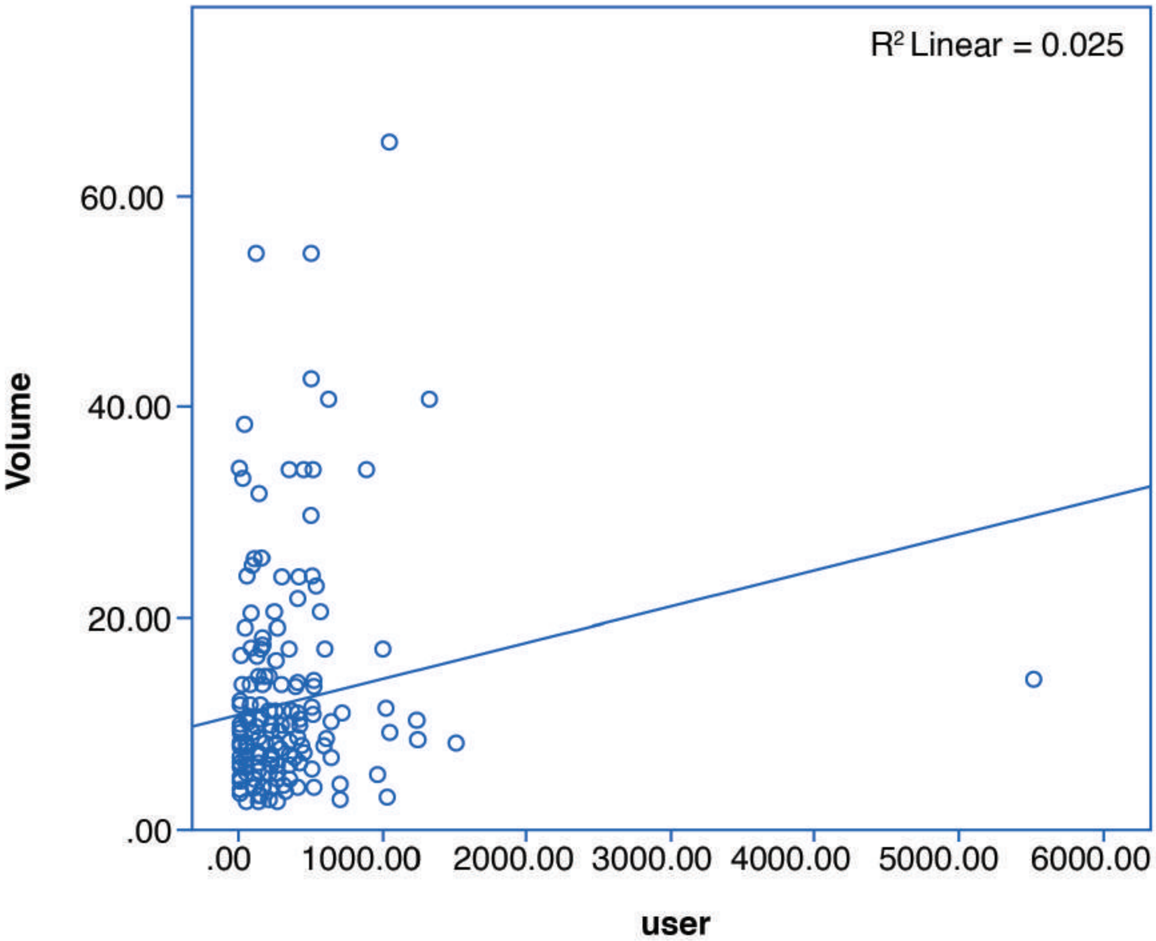

Figure 10: Relation between Size of Institutional Containment and User

3.2 Emptying and Transportation

Emptying ensure proper functioning of containment basically for septic tank which functioned well until the volume of sludge is one third of the total volume of the tank. Also, in other containments regular emptying prevents overflow of the sludge and blockages. 16.7% of households have emptied their containment at least once since the installation. These containments are emptied after it got filled. Both traditional manual scavenging and mechanical emptying of the containments are practiced in the municipality. In an average 60% of households which have emptied their containment got service from private desludging service provider.

3.2.1 Emptying Frequency

Emptying frequency of the containments were not uniform. Figure 11 shows emptying frequencies of the containments where 31% of containment were emptied once every 6 to 10 years. However, there exists containments which are being frequently emptied such as thrice times a year, twice a year or every year.

