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

Sanitation Situation Report of Dhulikhel Municipality

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Dhulikhel Municipality

Municipal Association of Nepal 2050

ENPHO
Creating Eco Societies

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Executive Summary

On 30 September 2019, Nepal has been declared as Open Defecation Free (ODF) country. However open disposal is becoming new common practices of faecal sludge management in the country. This is, in fact, not only threatening the public and environmental health but also challenging the Open Defecation Status. Therefore, the goal of Open Defecation Free and Total Sanitation Campaign cannot be achieved without proper management of faecal sludge. The entire sanitation services chain, which comprises mainly five stages i.e. user interface, containment, desludging and transportation, treatment and safe disposal, should be taken into consideration for proper management of faecal sludge to ensure better health and hygiene of the people.

Dhulikhel is a municipality in Kavrepalanchowk District of Nepal. There are two major highway B.P highway and Arniko highway passes through Dhulikhel. Arniko highway connects Kathmandu, Nepal's capital city, with Tibet's border town of Kodari. Dhulikhel is located at the Eastern rim of Kathmandu valley, south of Himalayas at 1550 m above sea level and is situated 30 km southeast of Kathmandu and 74 km southwest of Kodari. The majority of people in Dhulikhel are Newar and Brahmin, Chettri, Tamang and Dalits, who are also living in outer area of the town.

Dhulikhel Municipality constitutes of 9 wards and was established on 2043/11/05. At present, with the expansion of area, the municipality constitutes of 121 wards covering a total of 54.62 km square. Dhulikhel Municipality receives an annual rainfall of 1500 mm. The average temperature of 20 degree Celsius makes it a treat for tourists especially in summer season.

As per figure of Central Bureau of statistics, total population of Dhulikhel Municipality is 33,981 with 16,675 males and 17,306 females. The population density is 52 per km square with an average growth rate of 0.65. There are 7039 Households with average size of 4.5.

Dhulikhel Municipality boasts as a major touristic destination with attractions that range from natural scenario to cultural and historical elements. One can view the Himalayan range at an 180° panoramic view of mountains including Mt. Annapurna, Mt. Ganesh, Mt. Langtang, Mt. Phuribichyachu, Mt. Gaurishankar, Mt. Lhotse among others.

Presently, there are some treatment plants in place to treat the faecal sludge in Dhulikhel municipality but due to lack of proper management very few of them are functioning properly and the rest needs some proper management so that it can run properly. 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 the help of necessary arrangements.

FSTP's are principally similar to Decentralized Wastewater Treatment System (DEWATS) so far when the treatment technology is concerned. The latter terminology is used when the catchment area is relatively smaller and is localized and where treatment of wastewater takes place, whereas the former implies coverage of larger catchment, usually at a municipal level and where treatment of FS takes place. FSTP's are known to be a cheaper and a simpler option for treatment of FS compared to the conventional method and hence are gaining popularity in developing countries.

There are basically three types of treatment system i.e. biological, mechanical and hybrid system. Biological system comprises entirely nature-based processes to achieve the desired levels of faecal sludge treatment. Treatment systems as such have been able to gain popularity especially in developing countries, particularly owing to its cost-effective attribute. Mechanical treatment system consists of mechanical components like pumps, conveyers, rotating screen, aerators etc. and are operated using external forces. Generally, electricity is used to keep it running. Whereas Hybrid treatment system is combination of biological and mechanical treatment modules.

Based on the comparative analysis of its financial, institutional, environmental, technical and social aspects, nature based FSTP with dewatering machine or Hybrid Faecal Sludge Treatment Plant was selected as appropriate option for local context. The key component of plant includes Bar Screen, Sludge Thickening Tank, Sand Filter, Unplanted Sludge Drying Bed (as an alternative to Dewatering Machine), Sludge Storage Shed, Anaerobic Baffle Reactor, and Horizontal Flow Constructed Wetland.

Abbreviations

ABR	Anaerobic Baffle Reactor
BGD	Biogas Digester
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DEWATS	Decentralized Wastewater Treatment System
ENPHO	Environment and Public Health Organization
FS	Faecal Sludge
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plant
HFCW	Horizontal Flow Constructed Wetland
HH	Household
HLR	Hydraulic Loading Rate
HRT	Hydraulic Retention Time
MuAN	Municipal Association of Nepal
NSS	Non-Sewered Sanitation
O and M	Operation and Maintenance
ODF	Open Defecation Free
OLR	Organic Loading Rate
SDG	Sustainable Development Goal
TS	Total Solid
TSS	Total Suspended Solid
UCLG ASPAC	United Cities Local Government - Asia Pacific
USDB	Unplanted Sludge Drying Bed

Acknowledgment

We take this opportunity to extend our gratitude to Mr. Ashok Kumar Byanju, Mayor and Mrs. Bimala Kumari Chaulagain Sharma, Deputy Mayor of Dhulikhel Municipality. We would also like to express our sincere thanks to ward chairpersons and staffs of the municipality for continuous support and valuable feedback during the study. We sincerely thank Mr. Shree Bikram Byanju Shrestha, a focal person of the MuNASS Project in Dhulikhel Municipality for coordinating and mobilizing volunteers for the study.

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1. Introduction

1.1 Background

The "Municipalities Network Advocacy in Sanitation in South Asia (MuNASS)" project, focusses on capacity building, implementing 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. 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. Multiple Indicator Cluster Survey Report, 2014 reveals that 91.7% HH used non-sewered sanitation facilities when the toilet coverage was only 73.7% in the country. Now Nepal has been declared as Open Defecation Free but the scenario remains almost the same. 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 feasibility study on FSM was conducted to assist local government in making effective planning and implementation for it.

On the other side, the non-sewered sanitation facilities are filling up and there are immediate need of desludging service and safe disposal of sludge. The desludging services in the country is growing rapidly. Not only the private sector but municipalities are also providing the services to fulfil the public demand and necessity. However, the sludge taken out of the onsite facilities are being dumped into open environment or water bodies due to lack of faecal sludge treatment plant. Thus, the open disposal is becoming new common practices of faecal sludge management in the country. This is, in fact, threatening not only the public and environmental health but also challenging the Open Defecation Status of the country. Therefore, the goal of Open Defecation Free and Total Sanitation Campaign cannot be achieved without proper management of faecal sludge.

The entire sanitation services chain, which comprises mainly five stages, i.e. user interface, containment, desludging and transportation, treatment and safe disposal, should be taken into consideration for proper management of faecal sludge to ensure better health and hygiene of the people. Thus, Detailed Project Report (DPR) of affordable and locally suitable faecal sludge treatment plant (FSTP) has been prepared for Dhulikhel Municipality to protect public and environmental health of the municipality.

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

The limitations of the study are:

i. The study did not cover the sanitation status of the industries as there is national provision for industries to manage waste generated in it.
ii. Assessment of existing policies and institutional set up was not conducted as there is separate activity within the project regarding preparing a municipal policy on FSM.
iii. Also, financial assessment such as cost-effective assessment on FSM interventions was not performed as it is a totally non-profit 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

Dhulikhel is a municipality in Kavrepalanchowk District of Nepal. There are two major highway B.P highway and Arniko highway passes through Dhulikhel. Arniko highway connects Kathmandu, Nepal's capital city, with Tibet's border town of Kodari. Dhulikhel is located at the Eastern rim of Kathmandu valley, south of Himalayas at 1550 m above sea level and is situated 30 km southeast of Kathmandu and 74 km southwest of Kodari. The majority of people in Dhulikhel are Newar and Brahmin, Chettri, Tamang and Dalits, who are also living in outer area of the town. The municipality was established in the 1980s and was last restructured in 2017. The additional wards added to the municipality are more rural in character. These wards cover a total of 54.62 km square.

Dhulikhel Municipality receives an annual rainfall of 1500 mm. The average temperature of 20 degree Celsius makes it a treat for tourists especially in summer season. As per figure of Central Bureau of statistics Total population of Dhulikhel Municipality is 33,981 with 16,675 males and 17,306 females. The population density is 52 per km square with an average growth rate of 0.65. There are 7039 Households with average size of 4.5.

Dhulikhel Municipality boasts as a major touristic destination with attractions that range from natural scenario to cultural and historical elements. One can view the Himalayan range at an 180° panoramic view of mountains including Mt. Annapurna, Mt. Ganesh, Mt. Langtang, Mt. Phuribichyachu, Mt. Gaurishankar, Mt. Lhotse among others. Figure no. 1 below shows municipal map of Dhulikhel with its ward boundaries.

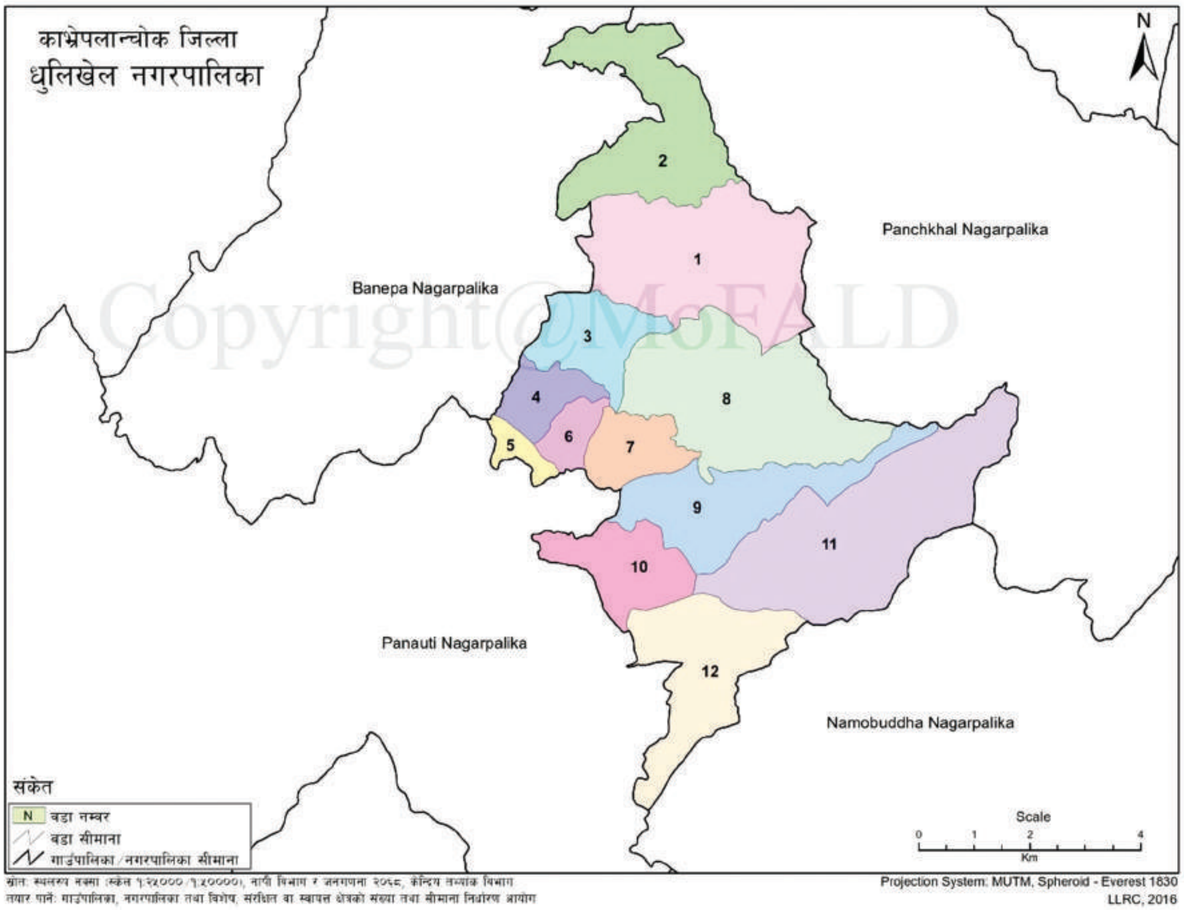


Figure 1: Municipal map and ward boundaries of Dhulikhel Municipality

2. Methodology

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

2.1 Household Survey

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

2.1.1 Determining Sample Size

The number of households to be sampled in the municipality were 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 ward in the municipality is considered as one stratum. The sample size 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 364 households were sampled at the interval of 18 from 6505 households distributed in 12 wards with proportionate stratification random sampling as shown in table 1.

