Faecal Sludge Management in Khulna City:
An Approach for Safe Emptying

by

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Declaration

This is to certify that the thesis work entitled “Faecal Sludge Management in Khulna City: An Approach for Safe Emptying” has been carried out by Sabok Mondal in the Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

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This is to certify that the thesis work submitted by Sabok Mondal entitled "Faecal Sludge Management in Khulna City: An Approach for Safe Emptying" has been approved by the board of examiners for the partial fulfillment for the degree of Master of Science in Civil Engineering in the Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna, Bangladesh in January 2018.

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Abstract

Faecal sludge (FS) comprises the human excreta both in liquid and semi-liquid contents which stored in pits and septic tanks. Faecal sludge management (FSM) refers to the containment technology, emptying, transport, treatment, and safe disposal or reuse of human waste. In this study, the aim is to identify the on-site containment management practices at three different types of settlements in Ward No. 9 of Khulna City Corporation (KCC). The selected three types of settlements are Muzgunni Second Phase as a residential area, Boro Boyra as a mixed-use area and Rail Junction Bosti as a slum area. The study has been conducted by a series of household questionnaire surveys, key informant interviews (KII) and focus group discussion (FGD). The data gathered from the questionnaire have been analyzed by Standard Package for Social Science (SPSS) and Microsoft Excel software.

The study finds that only 7% of septic tanks having soak well and rest of the septic tank is connected to a nearby drain or water body in the residential area. Also, in this area, about 81% of the containment is suitable and 77% is accessible for mechanical emptying wherein the mixed-use area about 41% containment is accessible and 59% are not. However, in the slum, about 78% of containment is not accessible. In the residential area, about 58% of containment has not emptied yet where this percentage is 41% and 5% respectively for the mixed-use and for the slum. About 31% of the septic tank has been emptied manually where only 13% is mechanically in the residential area. However, for the mixed-use area, manual emptying is about 50% and mechanical emptying is about 7% and all emptying operations have been done either manually or self. In all three areas, the emptied sludge is disposed to nearby drains if emptied manually and disposed to Khulna faecal sludge treatment plant (FTP) if emptied mechanically.

The study also reveals that the quality of emptying of the residential area is found unsafe emptying as 31.23%, partially safe emptying as 12.77%, and safe emptying as 56%. Again, for the mixed-use area, unsafe emptying is found as 41.28%, partially safe emptying as 14.24%, and safe emptying as 44.48%. And for the slum area, unsafe emptying is found as 61.53%, partially safe emptying as 13.74%, and safe emptying as 24.73%. Finally, the overall emptying quality found as 42.14% for the residential and as 35.57% for the mixed-use area which represents partially safe emptying practices in both

two areas where the score for the same is found as 17.35% in the slum which indicates totally unsafe emptying.

Septic tank outlet connection, inaccessibility of containment, emptying largely manually ignoring the safety issues, knowledge gap etc. issues are the main problems to achieve safe emptying. Khulna Development Authority (KDA) and KCC is the regulatory authority of FSM in Khulna where KDA is responsible mainly for septic tank design and construction supervision phase and KCC is in emptying of the septic tank. Safe emptying can be possible by enforcing the laws to septic tank outlet connection during design and construction, introducing alternative small emptying device where mechanical emptying is not possible and organizing different types of awareness building program to gather knowledge and triggering the mechanical emptying demand to the users.

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Abbreviation

ADB	Asian Development Bank
AIT	Asian Institute of Technology
BMGF	Bill & Melinda Gates Foundation
BNBC	Bangladesh National Building Code
BRAC	Bangladesh Rural Advancement Committee
CBO	Community-Based Organization
CDC	Community Development Organization
DPHE	Department of Public Health Engineering
EAWAG	Swiss Federal Institute of Aquatic Science and Technology
FGD	Focus Group Discussion
FS	Faecal Sludge
FSM	Faecal Sludge Management
FTP	Faecal Sludge Treatment Plant
GOB	Government of Bangladesh
GPS	Global Positioning System
JMP	Joint Monitoring Programme
KCC	Khulna City Corporation
KII	Key Informant Interview
KUET	Khulna University of Engineering & Technology
KWASA	Khulna Water Supply & Sewerage Authority
LGD	Local Government Division
LGED	Local Government Engineering Department
LGI	Local Government Institution
MAPET	Manual Pit Emptying Technology
MDG	Millennium Development Goal
MDHP	Manual Diaphragm Hand Pump
NWSSS	National Water Supply & Sanitation Strategy
NGO	Non-Governmental Organization
PPE	Personal Protective Equipment
PSU	Policy Protective Equipment
SAT	Situational Assessment Tool
SDG	Sustainable Development Goals
SFD	Shit Flow Diagram
SNV	SNV Netherlands Development Organisation
UNICEF	United Nations Children's Fund
UPPR	Urban Partnerships for Poverty Reduction
WHO	World Health Organization