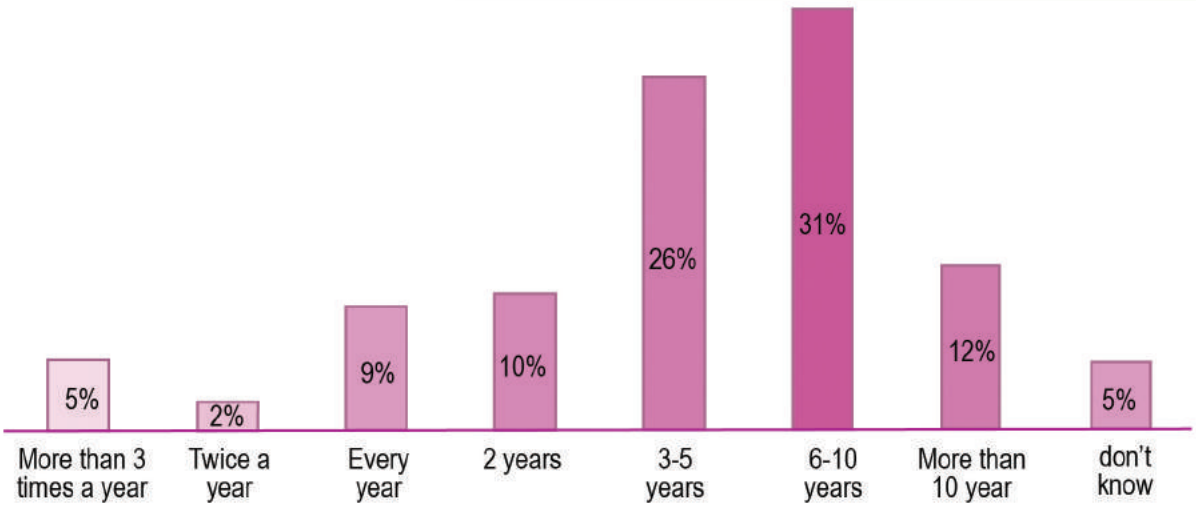

Figure 11: Emptying Frequency of the Containments

3.2.2 Relation between Emptying Frequency and Size of Containment

The correlation between volume and emptying frequency revealed that there is moderate negative relation existed with coefficient of correlation at -0.2 and coefficient of determination at 0.03 as shown in figure 12. This implies, greater the size of the containment lower is the emptying frequency.

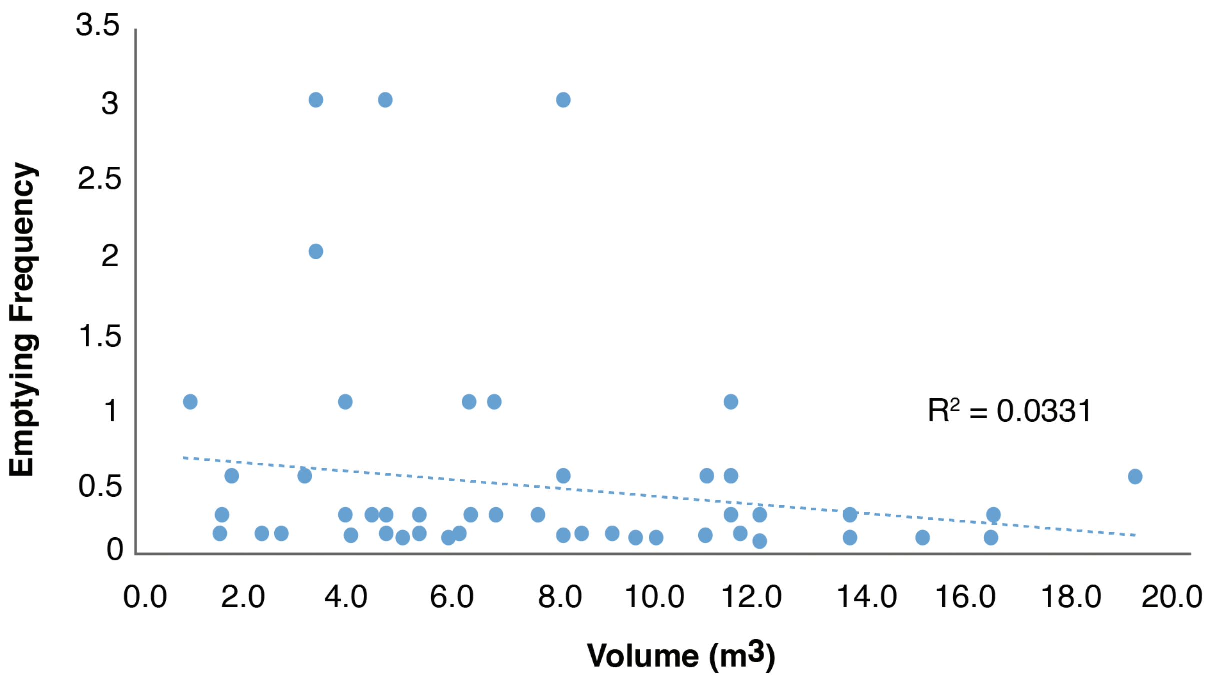

Figure 12 Graph on relationship between emptying frequency and size of the containment

3.2.3 Never Emptied Containment

The average number of user of non-emptied containment is 7 and average volume of 8.5 m^3. Table 3 shows types of containment and time period of their construction. It shows approximately 20% of the containment with never emptied were newly constructed. While old containment constructed more than 5 years old and have never emptied may be due to infiltration.