Table 1: Proportionate Stratified Sample Distribution in each ward

Ward	Households	Sample
1	534	29
2	617	35
3	466	27
4	498	28
5	354	20
6	362	21
7	497	28
8	667	38
9	732	41
10	349	20
11	833	47
12	596	30
	Total	364

2.1.2 Sampling Procedure

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

1. Calculate the ward sampling interval, i.e. the 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, the first household on the 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 were surveyed. The criteria used for selection are:

1. Educational and financial institutions operated in either its own building or rented building were selected but operating in a single room or flat were not selected.
2. All hotels with the provision of residential facilities were selected.
3. Health care center with the provisions of the bed was selected, i.e. small clinics were not selected.

4. Government/ Non-government Offices were selected.
5. Commercial Buildings were selected.

In total 112 institutions were surveyed and descriptions of surveyed institutions are shown in table 2.

However, renowned Dhulikhel Hospital and Kathmandu University were not surveyed as both these institutions have their own wastewater treatment plants within its premises. It was assumed these institutions solely manage wastewater and faecal sludge produced within their premises.

Table 2: Descriptions of Surveyed Institutions

Ward	Financial Institutions	Hotel/ Home Stay	Commercial Buildings	Educational Institutions	Government /Non-government Office	Community Buildings	Health Care Center	Total
1				2				
2	2			1		1	1	
3	1	11		9	3		1	
4	7			3	4			
5					1			
6	1	3		3	2			
7	1	1		5	4			
8		7		3	1		1	
9		4	2	2	1		1	
10				2	1	1	1	
11	1	1		7	1		1	
12				4	2	1		
Total	13	27	2	41	20	3	6	112

2.3 Key Informant Interview

Mr. Shree Bikram Byanju, officer from sanitation section of the municipality was interviewed to understand existing sanitation policies of the municipality, the planning process for developing a sanitation program and on-going programs. Mr. Ram Deula, a desludging vehicle of the municipality was also interviewed. The interview was focused on the existing service delivery mechanism.

2.4 Data Collection Process

The data was collected by using the KOBOCOLLECT application, which was uploaded into mobile phones through the 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 a questionnaire survey and using KOBOCOLLECT. During the training, enumerators familiarized themselves with questionnaire contents, the flow of questions, mobile data collection devices, and test runs of the devices.

2.5 Data Processing and Analysis

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

The data processing and analysis entailed the following steps:

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

The 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 were cleaned and verified before the analysis and interpretation of data.

3. Sanitation Status

The Dhulikhel municipality was declared as Open Defecation Free Zone in 2018. However, approximately 2.2% of the households at rural and isolated settlement do not have their own toilet. Majority of households located at the areas recently merged in the municipality have onsite sanitation system. While, the traditional urban clusters in ward numbers 5, 6 and 7 such as Khadpu, Ekache, Nastole, Lasangko tole, Chochhe, Etole, Dutole, Hospital area, Hurkha, Sarashwati Bajar, Watole, Guthucha, Adda Bajar, Sanjiwani Bazar, Bus park area, Dutole, Watole and so on facilitated with municipal sewer networks. Particularly, Decentralized Combined Sewer (DCS) were installed in ward number 5 which is connected to Shreekhandapur Wastewater Treatment Plant. The treatment plant is being managed and operated by community level organization. Similarly, Centralized Combine Sewer (CCS) networks from ward number 6 and 7 are connected to Wastewater Treatment Plants located at Thakuri Gaun and Pipal Bot area of the municipality. Both these treatment plants managed by the municipality are defunct and requires major rehabilitation. Direct discharge of wastewater from toilets into water bodies or open drains were observed in few rural areas. Thus, overall, 14.6% of households have offsite sanitation system in the municipality as shown in figure 2.

Similarly, as shown in figure 3, 12.5% of institutions in the municipality has connected their toilet into sewer network. Among these, 64.3% and 28.6% are connected to Centralized Combined sewer and Decentralized Combined Sewer respectively. However, 7.1% of these institutions do not have idea on what type of sewer network their toilet is connected.

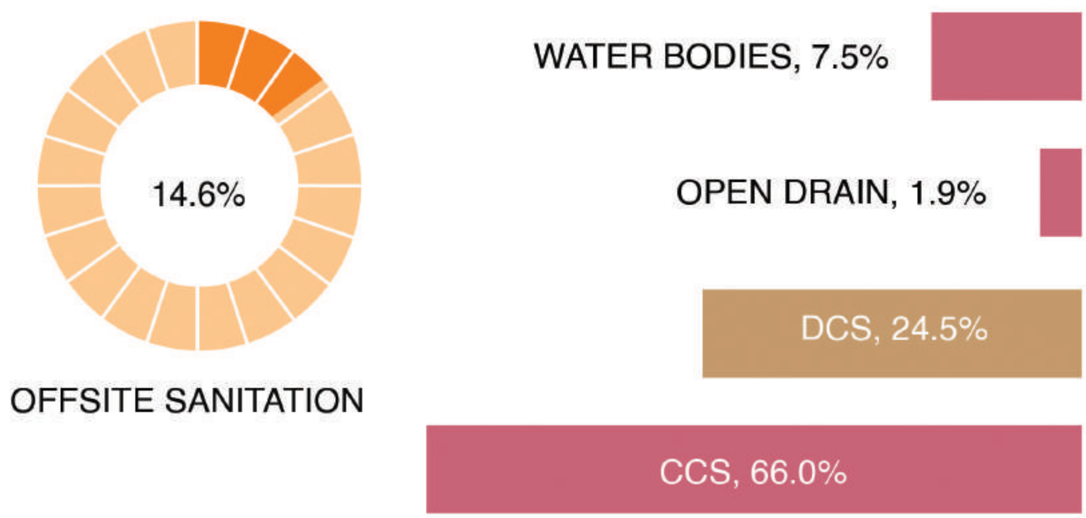


Figure 2 Percent of households with offsite sanitation and types of sewer network connected to

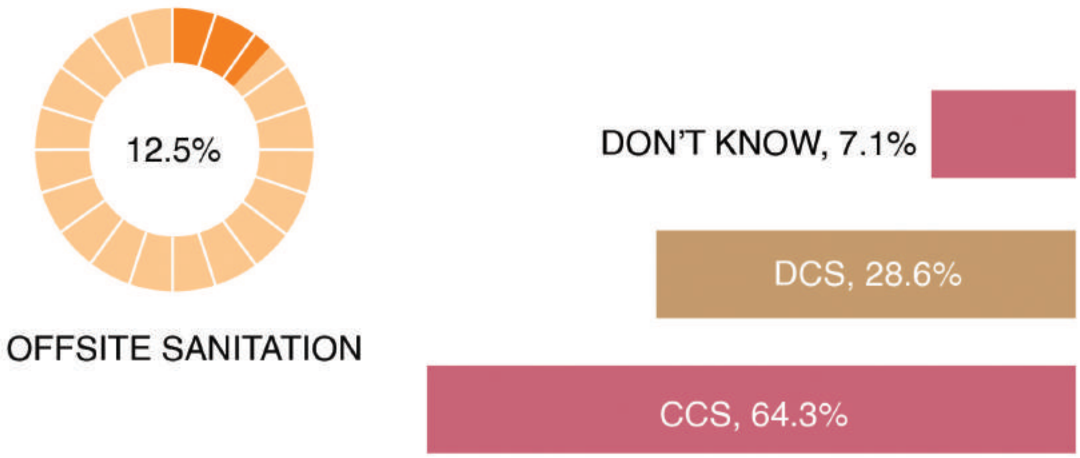


Figure 3 Percent of Institutions connected to various sewer network

3.1 Types of Containments

3.1.1 Types of Containments at Household Level

Figure 4 shows types of household containments in the municipality. Toilets in 37.9% of households have connected to an anaerobic biogas digester which receives the excreta and flushing water directly from a toilet through a pipe. The anaerobic biogas digester is designed for the integrated treatment of toilet products, animal manure and kitchen and garden waste. The system is observed in almost all rural wards of the municipality.

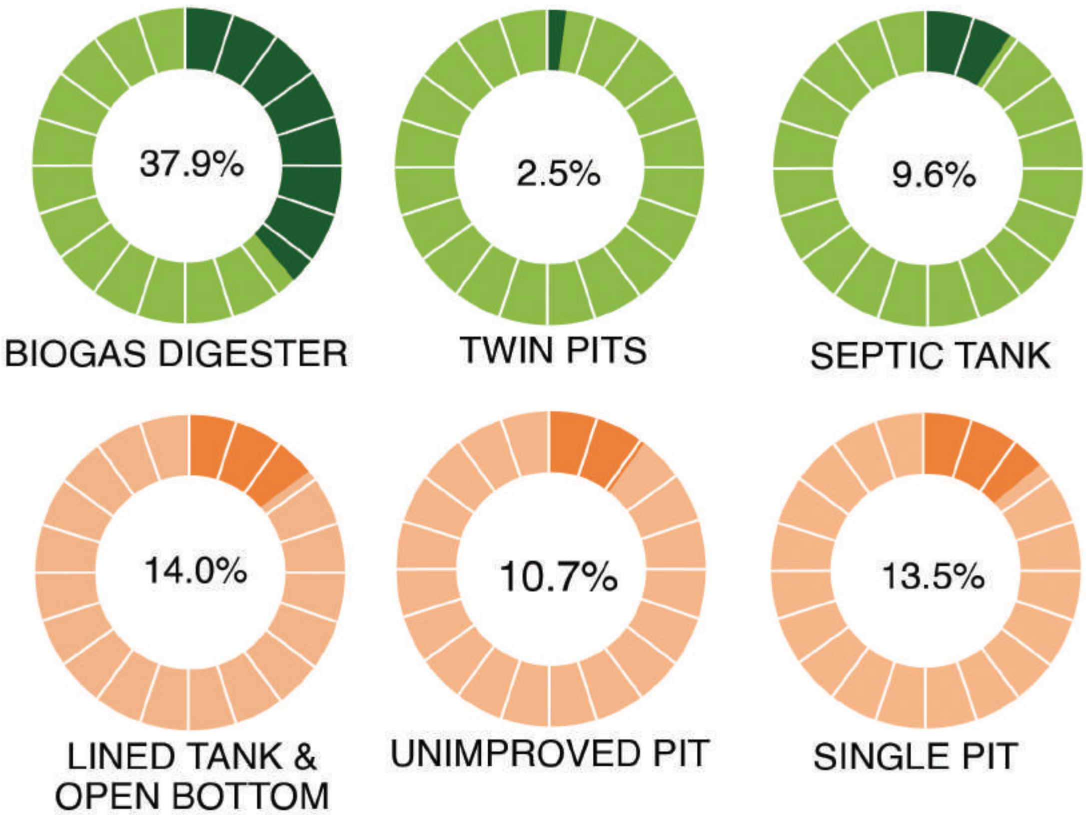


Figure 4 Percent of household's various types of containment

A technically appropriate septic tank, basically a containment and primary treatment unit at household was observed in 2.5% of households located in ward number 6, 8 and 11. Containment constructed with bricks and cement wall, plain cemented concrete flooring and totally lining without outlet or overflow system is termed as a fully lined tank. This containment is constructed to safely hold the faecal sludge for a certain duration of time and requires regular emptying. Such a system is observed in 9.6% of the households mostly located within peripheral area of traditional urban area and newly settled urban areas. While, a lined tank with impermeable walls but open bottom was observed in 14% of households located in ward number 3, 4, 5, 6, 8, 9, 10 and 12.