CHAPTER I

Introduction

1.1 Background

Historical records show that sanitation has been a matter of concern to the human race for a very long time (Rosen, 1994). According to WHO (2008), the importance of sanitation is indisputable for water supply and sanitation and it is a crucial stepping stone to better health that sanitation. Proper sanitation offers us the opportunity to save the lives of 1.5 million children a year who would otherwise succumb to diarrheal diseases, and to protect the health of much more. It is also key to economic development such as education and health, and bring measurable economic returns (Aygei, 2009). Urbanization is increasing the pressure on urban infrastructural services in the low-income and developing countries, as currently, over 50% (Montangero, 2004) of the population in developing countries live in the urban areas (Ruiz-Mier and Van Ginneken, 2006 as cited in Nkansah, 2009).

Bangladesh has reached to her goal of improved sanitation and mostly completed the Millennium Development Goal (MDG)-7 by 2015 (JMP, 2015). The country has also shown remarkable progress in sanitation sector, so it's urgent need for Faecal Sludge Management (FSM) in Bangladesh (Islam, 2016) mainly in urban areas, where most human waste is dumped untreated into waterways or onto marginal land, harming the health of the country poorest (Opel, 2011). In Bangladesh, 46 million urban inhabitants, more than 80% use on-site sanitation (UNICEF, 2015). Bangladesh has 522 urban centers accounting for 29% (44 Million) of the national population. Thus, we are on the edge of another "sanitation revolution" to manage the human excreta (Islam, 2016).

Water was declared an economic good and more emphasis was put on public health, affordable low-cost technologies, capacity building and community participation (WELL, 1998; Seppälä, 2002 as cited in Nkansah, 2009). The city-wide faecal sludge management requires regular emptying, the majority of which is done manually by marginalized service providers, while mechanical emptying is limited (Murungi, 2013)

to small areas. There have been a few development project initiatives to introduce mechanical emptying services using vacutugs in different cities (Islam, 2016). Most of the cities in Bangladesh, including the third largest city Khulna (Islam, 2012) and one of the most climate vulnerable cities in the world (Haque, 2013) having a population around 1.5 Million (KCC, 2017) has no sewer network. The household sanitation is predominantly on-site technologies, 68.4% septic tanks and 31.6% pits (Opel, 2011), which requires regular emptying. Sanitation- 21, a new approach towards planning for improved sanitation services in low-income and middle-income countries (Parkinson, 2014). Sanitation has been neglected because of lack of understanding of its economic benefits and consequences of policymakers (Nkansah, 2009). The relatively few mentions of sanitation were almost always done in conjunction with water supply and when sanitation was mentioned, the emphasis was on the coverage of latrines (Nkansah, 2009).

1.2 Problem Statement

Globally there has been little in-depth field research and evaluation of the entire faecal sludge management systems to date and acknowledges the non-existence of published documentation of comprehensive assessments comprising pit/septic tank emptying, haulage, storage or treatment, and use or disposal, based on actual practices (Aygei, 2009). Putting emphasis on coverage only while ignoring other equally important sanitation sides such as excreta collection, transport, and disposal, could bring about diseases and environmental pollution (Ingallinella *et al.*, 2002). The inadequate excreta management in many cities of developing countries, particularly in low-income areas, continuously leads to serious health and environmental hazards (Strauss and Montangero, 2002). So far, the latrines and their emptying services have been neglected or unsatisfactorily managed (Klingel *et al.*, 2002; Scott and Reed, 2006).

In Bangladesh, sanitation coverage is unhappily inadequate with about 15% in urban and about 6% in rural areas as of 2006 (WHO, 2008). The situation is worse in the peri-urban areas which are often plagued with inadequate water supply and low access to sustainable basic sanitation (Aygei, 2009). There are also instances where faecal sludge are disposed of into the environment untreated (Murungi, 2013). Such practices defeat the purpose of improved toilet facilities and make the management of faecal sludge

difficult (Aygei, 2009). Sweepers are declining in number as they are opting for safer, less stigmatized livelihoods. Currently, the costs of emptying tanks and pits are unaffordable and make customers unwilling to de-sludge their toilets regularly and safely (Strauss and Montangero, 2002).