Table 3: Descriptions on Never Emptied Containments

S.N.	Containment	Constructed Time Period				Total
		0 – 2 years ago	3 – 5 years ago	6 – 10 years ago	> 10 years ago	
1	Septic Tank	0%	1.37%	1.37%	1.71%	4.45%
2	Fully Lined Tank	8.9%	14%	12.33%	5.87%	41.10%
3	Lined Tank and Open Bottom	8.9%	14.34%	10.27%	11%	44.52%
4	Pits	2.06%	3.08%	1.7%	3.06%	9.9%
Total	19.8%	32.8%	25.67%	21.64%	100%	

3.2.4 Emptying and Transportation Services

Mahendra Safaai Sewa, registered as private firm in Inland Revenue Office and Bheemdatt Municipality has been providing desludging service since 2017. The firm owns a tractor and two set of tanks each 3000 liter and 6000 liter capacities with locally assembled suction pump. Each tanks are assembled in the tractor according to the size of containment that has to be desludged. The firm has invested NRP 2.5 million for the equipment and appointed a driver and two helper. Driver is paid NRP 16,000 per month while helpers were paid NRP 400 for each trip.

Bheemdatt and Belkot municipality are the service area of the firm. In an average 15 containments is being desludged and transported per month. In most cases 3000 liters tanker is mobilized. NRP 4000 to 5000 is being charged for a trip and additional amount is charged based upon the distance. The owner revealed that demand from core urban clusters is very low than their expectation which he assumed consequences of illegal discharge of FS from containments into stormwater drain. Additionally lack of awareness on unsafe practices of manual desludging and insufficient marketing were seen for low demand.

The major issues and challenges in the business as experienced were lack of designated disposal site, social discrimination for the operators and registration of vehicle in the Department of Transport Management. Similarly lack of trained human resources on desluging services has constrained effective and efficient service delivery. Also, occupational health safety is being a challenge though simple personal protective equipment is being provided to helpers.

3.3 Treatment and Safe Disposal/Reuse

The municipality does not have any FS treatment plant. The FS transported by the private firm is being disposed into a pit located approximately 6 km away from the city center. The pit is covered with soil after disposing. Occasionally, FS is disposed into farm land as fertilizer upon the request of land owner.

3.4 People's Perceptions and Knowledge on FSM

People's perception on emptying, disposal and its consequences was assessed. Also, their perception on improvement management of FS was measured.

3.4.1 Perception on Preferred Emptying Mechanism

Figure 13 shows perception on preferred emptying mechanism of containments after it get filled. Majority of household's that have never emptied their containment preferred mechanical emptying mechanism through contacting either municipality or private service providers. Whereas 18% perceived self-emptying and disposed into a pit.

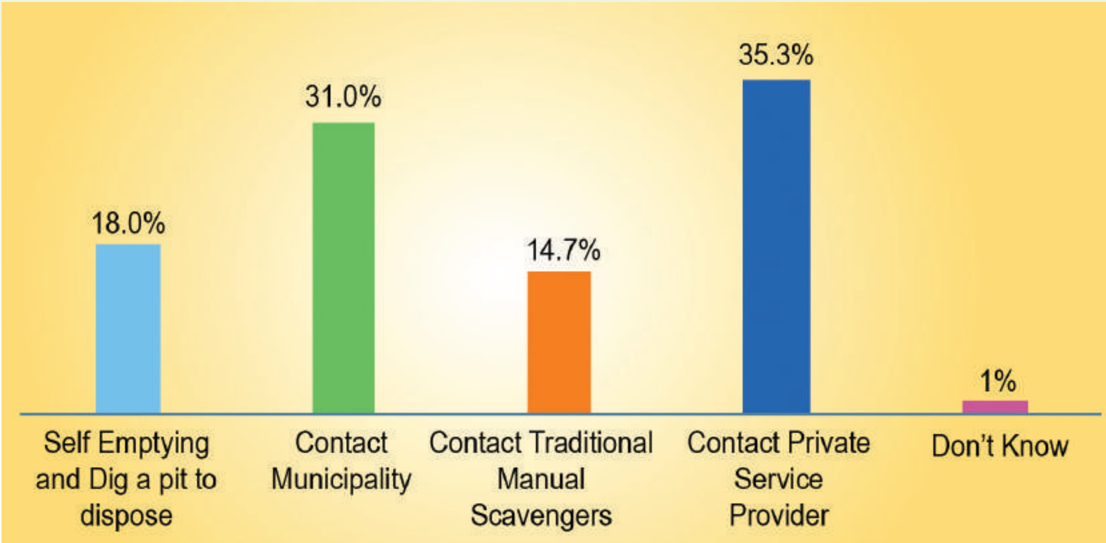

Figure 13: Perception on preferred emptying mechanism of containment

3.4.2 Perception on Current Practices of FSM

Figure 14 shows perception of local people on current FSM practices in the municipality. It shows that majority of the households applies FS into farmland. It also revealed that ideally only 1.1% of households have never emptied the containment and open emptying to open land, forest, and drain is being practiced.