Whereas single pits constructed out of concrete rings and unimproved pits were common in rural areas of the municipality. 13.5% and 10.7% of households have installed such containments.

3.1.2 Types of Containments at the Institutional Level

Majority of institutions, 25.9% have connected toilet into lined tank with impermeable walls and open bottom. While 26.8% have connected to either septic tank or fully lined tank. Also, 17.0% institutions in rural area have single pits. Whereas, approximately 11.6% of institutions operated in rented buildings do not know type of containments in the building as shown in figure 5.

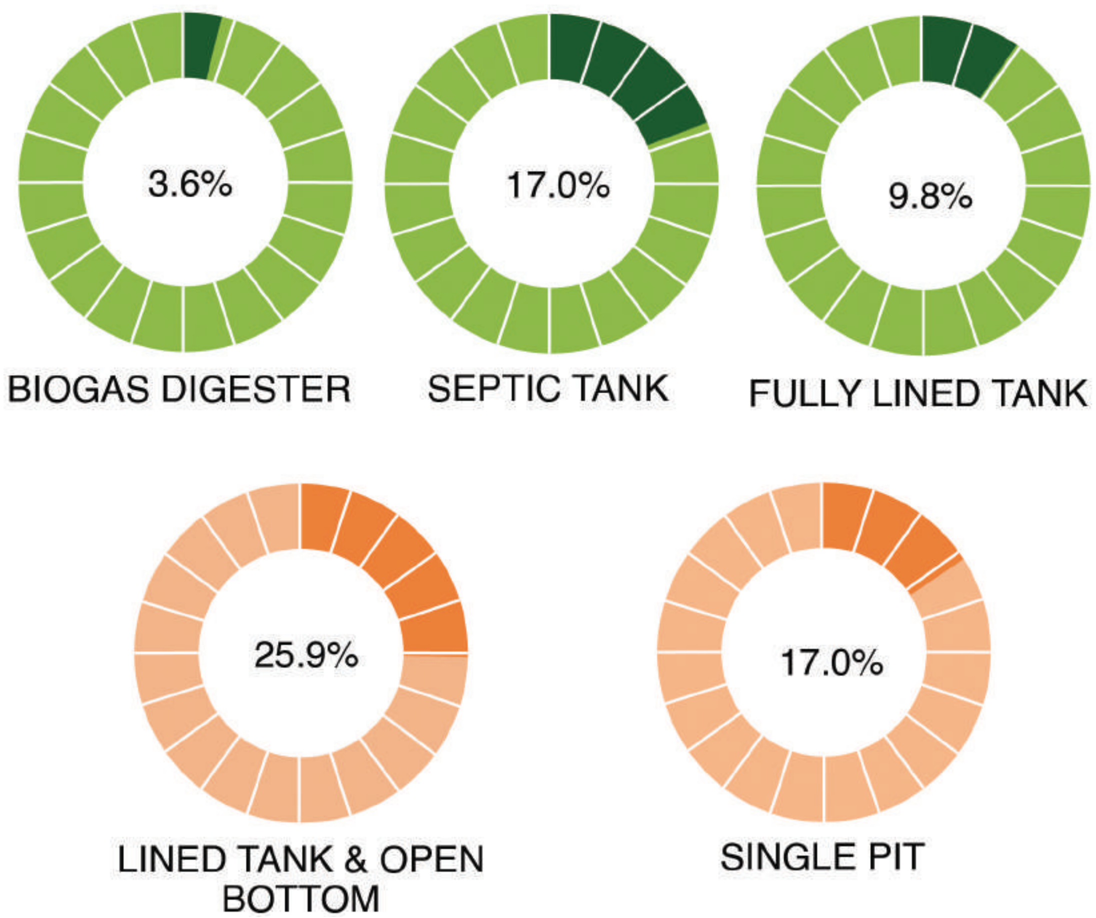


Figure 5 Percent of various types of containments in institutions

3.1.3 Sources of Drinking Water

Dhulikhel Drinking Water and Sanitation Users Committee has been providing drinking water since early 90s in the core traditional urban areas of the municipality. The major source of water is Kharkhola River located 14 km far from the city. Beside this, local springs are tapped and recently a deep boring has been installed to extract the ground water. All waters are treated in a well-established water treatment plant and supplied water maintaining WHO guideline (Devkota K., 2018). Currently, 2762 private taps are connected in its service area serving 29600 populations. Similarly, Deurali (Sisnekhola) Drinking Water Supply and Sanitation Committee in ward 2 supplies piped drinking water to 195 households serving 1008 populations. While, as per the census 2011, 81.93% of total households consumed tap/piped drinking water. The survey revealed that 51% of households have connected private taps and 30% consume water from public taps. Also, remaining depends upon natural springs or dug wells and tube wells.

3.1.4 Size of Containments

Size of containments is variable across various types of containments except with anaerobic biogas digester. Anaerobic biogas digester has been subsidized by the Government of Nepal and constructed with the volume of 6 m^3 to 8 m^3 according to its guideline. Figure 6 shows the histogram of the size of the containments. The minimum and maximum size is 0.34 m^3 and 18.69 m^3 respectively. The average size is 4.5 m^3 with 0.26 standard error of mean and standard deviation of 3.9. The skewness value is 1.58 indicating skewed at right. Also, kurtosis value is 2.7 that implies there are less significant outliers with respect to average size.

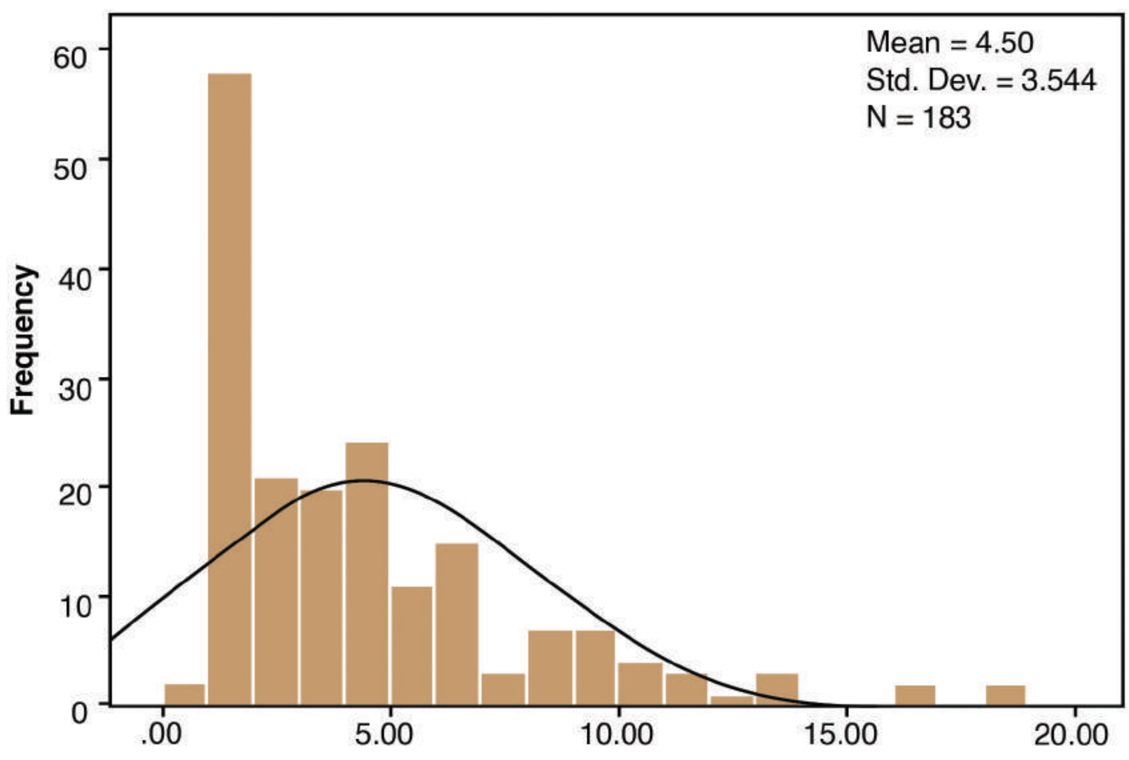


Figure 6 Histogram of size of containments

3.1.5 The relation between Size of Containment and User

Figure 7 shows the graph on relation between the size of the containment and the number of the user. Pearson's Coefficient of the Correlation value (r) is 0.150 with a probability value (p) 0.043 and coefficient of determination (r2) 0.023. This implies that there is significant relationship at level 0.05 between the size of the containments and user.

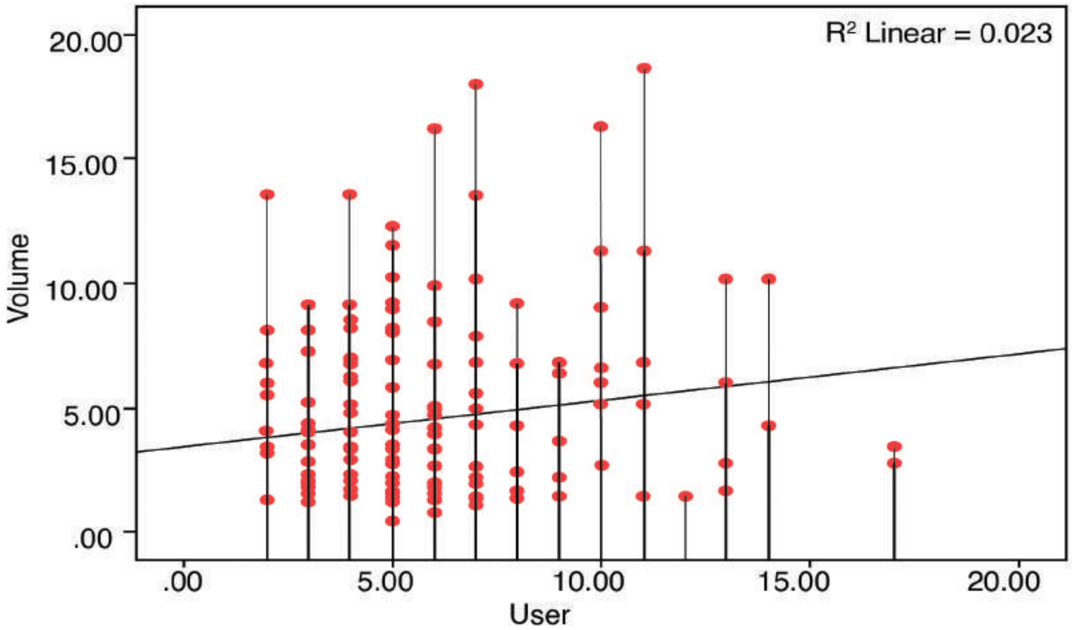


Figure 7 Graph on relationship between size and number of user

3.1.6 Size of Rectangular Containment

Figure 8 shows the histogram of the size of the rectangular containments. The average size of the containment is 6 m^3 with a standard error of the mean at 0.32 and a standard deviation of 3.32. The minimum and maximum sizes are 0.34 m^3 and 18.7 m^3 respectively. The skewness value is 1.4 which implies right hand skewed and kurtosis is 2.45.