Urban populations are growing very rapidly due to economic migration. As a result, most city residents connect their septic tanks directly to drains and local water bodies which is risky for the environment and have been unable to regulate pollution effectively despite the detrimental effects on the environment or the public health threat (Opel, 2012). The rest are mainly emptied manually by sweepers who often do not have the capacity to transport emptied sludge to a safe or designated place for disposal (Courilleau and Cartmell, 2010). Recently city and towns are ought to upgrade the vacutug service considering a fair tariff for better faecal sludge management (SuSanA, 2008).

A study in 2012 on 154 sludge emptying business in Asia and Africa concluded that FSM service can be a profitable business when operated by entrepreneurs (Chowdhary and Kone, 2012). Most of the people living in urban areas are not aware of the containment infrastructure, containment emptying mainly which is safe for the environment (Opel, 2011). They have a tendency is to do with manual emptying which is regarded as unsafe emptying because it doesn't ensure the health and safety issues (Pandey and Kaul 2000). Crude dumping is often occurred by manual emptying where emptying by the mechanical way is mostly safe (Murungi, 2013).

1.3 Objectives of the Study

The aim of the study is to explore and emphasize an existing management approach especially from emptying perspective for the urban on-site sanitation services. The following objectives are made for this research.

1. To identify the existing containment management practices and emptying process in the study area.
2. To identify the quality of sludge emptying in the study area categorized by safe emptying, partially safe emptying and unsafe emptying.
3. To find out the problems related to emptying of containment and to propose a respective probable solution.

1.4 Scope of the Study

The objectives of the study will cover the sanitation containment, emptying and collection portion of the sanitation value chain. Moreover, these objectives will take an inside view of the community people's perception about the sanitation system in the study area. The purpose of this work is to assess the existing situation of containment management and emptying and also the effective management of sustainable urban sanitation by examining the latrine emptying, transport and disposal mechanisms in the city. The study was limited in scope to Khulna, a city of Bangladesh. The resource in emptying perspective is limited for the study area. The scope of the study focused on an integrated management by all stakeholders in the provision and management of FS in Khulna City. Lastly, the assessment was relevant since it will be able to get the views of the public on how they consider the current FSM practices and also seek proposals from them on ways to improve upon these practices based on their assessment.

1.5 Limitation of the Study

The research study was conducted in specific areas of Khulna City Corporation based on the activities such as literature review, a collection of data and information, survey sampling etc. Research about FSM is very rare and difficult to find its similar research paper. Access to data was difficult due to poor data management and slowed down in-depth analysis during the study. So, to get data several times field visits were required for conversation with city corporation personnel and other stakeholders related to FSM. There is no preserve data and information in a systematic manner in City Corporation and other private operators.

1.6 Research Outline

This research entitled as 'Faecal Sludge management in Khulna City: An Approach for Safe Emptying' has been divided into six specific chapters comprising different options and portions according to the objectives of this study. The chapters expose the investigation of various activities, existing emptying practices and scope of services, health and safety issues etc. associated with FSM services.

CHAPTER I: This chapter deals with the primary description named as an introduction which presents the objectives, problem statement, scope and limitation of

the study and also gives a light background of the study with basic information and research outline. It also highlights the objectives, scope, justification and research questions of the study.

CHAPTER II: This chapter covers the comprehensive review of relevant literature to the study in Bangladesh besides all over the world. This chapter also touches on the existing environmental conditions and baseline data of the study area. Above all, data and information in the context of home and abroad and relevant case study report have been included in this chapter.

CHAPTER III: This chapter contains an elaborate description of the methodology of the research consisting field survey strategy, conceptual and analytical methods employed in this study along with the fundamental principles underlying those.

CHAPTER IV: This chapter describes the existing scenario of the FSM practices of the study area. The chapter has been arranged with all relevant data and information on study objective based on the investigation on the spot survey in the field with has been represented by tabular and graphically. Detail results and discussions of existing on-site containment management and emptying services of the study area are presented in this chapter. It also presents the findings and interprets them in the framework of FSM practices but mainly focusing on the emptying portion. This chapter also describes the identification of constraints, limitations, and problems and also finds the possible solutions and recommendations for improvement containment infrastructure, emptying and transportation services, health and hygiene issues in the study area.