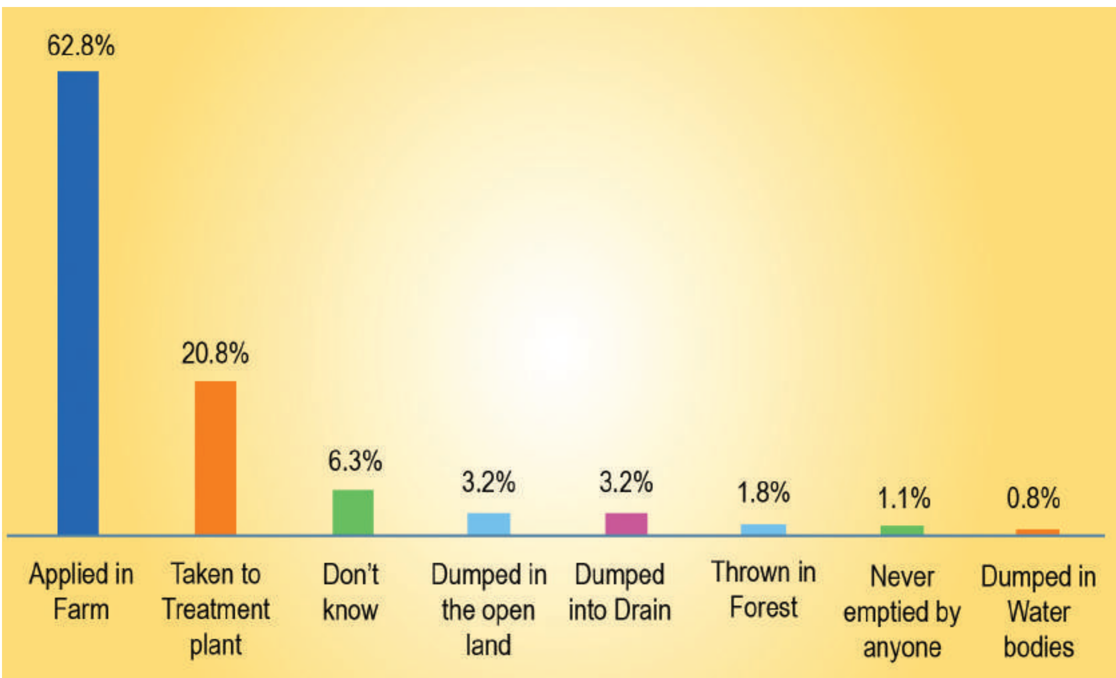

Figure 14: Perceptions on Current Practices of FSM

3.4.3 Perceptions on Improved FSM

Figure 15 shows perception on improved FSM, which shows that majority of people preferred construction of treatment plant. Also they insists for strict law and punishment disobeying the rule. Remarkably, 18% of people claimed encouraging reuse option would improve current practices of FSM.

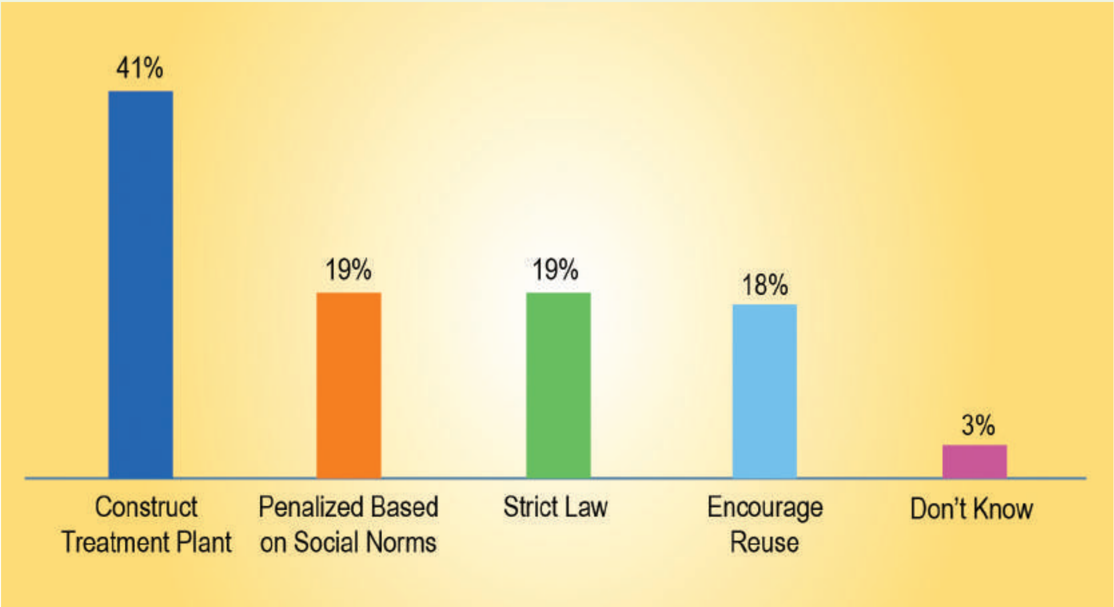

Figure 15: People's perception on Improved FSM

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4 Assessment of Feasibility on FSM

4.1 Shit Flow Diagram

Figure 16 represents Shit Flow Diagram (SFD) of the municipality that represents overall status of the faecal sludge. It shows that only 4% of FS collected in an anaerobic biogas digester has been treated while 44% of FS collected in the fully lined tank is considered safely managed until it is emptied. The rest of FS generated is being disposed haphazardly to the environment. It increased threat on groundwater contamination resulting degradation of human health upon consumption of contaminated water. It clearly indicate necessary intervention for safe management of FS.