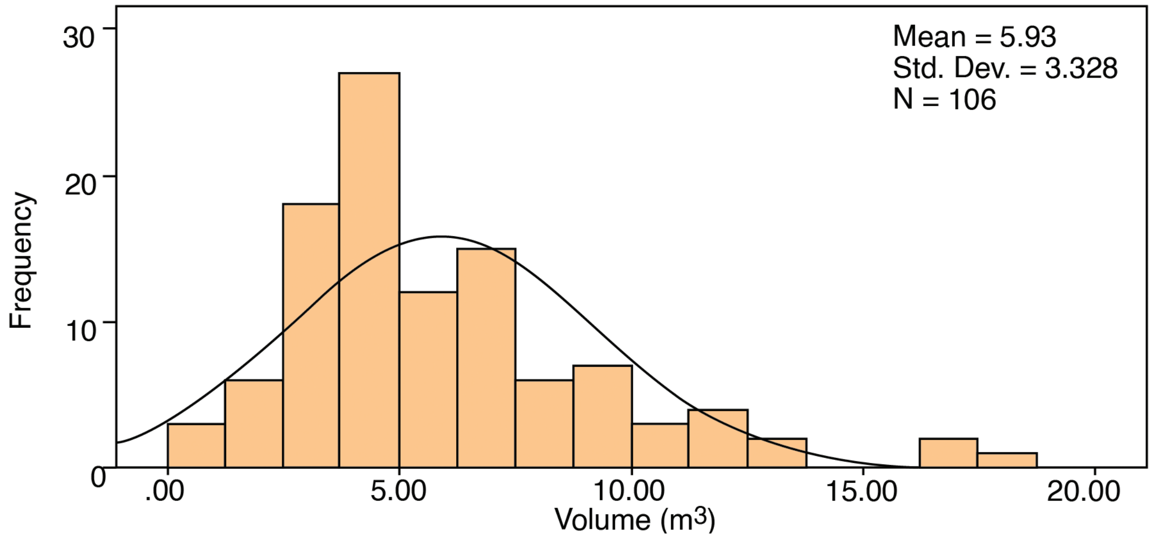


Figure 8 Histogram of size of rectangular containment

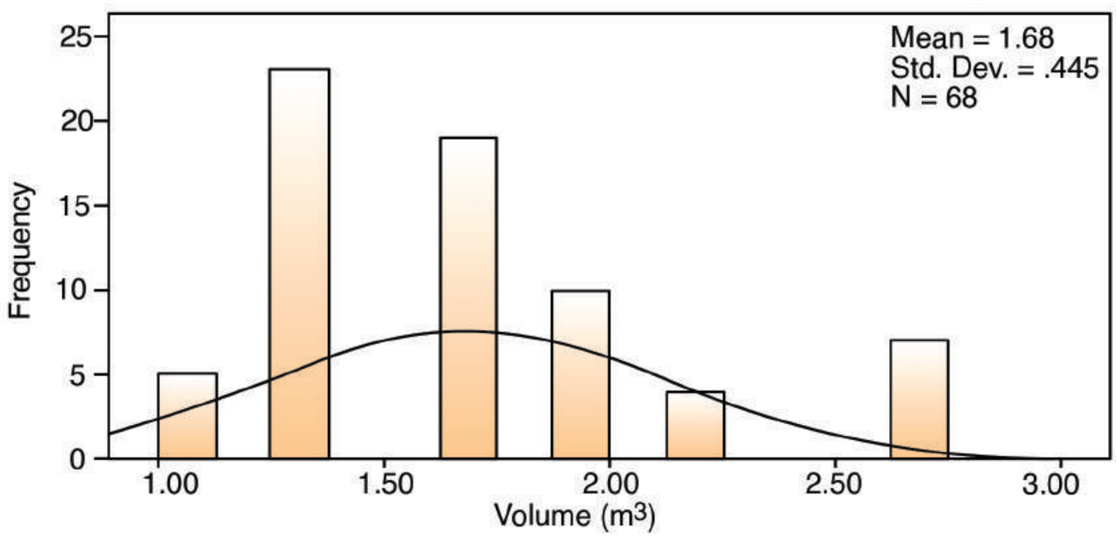


Figure 9 Histogram of size of single pits

3.1.7 Size of Circular Containment

Figure 9 shows a histogram of the size of circular containments with a skewness value of 1.14 and kurtosis of 0.7. The average size is 1.68 m^3 with 0.05 standard error of mean and standard deviation of 0.44. The minimum and maximum sizes are 1.09m^3 and 2.72 m^3 respectively.

3.2 Emptying and Transportation

Emptying is one of the major components of the sanitation value chain. It ensures the proper functioning of containment basically for the 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. However, anaerobic biogas digester has been designed in such a way that treated

Figure 10 Manual emptying of containment

slurry is automatically overflowed from the outlet chamber which is used as manure. Thus, anaerobic biogas digester has been excluded in the analysis. The data revealed 33.86% of households have emptied their containment at least once since the installation among total of 189. These containments were emptied after it got filled. Both traditional manual scavenging and mechanical emptying of the containments are practiced in the municipality. In an average 84% of household emptied manually in a way which is shown in figure 10.

3.2.1 Emptying Frequency

Emptying frequency is variable with respect to types of the containment. Majority of containments get emptied either once every two years or within four years. While some single pits and unimproved pits requires emptying frequently. The overall emptying frequency of containments is shown in figure 11.

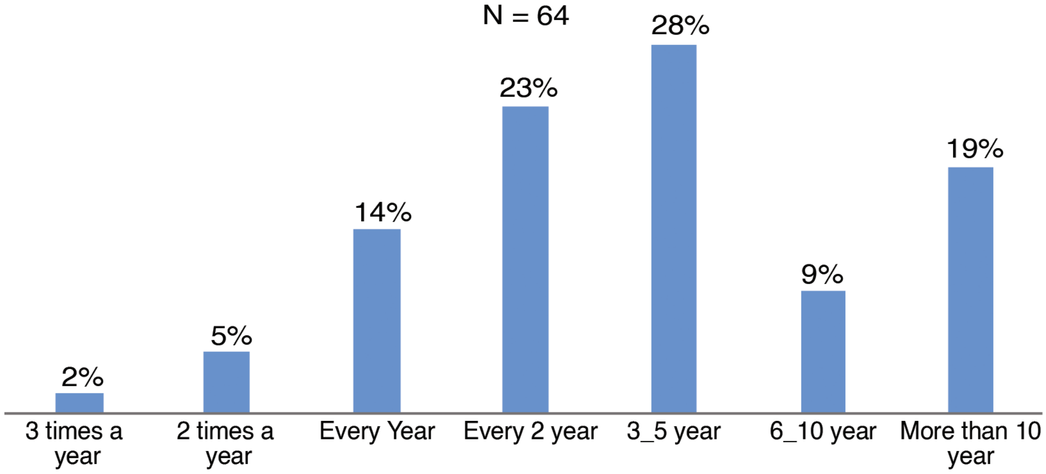


Figure 11 Emptying frequency of household containments

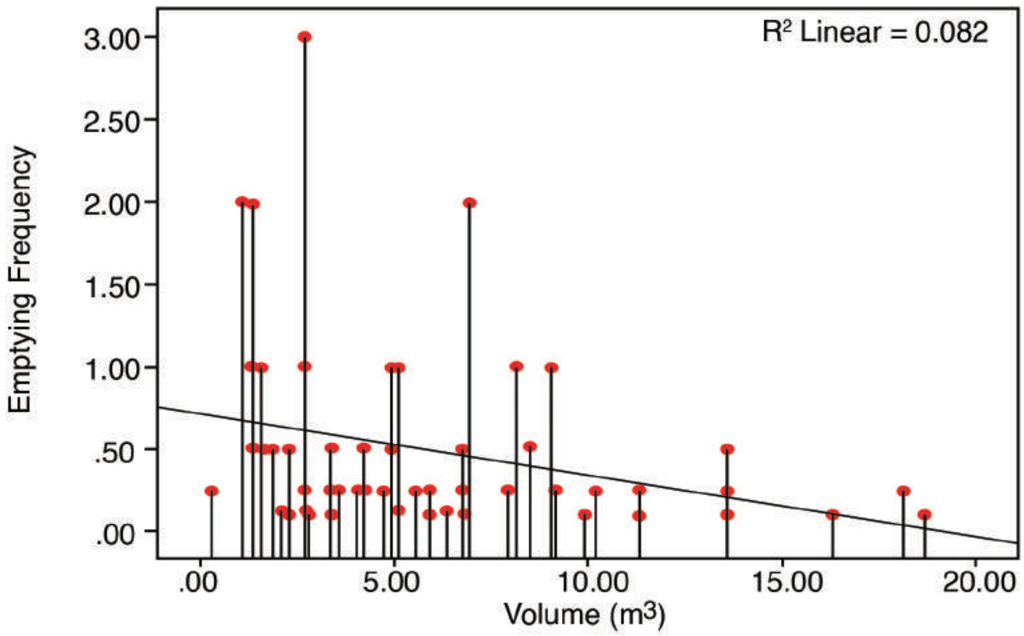


Figure 12 Graph on relationship between size and emptying frequency of containments

3.2.2 The relation between Size of containment and Emptying Frequency

Generally, the size of the containment is one of the major factors determining the emptying frequency. Table 3 shows correlation between the size and emptying frequency. It shows that there exists negative medium level relationship such that when size is increased emptying frequency is reduced. Similarly, figure 12 shows a graph on relationship with the

Coefficient of determination (r2) is 0.082.

Table 3 Pearson's coefficient of correlation between size and emptying frequency

		Emptying Frequency
Size of Containment	Pearson Correlation (r)	-0.287*
	Sig. (2-tailed) (p)	0.022
	N	64
*. Correlation is significant at the 0.05 level (2-tailed).		

3.2.3 Characteristics of Never Emptied Containment

66% of the containments that requires regular emptying for effectiveness have never been emptied since their installation as none of these were filled or overflowed. The average volume of these never emptied containments with its average users and age of containment is as shown in table 4. It shows that except for rectangular containments, these containments must have been filled. However, they have never emptied indicates high percolation of leachates into ground.

T*able 4: Descriptions on Average Size and Number of User of Never Emptied Household Containments*

S.N.	Types of Containments	Average Size (m^3)	Average no. of Users	Average Age of Containment
1	Septic Tank	7.5	6.2	4
2	Fully Lined Tank	5.3	5.3	7.7
3	Lined Tank and Open Bottom	6.4	5.6	9
4	Pits	1.7	5.6	4.3
5	Unimproved Pits	3	5.4	5.5

The age of these containments is shown in table 5. It shows that almost 57.14% of the containments were installed only either 2 years ago or within 5 years ago. Thus, it is possible that these never emptied containments have never been filled whereas there may be unauthorized open emptying or higher seepage from the remaining containments.

Table 5: Descriptions of Types of Never Emptied Household Containment and its Age

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	1.68%	0%	1.68%	0%	3.36%
2	Fully Lined Tank	5.88%	5.04%	2.52%	5.88%	19.33%
3	Lined Tank and Open Bottom	5.88%	2.52%	3.36%	9.24%	21.01%
4	Single Pit	15.97%	4.20%	7.56%	2.52%	30.25%
5	Unimproved Pit	6.72%	9.24%	7.56%	2.52%	26.05%

3.2.4 Emptying and Transportation Services

Dhulikhel Municipality has been providing desludging service since 2006 in its municipal area and neighboring municipalities like Banepa and Panchkhal. The municipality owns a fully mechanized desludging vehicle with a capacity of 4000 liters tank which is shown in figure 13. The service charge for each trip within its municipal area, Banepa and Panchkhal are NPR 6500, 9500 and 15000 respectively with additional NPR 500 to driver and helper. The demand for desludging services are very low and generally it receives demands from Kathmandu University Area, Khadbu and Banepa. In an average two to three trips of FS is desludged in a week. The consumer has to pay service charge in an advance in the municipality to receive service.

A driver and a helper are mobilized for desludging. These staffs are engaged in sanitation section of the municipality. Most of time they are engaged in solid waste management of the municipality. These staffs were provided with personal preventive equipment like gloves and mask while none of them are trained on desludging service and health and hygiene.

Figure 14 Mechanized desludging vehicle of Dhulikhel Municipality

3.3 Treatment and Disposal/Reuse

The municipality does not have any forms of the treatment plant for faecal sludge. The FS emptied and transported by the municipality is disposed into its temporary landfill site as shown in figure 14. However, in some instances the FS is disposed into biogas chamber in Shreekhandapur Wastewater Treatment Plant.