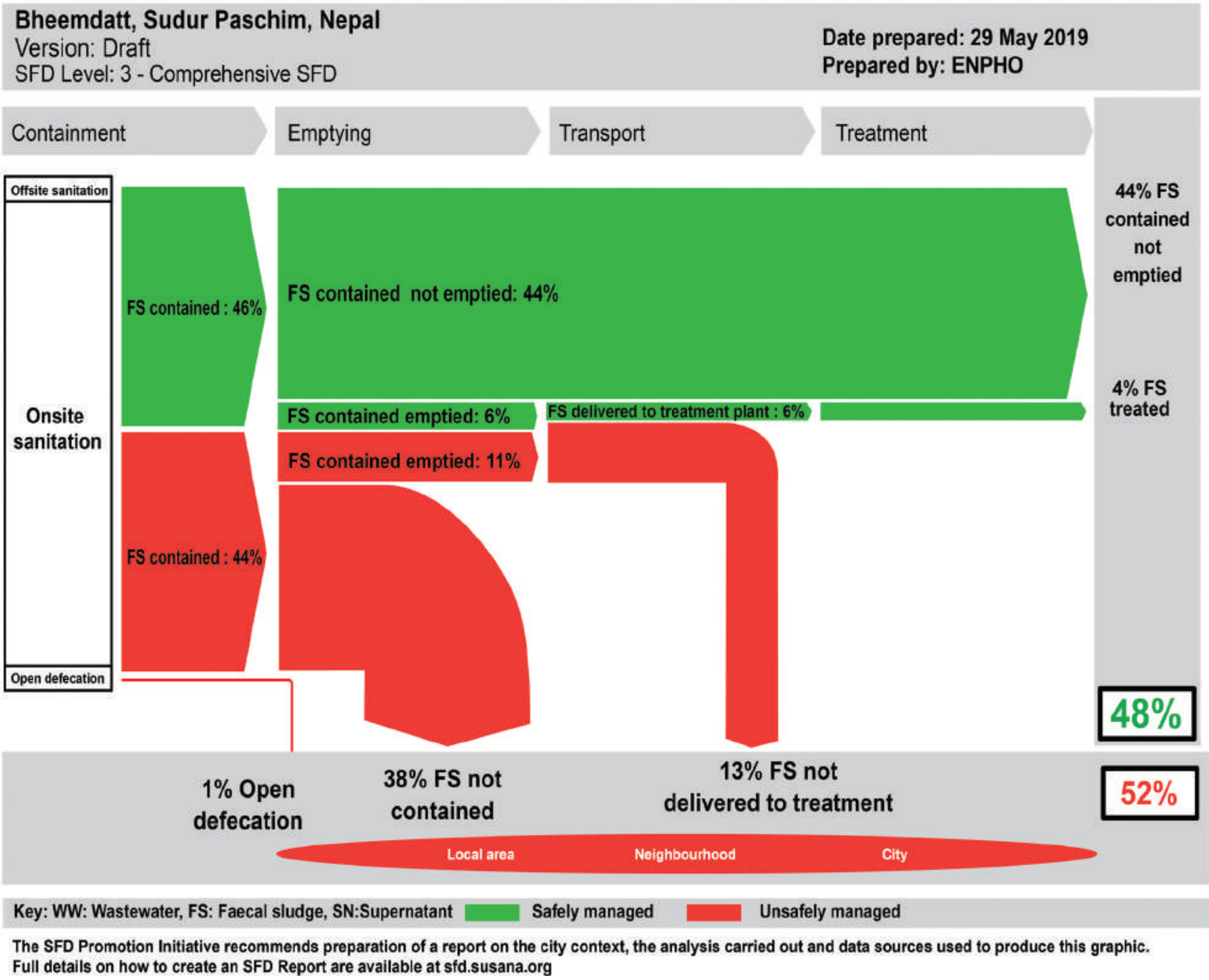


Figure 16: Shit Flow Diagram of Bheemdatt Municipality

4.2 Technical Assessments

4.2.1 Appropriateness of the Containment

Anaerobic biogas digester and twin pits functions as treatment unit together with storage of FS. Upon proper O&M, these technologies effectively recover energy and nutrients contained in the FS through generation of biogas and nutrient rich manure. Also, septic tank is primary treatment unit that increases quality of effluent which would reduce environmental and health hazard upon disposal of the effluent in soak pits. However, discharge of effluents to open drain or environment could have negative impact on environment and human health. Whereas fully lined tanks safely store the FS and prevent from contamination of groundwater through seepages and leakages. These technologies requires regular emptying for its effectiveness. Despite of being appropriate technology, illegal discharge of FS from these containments particularly practiced to avoid regular emptying in the absence of effective monitoring mechanism lead to environmental pollution.

Whereas, lined tanks or pits with impermeable or semipermeable walls and open bottoms reduces the filling rate of the tanks as seepage and leakages increases. Together, it increases the high risk towards contamination of groundwater. Thus, these technologies could be considered effective only when groundwater is not contaminated. The assessment of drinking water quality shows that presence of total coliform in 58% and E.coli in 16% out of 50 water samples. Water from hand/tube wells were more contaminated than piped/tap water most probably due to faeces (Bohara, 2015). Hence it indicates installation of appropriate containment and regular monitoring to prevent groundwater contamination from seepages and illegal discharge of FS into storm water drain.

4.2.2 Quantification of Faecal Sludge

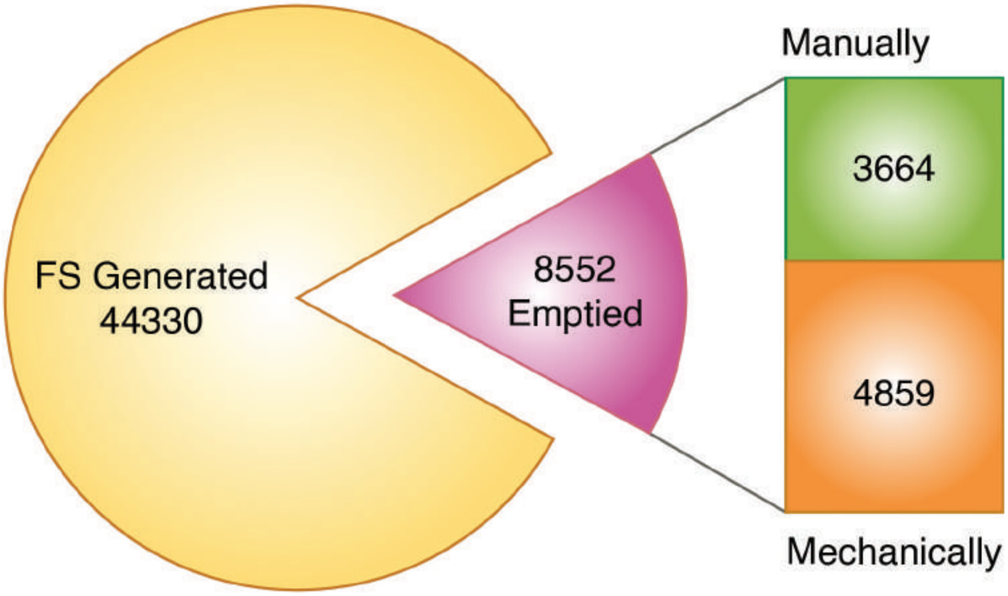
Quantification of faecal sludge depends upon many factors like type of the containment, water content, climate, inflow and infiltration, presence of overflow pipe, user behaviours, sludge age, non-biodegradable fraction and soil characteristics (Borouckaert CJ, 2013). Amount of FS generated in the municipality is estimated based upon FS accumulation rate and total population using some kinds of containments. Quantity of FS is estimated based upon average size of various containment and their emptying frequency obtained from primary data collected during household survey. In an average 44,330 m3 of FS is generated in the municipality as shown in table 4.

Table 4: Calculation of FS Generation based on Size of Containment in Household

Containment	HHs	Average Volume of containment	Emptying frequency	Total FS in containment
Septic tank	1056	9	0.187	1,777
Fully lined tank (sealed)	8689	9	0.25	19,550
Lined tank with impermeable walls and open bottom	9744	9	0.25	21,924
Twin Pits	931	2.4	0.125	279
Single Pit	1428	1.4	0.4	799
FS produced per year (m3)				**44,330**

4.2.2.1 Volume of Faecal Sludge Emptied from Household

In an average total of 8552 m^3 of FS is being emptied in the municipality. The amount is approximately 19% of calculated total volume of FS generated per year. Figure 17 shows total FS generated calculated based upon size of containment and emptied potion. Among this an average 4859 m^3 and 3664 m^3 of FS per year is being mechanically and manually emptied in the municipality. Mainly FS is being emptied from fully lined tank and lined tank with impermeable walls and open bottom. Also considerable volume of FS from twin pits is being emptied mechanically. Calculation of volume of FS emptied is given in Annex 1, 2, 3, 4, 5.



4.2.2.2 Volume of Faecal Sludge Emptied from Institutional Containment

In a total 1100 m^3 of FS per year is being emptied from institutional containment. The volume of manually emptied is 850 m^3 per year. Table 5 shows volume of FS being emptied manually and mechanically from various types of institutional containment.

Table 5: Volume of FS emptied from Institutional Containment

Containment	Manual Emptying (m^3 /year)	Mechanical Emptying (m^3/year)
Septic Tank	75	95
Fully Lined Tank	60	390
Lined Tank and Open Bottom	112	348
Single Pit	3	20
Total	**250**	**853**

Thus in total 9626 m^3 of FS per year is being emptied form both households and institutions which is equivalent to 26 m^3 of FS per day. While volume of mechanically emptied FS is 5712 m^3 per year, i.e. 15.6 m^3 per day. However, considering the fact that only 80% of FS in the tanks are pumped by the emptying vehicle, the estimated actual volume of FS emptied per day is 12.5 m^3.

4.2.3 Options for Faecal Sludge Treatment Processes

Fecal Sludge Treatment comprises of solid-liquid separation, stabilization, dewatering/drying, pathogen reduction and production from end-products. These processes are determined by the characteristics of faecal sludge. Since characteristics of FS was not conducted during the study, thus characteristics can be assumed based upon following information.

4.2.3.1 Source of Sludge (Types of containment)

Currently 48% and 41% of FS are mechanically emptied from lined tank with impermeable walls and open bottom and fully lined tank respectively. Also, emptying frequency for lined tank with impermeable walls and open bottom is higher than fully lined tank, it could be assumed inflow of water into the containment. Thus, the volume of liquid is higher in both cases which demands liquid-solid separation unit in the treatment technology.