Figure 13 Direct disposal of FS in landfill site

3.4 People's Perceptions and Knowledge on FSM

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

3.4.1 Perception of Preferred Emptying Mechanism

Figure 15 shows perception of the preferred emptying mechanism of containments after it gets filled. Majority of household's that have never emptied their containment preferred self-emptying. Whereas 37% of household responded that they would contact to either municipality or private desludging service providers to get their containment emptied. Also, some preferred open emptying during rainy season and permanently abandon the containment.

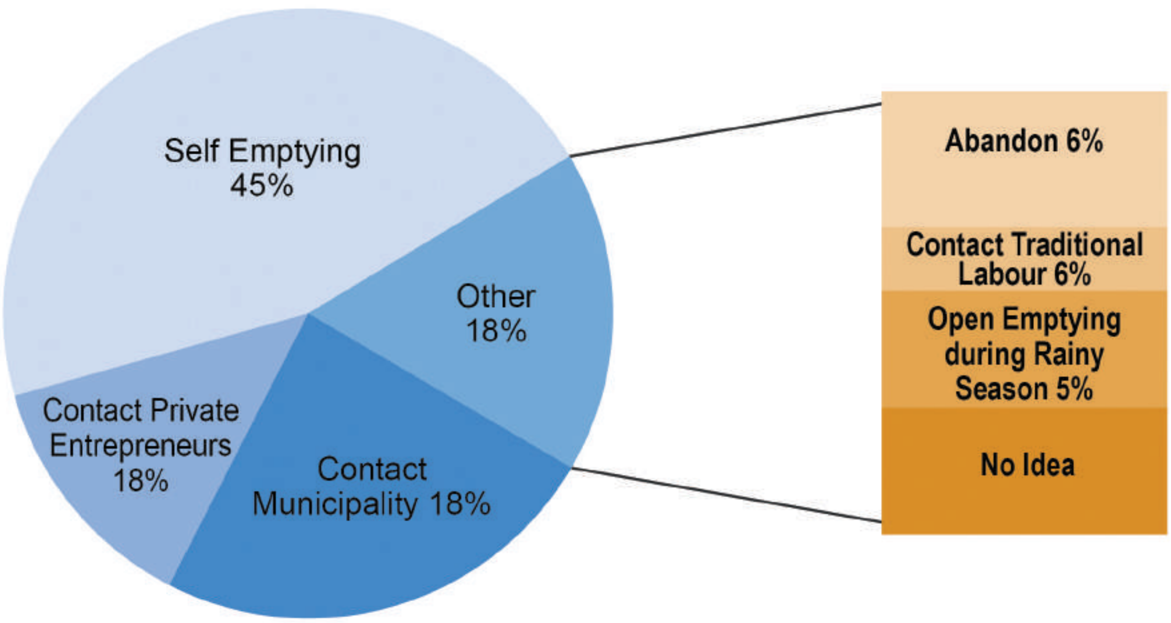


Figure 15 People's perception on preferred emptying mechanism

3.4.2 Perception of Current Practices of FSM

Figure 16 shows the perception of local people on current FSM practices in the municipality. It shows that the majority of the households applies FS into farmland. It also revealed that almost 9% of FS is being disposed into either open land, forest, water bodies or drains. People perceived FS emptied and collected by the municipality is treated in the treatment plant. While large number of households do not have any idea on how FSM is being managed currently.

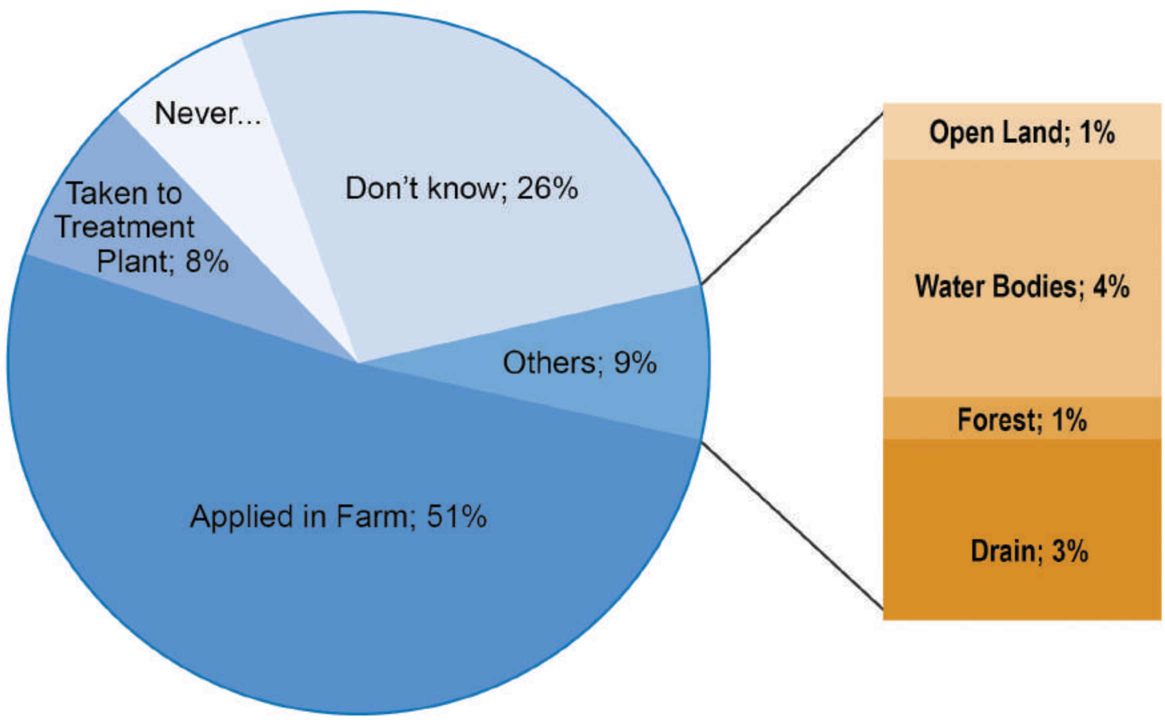


Figure 16 People's perception on current practices of FSM

3.4.3 Perceptions of Improved FSM

Figure 17 shows the perception of improved FSM, which shows that the majority of people preferred the construction of the treatment plant. Also, they insist for strict law and punishment for disobeying the rule. Remarkably 27% of people claimed encouraging reuse option would improve current practices of FSM despite the majority of households using FS in farmland.

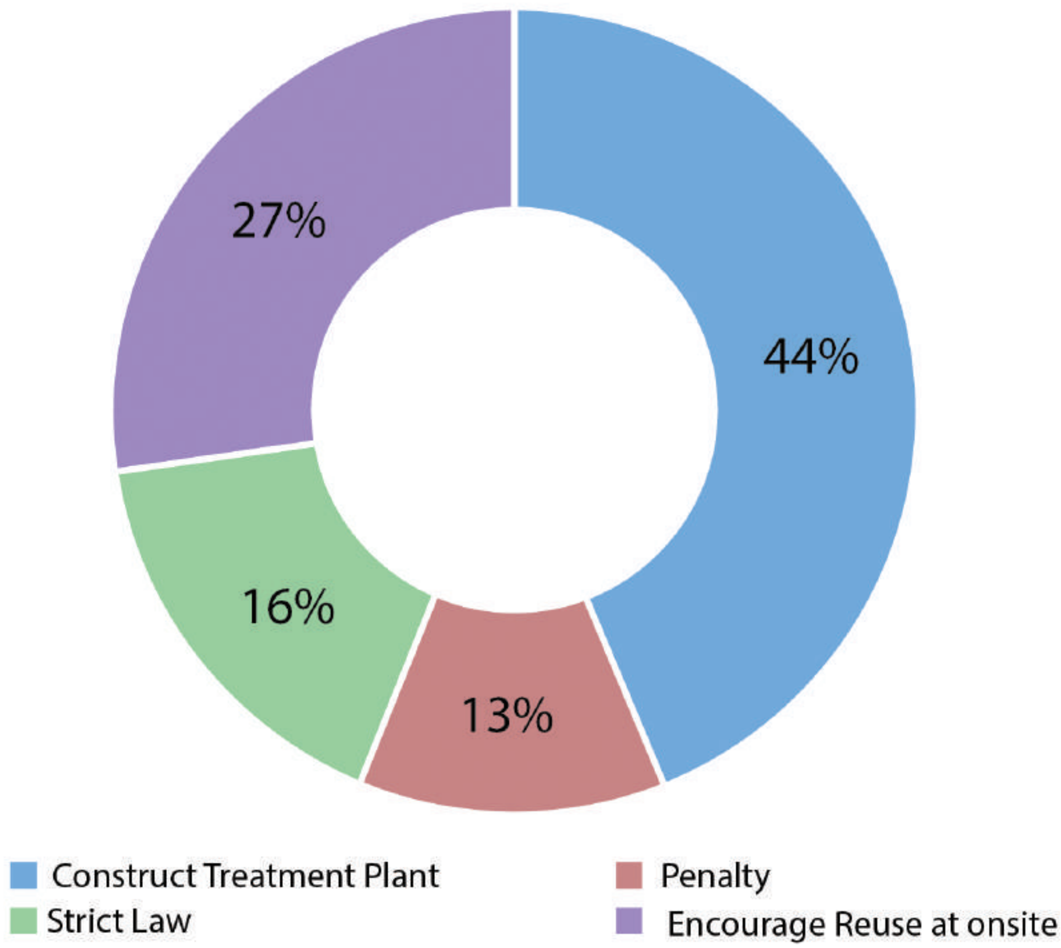


Figure 17 People's perception of improved FSM

4. Assessment of Feasibility on FSM

4.1 Shit Flow Diagram

The overall status of the flow of faecal sludge is represented by the Shit Flow Diagram (SFD) as shown in figure 18. Interestingly 21% of FS collected in an anaerobic biogas digester has been treated while 25% of FS collected in the fully lined tank is considered safely managed until it is emptied. Also, 14% wastewater is being delivered to treatment plant, however only 4% is being treated. Thus, in an overall 49% of WW and FS is being disposed without any treatment. Hence, intervention towards WW and FS management should be prioritized to improve environment and health hygiene of the people.