4.2.3.2 Age of accumulated sludge

The emptying frequency of the various containments shows that age of accumulated sludge ranges from 2 years to more than 8 years old. Thus the nature of FS being emptied does not have same characteristics. Comparatively, a fresh sludge (accumulated for only 2 years) will require additional stabilization whereas 8 years old sludge would be digested. Hence, it requires stabilization process in treatment technologies to effectively treat FS emptied from the municipality.

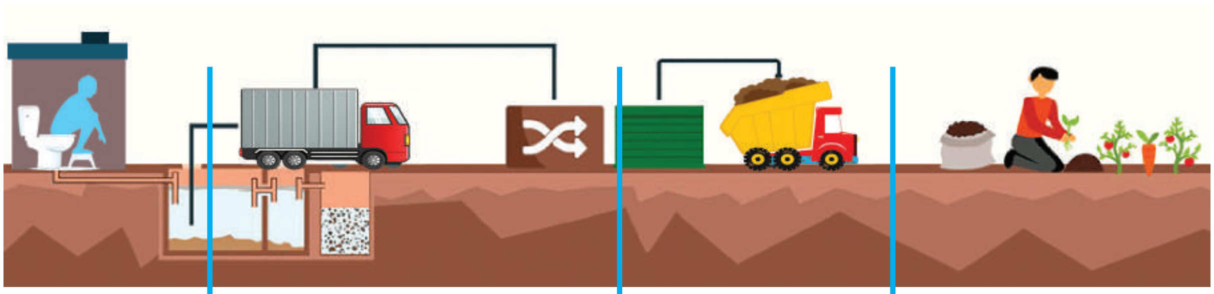
4.2.3.3 People's perception towards acceptable of end-products

People's perception on current management of FS revealed that farm application of faecal sludge is practiced by many households. The fact is supported by the disposal of collected FS by private service provider into farmland upon request of famers. Also, people insisting on encouragement of reuse options as improved FSM indicates social acceptance of end products. Thus, the treatment technologies should incorporate end product to safety level. Hence, it requires pathogen reduction mechanism after dewatering/drying for safe use of treated faecal sludge as soil conditioner or organic fertilizer.

5 Conclusion and Recommendation

The overall sanitation status of the municipality indicates urgent need of FSM interventions. Installation of anaerobic biogas digester at household level is remarkable and has tendency to promote whereas other existing containments are not appropriate owing to groundwater pollution except for fully lined tanks. Higher portion of containment never emptied indicates leakages into environment with potential to human health hazard. The FS being emptied and disposed without any treatment is serious issue. In the absence of regulating agency and lack of treatment plants the problem could led to outbreak of epidemic. Hence, the municipality should urgently act on to improve FSM for better environment and human health.

The specific recommendation on each of sanitation value chain for improved FSM are:



1. Containment

- Promote anaerobic biogas digester in the farming community having enough space for installation.
- Proper installation of twin pits and upgrading single pits to twin pits could effectively manage FS onsite.
- Lined tank with impermeable walls and open bottoms should be gradually improved to fully sealed tank with respect to potential ground water contamination.
- Finally, manage data base with information such as types of containment, size and last emptied date.

2. Emptying and Transport

- Regular monitoring to discourage unauthentic discharge of FS into open drains and environment by the municipality.
- Rules and regulation in place for emptying business.
- Occupational health safety of the emptying operators should be highly prioritized and discourage manual emptying practices.

3. Treatment

- Ideally, it is important to treat all FS generated in the municipality, however, behavior changes is a long process so it cannot be expected that all containment will be emptied regularly. So at least at present the municipality should focus on establishing treatment plant with a capacity to treat current FS emptied and transported.
- Installed and select natural process with low skilled operational technologies.
- Prepare detail improvement planning with tangible target and interventions.

4. Reuse/ Safe Disposal

- Since there is demand and social acceptance for fertilizer/soil conditioner out of FS, promote reuse options of FS in the treatment plants.

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Annexure

Annex 1: Calculation of Manually and Mechanically emptied Containment

				Emptied			Emptied Manually			Emptied Mechanically		
Containment	Count	Percent	HHs (Population)	Count (sample)	Percent	HHs (population)	Count	Percent	HHs	Count (sample)	Percent	HHs
Septic tank	17	4.5%	1056	4	23.5%	249	2	50.0%	125	2	50.0%	125
Fully lined tank (sealed)	140	36.9%	8689	20	14.3%	1242	8	40.0%	497	12	60.0%	746
Lined tank with impermeable walls and open bottom	157	41.4%	9744	27	17.2%	1676	10	37.0%	621	17	63.0%	1056
Twin Pits	15	4.0%	931	2	13.3%	125	1	50.0%	63	1	50.0%	63
Single Pit	23	6.1%	1428	5	21.7%	311	2	40.0%	125	3	60.0%	187