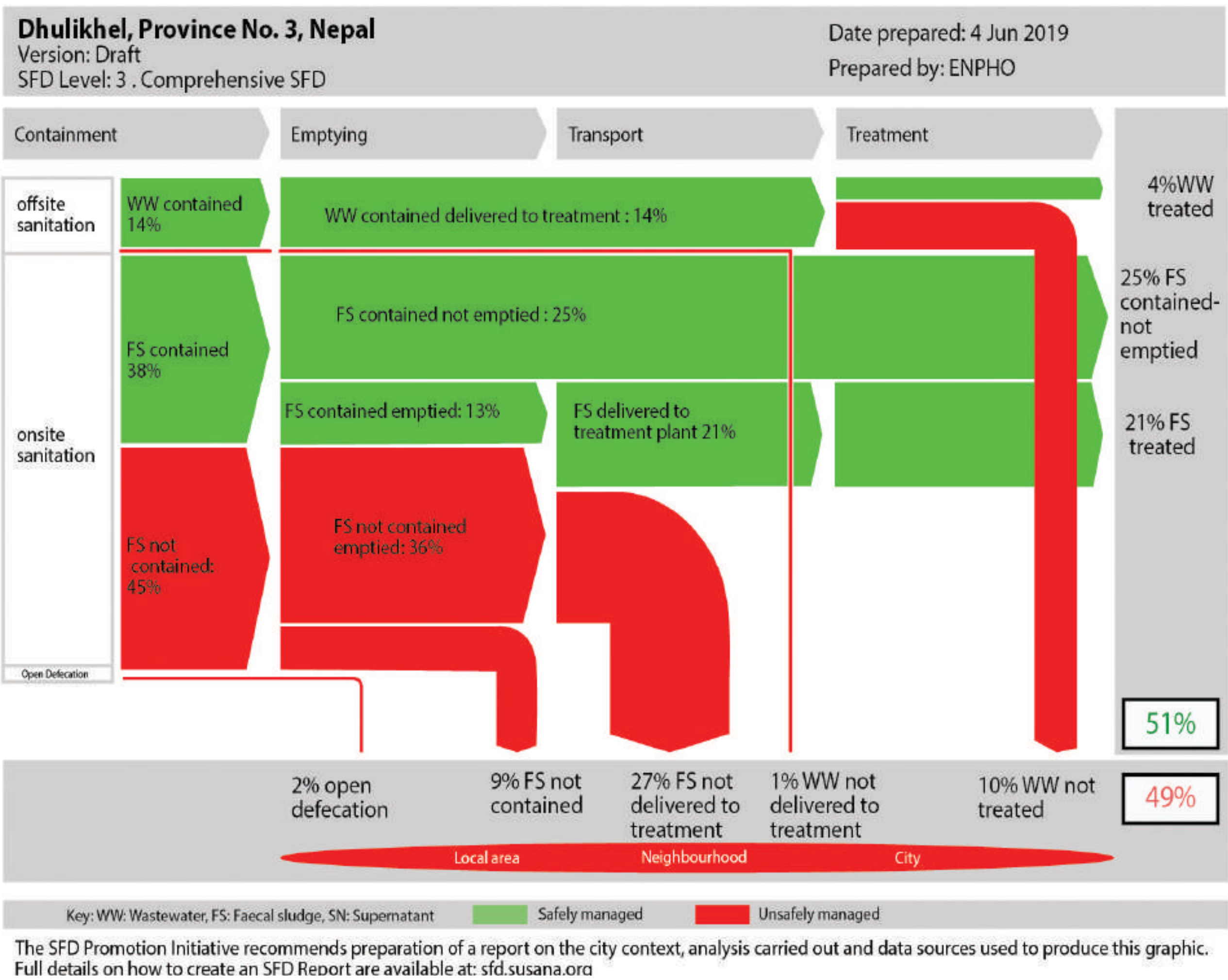


Figure 18 Shit flow diagram of Dhulikhel Municipality

4.2 Quantification of Faecal Sludge

Quantification of faecal sludge depends upon many factors like the type of the containment, water content, climate, inflow and infiltration, presence of overflow pipe, user behaviors, 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. Similarly, FS generated was estimated based upon the average size of various containment and emptying frequencies. In both cases, FS produced from anaerobic biogas digester was excluded as the technology treat the FS onsite.

4.2.1 Based on Accumulated Rate and Population

The rate of accumulation of sludge and scum in septic tanks in the United States of America by Weibel et.al, in 1949 is illustrated in figure 19. Based upon the graph, the rate of faecal sludge accumulated was derived to be 80 liters per capita per year for septic and fully lined tanks. Whereas, L. Strande et. al. in 2018 has reported FS accumulation rate per capita per year for septic tank and pit latrines are 280 liters and 270 liters. Similarly, the accumulation rate for pit latrines is 81 liters per capita per year (Yvonne Lugali, 2016).

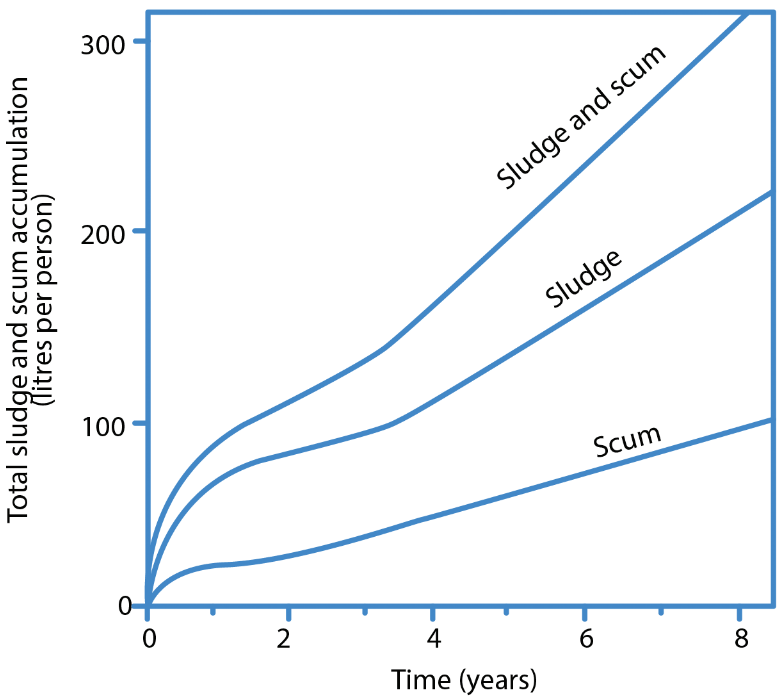


Figure 19: Sludge Accumulation Rate in Septic tank and Pits.

The calculated estimated FS accumulated per year is 6222 m^3 and 21779 m^3 with respect to references on WHO 1974 and L.

Strande 2018 respectively as shown in table 6.

Table 6: Calculation of FS Generated based on Accumulation Rate

Containment	Coverage Percent	Population	FS accumulation rate (m^3 per capita per year)		FS Accumulated (m^3 per year)	
			1	2	1	2
Septic tank	2.5%	725	0.08	0.28	58	203
Fully lined tank	9.6%	2817	0.08	0.28	225	789
Lined tank with impermeable walls and open bottom	14.0%	4104	0.08	0.28	328	1149
Single Pit	13.5%	3942	0.08	0.27	315	1104
Unimproved Pits	10.7%	3137	0.08	0.27	251	878
Total FS Accumulated per year					1178	4123

1 WHO 1974

2 L. Strande et. al.,2018

4.2.2 Based on Size of Containment and Emptying Frequency

Quantity of total septage is estimated based upon the average size of various containment and their emptying frequency obtained from primary data collected during the household survey. The calculation in table 7 shows 6734 m^3 of total septage is produced per year excluding septage from anaerobic biogas digester. The estimated volume is 5.7 times more than the estimated volume calculated based on FS accumulation rate given by WHO which is 80 liters per capita per year. The estimated total septage generated is 1.6 times greater than estimated FS based upon FS accumulation rate given by L. Strande et.al in 2018.

Table 7: Calculation of Total Septage based on Size of Containment in Household

Containment	HHs	Average Volume of containment	Emptying frequency	Total FS in containment
Septic tank	161	8.8	0.25	354.2
Fully lined tank (sealed)	626	6	0.45	1690.2
Lined tank with impermeable walls and open bottom	912	6.38	0.32	1861.9392
Single Pit	876	1.76	0.875	1349.04
Unimproved pit	697	3.03	0.7	1478.337
FS produced per year				6734
FS produced per day				18.5
Total Number of Trips (Vehicle Capacity 4 m^3)				4.5

4.2.3 The volume of Faecal Sludge Emptied from Household

In an average total of 2090 m^3 of FS is emptied in the municipality. The amount is approximately 31% of the calculated total volume of FS generated per year based on the size of containment and emptying frequency.

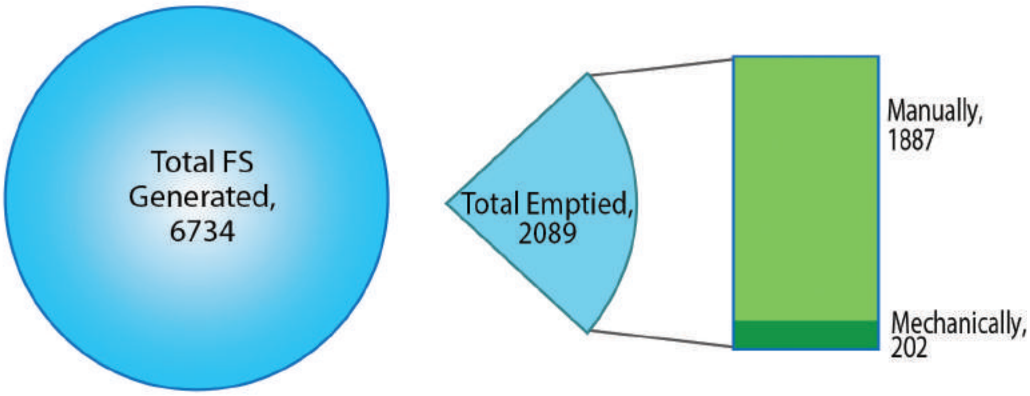


Figure 20 Volume of FS being emptied in Dhulikhel Municipality from households

Figure 20 shows the total FS generated calculated based upon the size of the containment and emptied portion. Among this, an average 202 m^3 and 1887 m^3 of FS per year is being mechanically and manually emptied in the municipality. The total volume of mechanically emptied accounts to 4 trips per week which is almost close to the response given by driver from desludging vehicle in the municipality. 56% of FS is being emptied from septic tank, fully lined tank and lined tank with impermeable walls and open bottom. While remaining from single pits and unimproved pits is being emptied. Calculation of volume of FS emptied is given in Annex 1, 2, 3, 4, 5.

4.2.4 The volume of Faecal Sludge Emptied from Institutional Containment

The volume of FS generated from institutional containments is calculated based upon the size of the containment and its emptying frequency. The calculation is shown in table 8 and in an average 395 m^3 of FS per year is generated from institutions which is equivalent to 1.08 m^3 per day.

Table 8: Calculation on FS Generated from Institutional Containment

Types of Institutional Containment	No. of Institutions	Average Volume (m^3)	Emptying Frequency Factor	Total Volume of FS per year (m^3)
Septic tank	39	18.86	0.12	88.2648
Fully lined tank (sealed)	22	20	0.2	88
Lined tank with impermeable walls and open bottom	59	13	0.25	191.75
Single Pit	39	2.73	0.25	26.6175
			Total	395
			Total FS generated per day	1.08
			Total FS generated per week	7.5
			Total number of Trip per week (4m^3 capacity of tanker)	2

However, approximately only 50 m^3 of FS per year is being emptied from institutional containment. Table 9 shows the volume of FS being emptied mechanically from various types of institutional containment. It shows currently approximately one trip of FS is being emptied from institutional containment per month.

Table 9: Calculation of FS Emptied from Institutional Containment

Containment	Mechanical Emptying (m^3 /year)
Septic Tank	0
Fully Lined Tank	28
Lined Tank and Open Bottom	16
Single Pit	1.5
Total FS emptied per year	50.15

4.2.5 Estimation of FS Generated with Proper FSM in Place

It is assumed that with the implementation of the FSM program, there would be the gradual improvement of containment such as proper lining to prevent seepages and groundwater contamination with regular emptying frequency of 4 years. Also, all pits latrine will be emptied regularly in one every two years. Then the total volume faecal sludge generation would be as calculated shown in table 10.

Table 10: Estimated Volume of FS if Improved FSM is in Place

Estimated Faecal Sludge (FS) Volume			
1	FS Volume from Households		Unit
	Total number of households with onsite sanitation (excluding biogas digester)	6505	households
	Percentage of households with lined containment	26%	per cent
	Percentage of lined containment that is desirable	95%	per cent
	Number of days per year	365	days
	The average volume of lined containment		
	Frequency of desludging	6	cubic meter
	Number of days per week that the FSM program will operate	4	years
	Estimated FS volume per day from households	6	days
	Per cent of households with pit	8	cubic meter per day
	Percentage of pits desirable	24%	per cent
	The average volume of pits	80%	per cent

	Frequency of emptying	1.7	cubic meter
	Total FS generated from the pit	2	year
	FS Volume from Institutions	3	cubic meter
2	Total number of Institution		
	Percent of lined containments	224	institutions
	Per cent of lined tank accessible for desludging	62.7%	per cent
	The average volume of lined containment	97%	per cent
	Emptying Frequency	17	cubic meter
	Estimated Volume of FS per day from Institutions	4	year
	Percent of institutions with pits	2	cubic meter per day
	Percent of pits that are accessible for desludging	17%	per cent
	Average volume of pits	80%	per cent
	Frequency of desludging	2.73	cubic meter
	Estimated Volume of FS	2	year
	The total volume of FS per day	0.13	cubic meter
		13	cubic meter per day

Figure 24 shows the projection of FS volume for 20 years at an annual growth rate of 3% of households and 2% of institutions.