Annex 2: Calculation of FS emptied from Septic Tank

Septic Tank															
	Manual							Mechanical							
Emptying Frequency	Count (sample)	Percent	HHs (population)	Volume	FS emptied Manually	Total FS emptied Manually per year	Average Volume	Count (sample)	Percent	HHs (population)	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied Mechanically
Three Times a year	0	0%	0	0	0	213	9	0	0.0%	0	0	3	0	213
Twice a year	0	0%	0	0	0			0	0.0%	0	0	2	0	
Every Year	0	0%	0	0	0			0	0.0%	0	0	1	0	
Every 2 Years	0	0%	0	0	0			0	0.0%	0	0	0.5	0	
Once every 3_5 years	1	50%	63	617.4	154.35			1	50.0%	63	617.4	0.25	154.35	
Once every 6_10 Years	1	50%	63	686.7	85.8375			1	50.0%	63	686.7	0.125	85.8375	
more than 10 years	0	0%	0	0	0			0	0.0%	0	0	0.1	0	

Annex 3: Calculation of FS emptied from Fully Lined Tank

Fully Lined tank														
	Manual Emptying							Mechanical Emptying						
Emptying Frequency	Count (sample)	Percent	HHs (population)	Volume	FS emptied Manually	Total FS emptied Manually per year	Average Volume	Count (sample)	Percent	HHs (population)	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied Mechanically
Three Times a year	0	0%	0	0	0	1469	9	2	16.7%	125	512.5	3	1537.5	2300
Twice a year	0	0%	0	0	0			1	8.3%	63	214.2	2	428.4	
Every Year	1	13%	63	428.4	428.4			0	0.0%	0	0	1	0	
Every 2 Years	1	13%	63	630	315			2	16.7%	125	1250	0.5	625	
Once every 3_5 years	3	38%	187	1776.5	444.125			2	16.7%	125	1187.5	0.25	296.875	
Once every 6_10 Years	2	25%	125	812.5	101.5625			3	25.0%	187	1215.5	0.125	151.9375	
more than 10 years	1	13%	63	516.6	51.66			2	16.7%	125	1025	0.1	102.5	

Annex 4: Calculation of FS emptied form lined tank with impermeable walls and open Bottom

Lined Tank with Impermeable Walls and Open Bottom														
	Manual Emptying							Mechanical Emptying						
Emptying Frequency	Count (sample)	Percent	HHs (population)	Volume	FS emptied Manually	Total FS emptied Manually per year	Average Volume	Count (sample)	Percent	HHs (population)	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied Mechanically
Three Times a year	0	0%	0	0	0	1939	9	1	5.9%	63	516.6	3	1549.8	2180
Twice a year	0	0%	0	0	0			0	0.0%	0	0	2	0	
Every Year	2	20%	125	900	900			1	5.9%	63	453.6	1	453.6	
Every 2 Years	0	0%	0	0	0			2	11.8%	125	1387.5	0.5	693.75	
Once every 3_5 years	4	40%	249	1743	435.75			3	17.6%	187	1309	0.25	327.25	
Once every 6_10 Years	2	20%	125	975	121.875			5	29.4%	311	2425.8	0.125	303.225	
more than 10 years	2	20%	125	1387.5	138.75			5	29.4%	311	3452.1	0.1	345.21	

Annex 5: Calcualtion of FS emptied from Twin pits

Lined Pits with semipermeable Walls and Open Bottom (Twin Pits)														
	Manual Emptying							Mechanical Emptying						
Emptying Frequency	Count (sample)	Percent	HHs (population)	Volume	FS emptied Manually	Total FS emptied Manually per year	Average Volume	Count (sample)	Percent	HHs (population)	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied Mechanically per year
Three Times a year	0	0%	0	0	0			0	0.0%	0	0	3	0	
Twice a year	0	0%	0	0	0			0	0.0%	0	0	2	0	
Every Year	0	0%	0	0	0			0	0.0%	0	0	1	0	
Every 2 Years	0	0%	0	0	0	22.05	2.8	0	0.0%	0	0	0.5	0	22.05
Once every 3_5 years	0	0%	0	0	0			0	0.0%	0	0	0.25	0	
Once every 6_10 Years	1	100%	63	176.4	22.05			1	100.0%	63	176.4	0.125	22.05	
more than 10 years	0	0%	0	0	0			0	0.0%	0	0	0.1	0	

Annex 6: Calculation of FS emptied form single pits

Lined Pits with semipermeable walls and open Bottom (Single Pits)														
	Manual Emptying							Mechanical Emptying						
Emptying Frequency	Count (sample)	Percent	HHs (population)	Volume	FS emptied Manually	Total FS emptied Manually per year	Average Volume	Count (sample)	Percent	HHs (population)	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied Mechanically
Three Times a year	0	0%	0	0	0	22.05	1.4	0	0.0%	0	0	3	0	143
Twice a year	0	0%	0	0	0			0	0.0%	0	0	2	0	
Every Year	0	0%	0	0	0			1	33.3%	63	88.2	1	88.2	
Every 2 Years	0	0%	0	0	0			1	33.3%	63	88.2	0.5	44.1	
Once every 3_5 years	1	50%	63	88.2	22.05			0	0.0%	0	0	0.25	0	
Once every 6_10 Years	0	0%	0	0	0			1	33.3%	63	88.2	0.125	11.025	
more than 10 years	0	0%	0	0	0			0	0.0%	0	0	0.1	0	

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