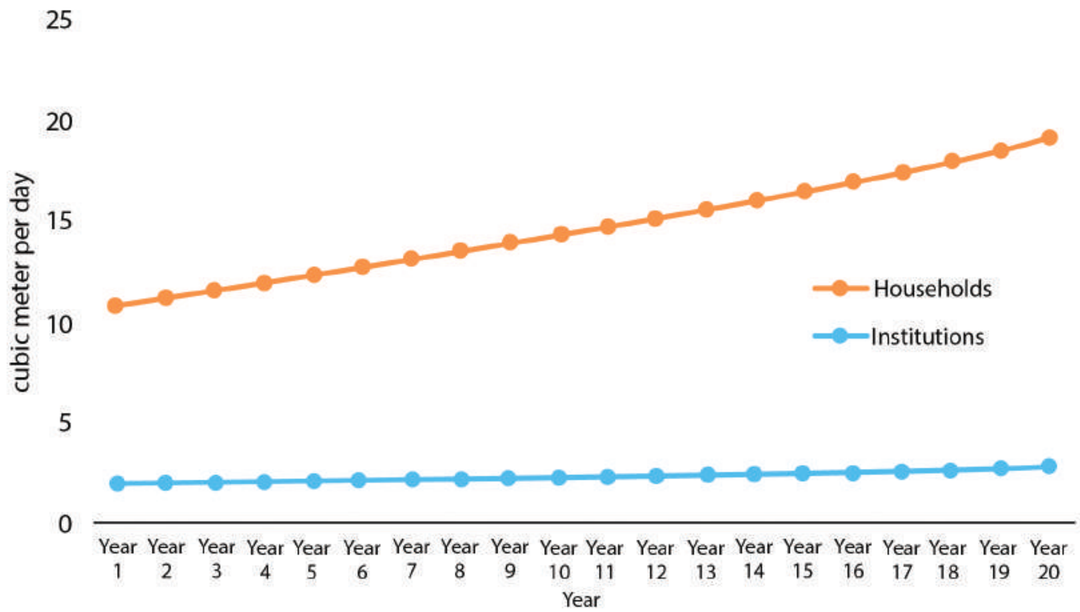


Figure 21 Projected volume of FS generated under improved FSM

4.3 Options for Faecal Sludge Treatment Processes

Faecal 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 the following information.

4.3.1 Source of Sludge (Types of containment)

Currently, 59% of FS are mechanically emptied from the septic tank, lined tank with impermeable walls and open bottom and fully lined tank. The emptying frequency for these containments is between once every two years and once every three and a half year. Thus, it could be estimated that FS would have a higher amount of liquid portion and higher emptying frequency suggest inflow of water into the containment. So, it demands a liquid-solid separation unit in the treatment technology.

4.3.2 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 the same characteristics. FS from pit toilets are emptied frequently that means, comparatively, a fresh sludge (accumulated for only 2 years or less). Thus, such FS would require additional stabilization whereas 8 years old sludge would be digested. Hence, it requires stabilization process in treatment technologies to effectively treat FS.

4.3.3 People's perception towards acceptable of end-products

People's perception of 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 a private service provider into farmland upon request of farmers. Also, people insisted on encouragement of reuse options as improved FSM indicates social acceptance of end products. Thus, the treatment technologies should incorporate the end product to the safety level. Hence, it requires pathogen reduction mechanism after dewatering/drying for safe use of treated faecal sludge as a soil conditioner or organic fertilizer.

4.4 Assessment on Technological Options

Assessment on technological options was assessed based upon occasional flooding in some low land areas, high to moderate groundwater table and tropical climatic condition. The municipality has yet to acquire land for construction of Faecal Sludge Treatment Plant (FSTP) while there is a high priority for reuse options.

Also, regarding resource availability, there is sufficient energy and low level of skilled human resource. The municipality prioritized low operational cost technology and comparatively low to the medium level capital cost. Thus, based upon these criteria possible technologies for primary, dewatering, pre-effluent, post effluent and sludge treatment is shown in a table with their brief descriptions in table 11.

Table 11: Descriptions on Process, Available Technologies with its Merits and Demerits

Process	Possible Technologies	Descriptions
Primary	Settler	BOD removal efficiency is 20 – 40 %, TSS is 50 – 70 %, low pathogen removal, simple and robust technology. Requires frequent sludge removal that is not designed for anaerobic processes.
	Imhoff Tank	BOD removal efficiency at 25 – 40 %, TSS 25 – 50 %, low pathogen removal, solid-liquid separation and sludge stabilization are combined in one single unit. Resistant against organic shock loads, small space requirements. Disadvantages are; very high or deep infrastructure, depth may be a problem in case of high groundwater table or flood, insufficient treatment option if not regularly desludging.
	Anaerobic Tank	BOD removal efficiency 60 – 70 %, TSS 20 – 50 %, Required small land area, no electrical energy required. Disadvantages are; requiring seeding and expert design and skilled construction.
	WSP (Anaerobic Pond)	BOD removal efficiency 60 – 70 %, TSS 40 – 60 %. Simple to build and appropriate for tropical climates. Resistant to organic and hydraulic shock loads. Disadvantages are required a large land area and high solid accumulation rate.
	Thickening Pond	BOD removal efficiency 30 -50 %, TSS 40 – 60 %. Thickened sludge easier to handle and less prone to splashing spray. Potential for local job creation for collecting and emptying of the sludge. Disadvantages are; required a large land and front-end loader for desludging.
Dewatering	Sludge Drying Bed	30 – 50 % dry solid level. Good dewatering efficiency especially in dry and hot climates. Simple operation and local materials can be used to build. Disadvantages are; required large land area, limited stabilization and pathogen reduction.
	Belt Filter Press	20 – 40 % dry solid level. Staffing requirements are low, especially if the equipment is large enough to process the solids in the shift. Wastewaters solids must be screened and /or ground to minimize the risk of sharp objects damaging the belt. Belt washing is required at the end of each shaft or more frequent.
	Centrifuge	20 – 40% dry solid level. Compact technology and gives speed to the process. Disadvantages are; a high dependency on electricity, maintenance is more complex and effluent and sludge require further treatment.

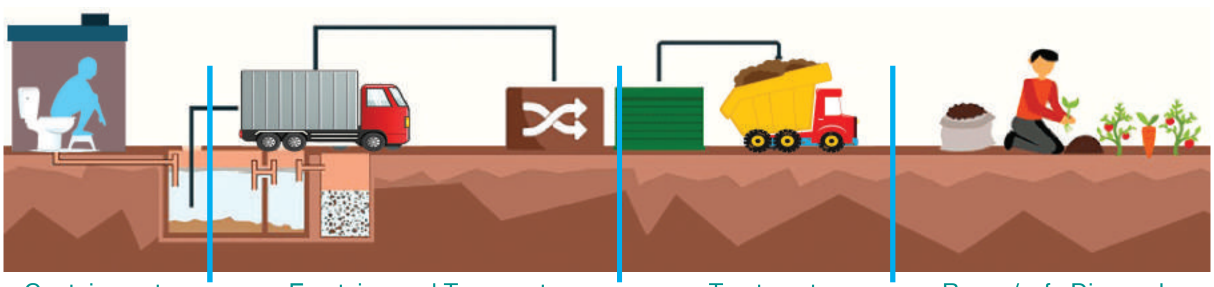
Pre-Effluent	Anaerobic Filter	BOD removal efficiency 70 – 90 % and TSS 80 – 90 %. Resistant to organic and hydraulic shock loads. No electrical energy required high BOD reduction. Disadvantages are; effluent and sludge require further treatment, removing and cleaning the clogged filter media is cumbersome.
	Constructed Wetland	BOD removal efficiency 80 – 95 % and TSS 80 – 90 %. High reduction of BOD, TSS and pathogen. Ability to nitrify due to good oxygen transfer. Disadvantages are; required large land area, long storage times, labor intensive removal, leachate requires further treatment.
	Activated Sludge	BOD removal efficiency 80 – 95 % and TSS 80 – 90 %. Resistant to organic and hydraulic shock loads, high reduction of BOD and pathogens, High nutrient removal possible. Disadvantages are; high energy consumption, a constant source of electricity is required, requires operation and maintenance by skilled personnel and prone to complicated chemical and microbiological problems.
	SBR	BOD removal efficiency 90 – 95 % and TSS 90 – 95 %. Little land required, high effluent quality, fully automated and resistant against shock loads. Disadvantages are; required a continuous supply of energy, highly mechanized equipment and high CapEx and OpEx.
Post-Effluent	Chlorination	It is simple, inexpensive and reliable. It can effectively kill bacteria and virus. Disadvantages are; purchase chlorine on a continuous basis and chlorination of water with high organic matter leads to the risk of toxic disinfection by-products formation.
	Filtration	Additional removal of pathogens and /or chemical contaminants and allows for direct reuse of the treated wastewater. Disadvantages are; required continuous monitoring of influents and effluents. Filter media need regular backwashing or replacement.
	Ozonation	Rapidly reacts with bacteria, viruses and protozoa over a wide pH range, strong germicidal properties than chlorination, and No chemicals are added to water. Disadvantages are; relatively high equipment costs, requires large amounts of energy, qualified professionals required for design and maintenance.
	UV Disinfection	UV disinfection is effective at inactivating most viruses, spores and cysts. It is a physical process rather than chemical disinfectant. Disadvantages are; turbidity and total suspended solids in the wastewater can render UV disinfection ineffective. It is not as cost-effective as chlorination.

Sludge	Vermi Composting	Economic and environment-friendly waste management, simple methods available, compost is a valuable resource for farmers. Disadvantages are; maintained proper environmental condition for worms and time span until matured compost is reached can be longer than for thermal composting.
	Co-composting	Large scale composting reduces the amount of waste that needs to be transported to the final disposal site and will encourage the use of organic farming. Disadvantages are; a large land area, long storage time, professional collection and marketing of compost required.
	Deep Row Trench	No expensive infrastructure or pumps are required and growing trees have many benefits. Disadvantages are; sufficient land is required with the low groundwater table.
	Thermal Drying	Significant reduction in volume as well as a pathogen in content dried sludge easy to handle and the market for agricultural purposes. Disadvantages are; expensive technology, high energy requirement, potential risk of fire or explosion due to gas or dust and high maintenance required.

5. Conclusion and Recommendation

The overall sanitation status of the municipality indicates the urgent need for FSM interventions and rehabilitation of existing wastewater treatment plants. Installation of anaerobic biogas digester at the household level is remarkable and should be promoted. The other existing containments, on the other hand, are not appropriate owing to groundwater pollution except for fully lined tanks. The higher portion of containment that had never emptied indicates leakages or unauthorized open emptying practices into the environment with potential threat to human health. The FS that were emptied and disposed of without any treatment by the municipality is also another serious issue. Hence, the municipality should immediately act to improve FSM for better environment and human health.

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



Containment

i. Promote anaerobic biogas digester in the farming community that have enough space for installation.
ii. Proper installation of twin pits and upgrading single pits to twin pits to effectively manage FS onsite.
iii. Lined tank with impermeable walls and open bottoms should be gradually improved to fully sealed the tank with respect to potential groundwater contamination.
iv. Finally, manage a database with information such as types of containment, size and last emptied date.

Emptying and Transport

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

Treatment

i. Ideally, it is important to treat all FS generated in the municipality, however, behavior changes are 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.
ii. Select a natural process with low skilled operational technologies for treatment.
iii. Prepare detail improvement planning with tangible target and interventions.

Reuse/ Safe Disposal

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

References

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ANNEXURE

Annex 1 Description on percentage of containments manually and mechanically emptied

Containments	Percent	HHs	Emptied		Manual Emptying		Mechanical Emptying	
			Percent	HHs	Percent	HHs	Percent	HHs
Septic tank	2.5%	161	55.6%	90	80.0%	72	20.0%	18
Fully lined tank (sealed)	9.6%	626	34.3%	215	75.0%	162	25.0%	54
Lined tank with impermeable walls and open bottom	14.0%	912	51.0%	465	84.6%	394	15.4%	72
Single Pit	13.5%	876	26.5%	233	84.6%	198	15.4%	36
Unimproved pit	10.7%	697	20.5%	143	100.0%	143	0.0%	0
				1146		969		180

Annexe 2: *Calculation of FS emptied manually and mechanically from septic tank*

Septic Tank	Manual						Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS per year	Total FS emptied	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied
Three Times a year	0%	0	0	0	176.4	9.8	0.0%	0	0	3	0	44.1
Twice a year	0%	0	0	0			0.0%	0	0	2	0	
Every Year	0%	0	0	0			0.0%	0	0	1	0	
Every 2 Years	0%	0	0	0			0.0%	0	0	0.5	0	
Once every 3_5 years	100%	72	705.6	176.4			100.0%	18	176.4	0.25	44.1	
Once every 6_10 Years	0%	0	0	0			0.0%	0	0	0.125	0	
more than 10 years	0%	0	0	0			0.0%	0	0	0.1	0	

Annexe 3 *: Calculation of FS emptied from fully lined tank*

Fully lined Tank												
	Manual						Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	0%	0	0	0	688.5	7.5	0.0%	0	0	3	0	40.5
Twice a year	11%	18	135	270			0.0%	0	0	2	0	
Every Year	11%	18	135	135			0.0%	0	0	1	0	
Every 2 Years	33%	54	405	202.5			0.0%	0	0	0.5	0	
Once every 3_5 years	11%	18	135	33.75			0.0%	0	0	0.25	0	
Once every 6_10 Years	22%	36	270	33.75			0.0%	0	0	0.125	0	
more than 10 years	11%	18	135	13.5			100.0%	54	405	0.1	40.5	

Annexe 4

Calculation of FS emptied manually and mechanically from lined tank and open bottom

Lined tank with impermeable wall and open bottom												
	Manual						Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	0%	0	0	0	59.4375	7.5	0.0%	0	0	3	0	54
Twice a year	0%	0	0	0			0.0%	0	0	2	0	
Every Year	14%	54	22.5	22.5			0.0%	0	0	1	0	
Every 2 Years	18%	72	30	15			0.0%	0	0	0.5	0	
Once every 3_5 years	41%	162	67.5	16.875			0.0%	0	0	0.25	0	
Once every 6_10 Years	14%	54	22.5	2.8125			0.0%	0	0	0.125	0	
more than 10 years	14%	54	22.5	2.25			100.0%	72	540	0.1	54	

Annexe 5

Calculation of FS emptied manually and mechanically from single pits

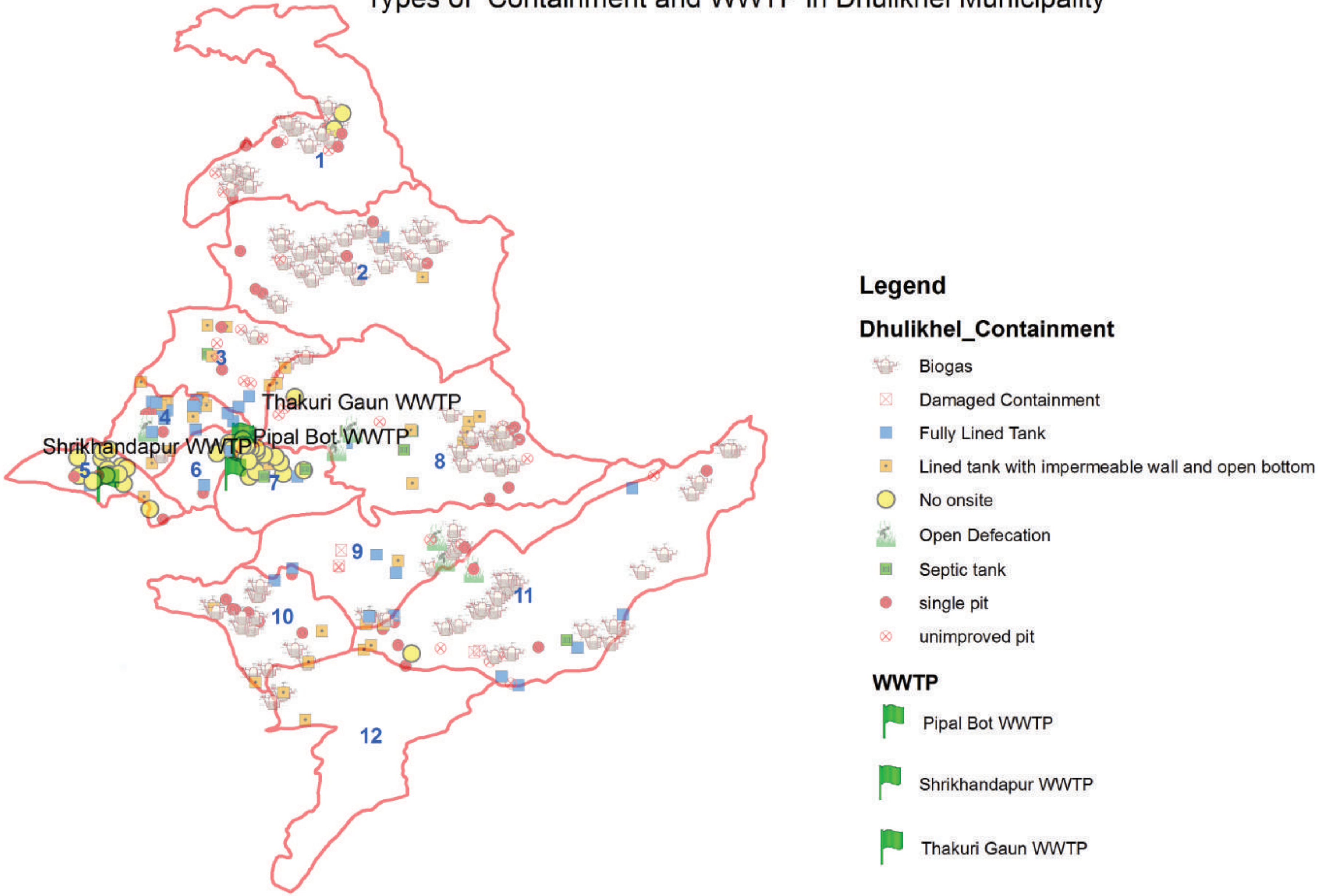
Single pit												
	Manual						Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	9%	36	63.36	190.08			0.0%	0	0	3	0	
Twice a year	9%	36	63.36	126.72			0.0%	0	0	2	0	
Every Year	27%	108	190.08	190.08			0.0%	0	0	1	0	
Every 2 Years	36%	144	253.44	126.72			100.0%	72	126.72	0.5	63.36	
Once every 3_5 years	9%	36	63.36	15.84	657.36	1.76	0.0%	0	0	0.25	0	63.36
Once every 6_10 Years	9%	36	63.36	7.92			0.0%	0	0	0.125	0	
More than 10 years	0%	0	0	0			0.0%	0	0	0.1	0	

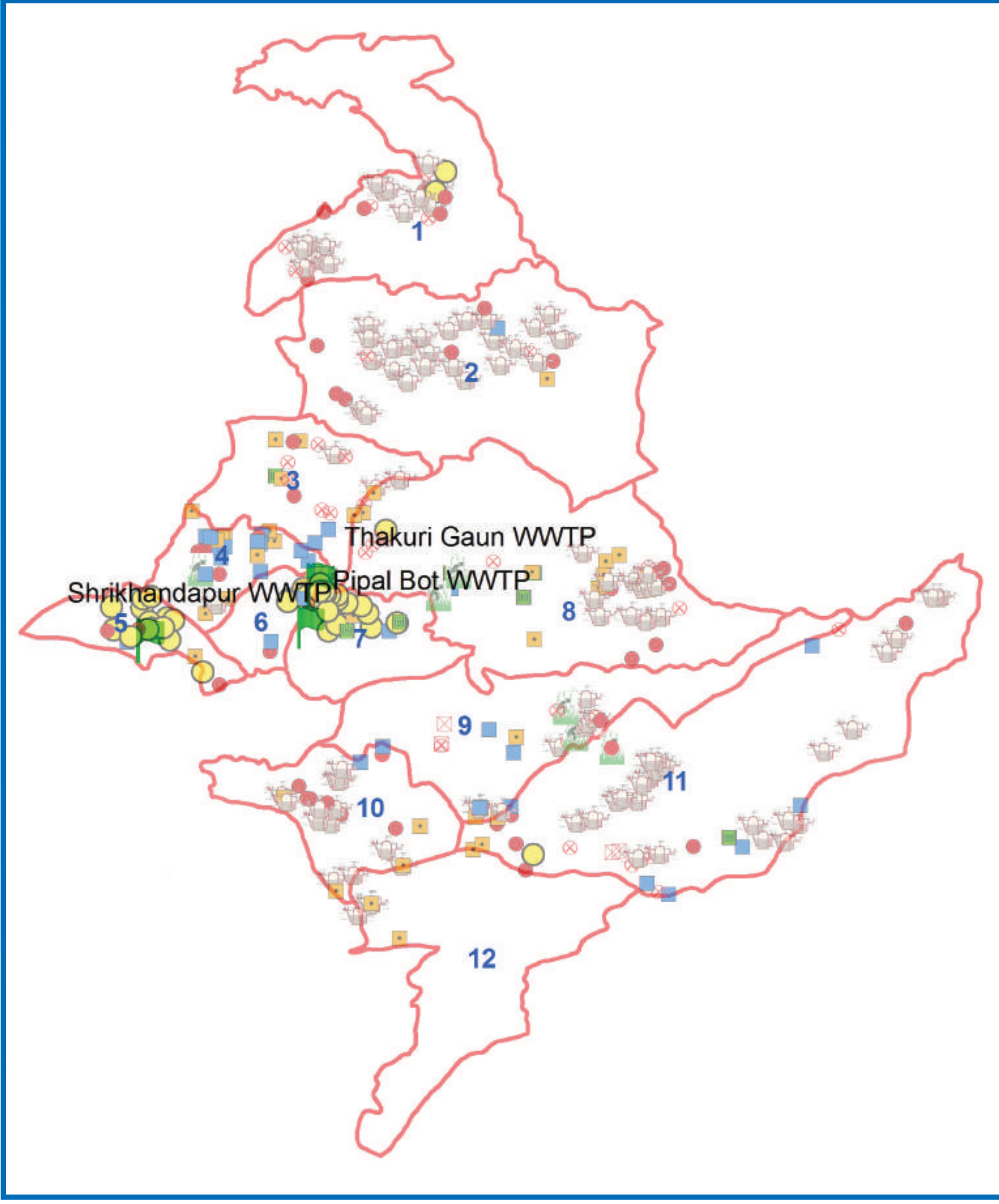
Annexe 6

Calculation of FS emptied manually and mechanically from unimproved pit

Unimproved Pit												
Manual							Mechanical					
Emptying Frequency	Percent	HHs	Volume	FS emptied per year	Total FS emptied per year	Average Volume	Percent	HHs	Volume	Emptying frequency factor	FS emptied per year	Total FS Emptied per year
Three Times a year	0%	0	0	0	305.424	3.03	0.0%	0	0	3	0	0
Twice a year	9%	18	54.54	109.08			0.0%	0	0	2	0	
Every Year	18%	36	109.08	109.08			0.0%	0	0	1	0	
Every 2 Years	18%	36	109.08	54.54			0.0%	0	0	0.5	0	
Once every 3_5 years	18%	36	109.08	27.27			0.0%	0	0	0.25	0	
Once every 6_10 Years	0%	0	0	0			0.0%	0	0	0.125	0	
More than 10 years	9%	18	54.54	5.454			0.0%	0	0	0.1	0	

Types of Containment and WWTP in Dhulikhel Municipality





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