CHAPTER V: This chapter is the final description named as conclusions and recommendations which mainly comes from the results and discussion chapter. However, this chapter concludes the findings of the study with necessary recommendations for the study areas.

An interpreted reference list of the literature cited in the dissertation following after chapter five. The appendices are the complementary part of this thesis that contains the initial data, relevant interview data and numerical information of analysis portion.

CHAPTER II

Literature Review

2.1 General

The global trends in fecal sludge management history and value chain and the practices in Bangladesh were focused. FSM is a relatively new sector and currently rapidly developing and gaining acknowledgment. This chapter discusses the literature about the comprehensive human excreta containment, emptying, transport and disposal mechanisms starting from where the excreta are taken through to their final destination points. Moreover, this study mainly focused on containment and emptying of faecal sludge (FS).

2.1.1 Faecal Sludge

FS is a slurry or semisolid that is raw or partially digested and comes from the collection, storage or treatment of a mixture of excreta and black water (Singh *et al.,* 2017). Faecal sludge comprises all liquid and semi-liquid contents of pits and vaults accumulating in on-site sanitation installation, namely un-sewered public and private latrines or toilets, aqua privies and septic tanks (Strande *et al.,* 2014). The solid part that has been the partially digested and settled at bottom of the onsite sanitation systems is known as fecal sludge (Koottatep, 2014).

Faecal sludge contains infectious organisms contained in human faeces. These organisms can survive outside the human body for a limited period. Pathogenic bacteria die off within a few weeks, while the eggs of parasitic worms can survive years in the environment. Fresh faecal sludge from public toilets contains the highest quantity of infectious organisms. However, sludge from septic tanks also contains bacteria from fresh excreta and a large number of viable worm eggs (Repon *et al.,* 2015).

2.1.2 On-Site Sanitation

On-site sanitation is a system of sanitation whose storage facilities are contained within the plot occupied by a dwelling and its immediate surroundings (WHO, 2008). Maintenance of conventional on-site sanitation and sewerage is a serious problem in developing countries (Frenoux and Tsitsikalis, 2013). On-site sanitation is the dominant form of sanitation in Africa and South Asia countries. In most cases, this type of sanitation is the most economical solution to sanitation provision (Still, 2002). Worldwide, several hundred thousand tons of faecal matter is collected from on-site sanitation installations are disposed of every day largely untreated and totally uncontrolled into the urban and peri-urban environment (Strauss and Montangero, 2002). In Bangladesh, from different research, it has been seen that on-site sanitation is dominant in both urban and rural areas as shown in Table 2.1.

Table 2.1: Extent of on-site sanitation usage in three cities in Bangladesh

Towns	On-site Sanitation Percentage
Dhaka	79%
Khulna	98%
Faridpur	99%

(Source: Opel *et al.*, 2011)

2.1.3 Sanitation Service Chain

Sanitation refers to the maintenance of hygienic conditions by proper treatment and disposal of human urine and FS. Inadequate sanitation is a major cause of disease worldwide, and improved sanitation is known to have a significant positive impact on health both in households and communities (Singh *et al.*, 2017). It is estimated that about 31% of people (JMP, 2015) in rural or developing areas resort to inadequate sanitation method and human waste disposals such as rivers or dumpsites and open defecation. Increasing sanitation coverage in many developing countries in Asia and Africa has led to a tremendous rise in on-site sanitation because it is cheaper than sewerage systems (Frenoux and Tsitsikalis, 2013), affordable for low-income people (Nkansah, 2009).

In developed countries, sanitation service chains usually include central sewage systems that provide a direct way of disposing of excreta produced in each household safely and hygienically (WASH, undated). Poorly and unscientifically designed onsite disposal facilities affect the sources of groundwater with substantial environmental and health

hazards (Singh *et al.*, 2017). Increasing access to sanitation is a global priority. Currently, one in five children die from diarrheal-related diseases, which is more than that of aids, malaria, and measles combined (UNICEF, 2015).

Bangladesh has a remarkable improvement in coverage of sanitation (JMP, 2015). According to JMP, in 2015 Bangladesh has made good progress towards MDG target. Open defecation has been reduced to only 1%, a milestone change from 42% in 2003. Improved sanitation coverage is 61%, an increase of 28% since 2003. Still 28% people are sharing latrines and 10% people are using unimproved latrines (JMP, 2015).

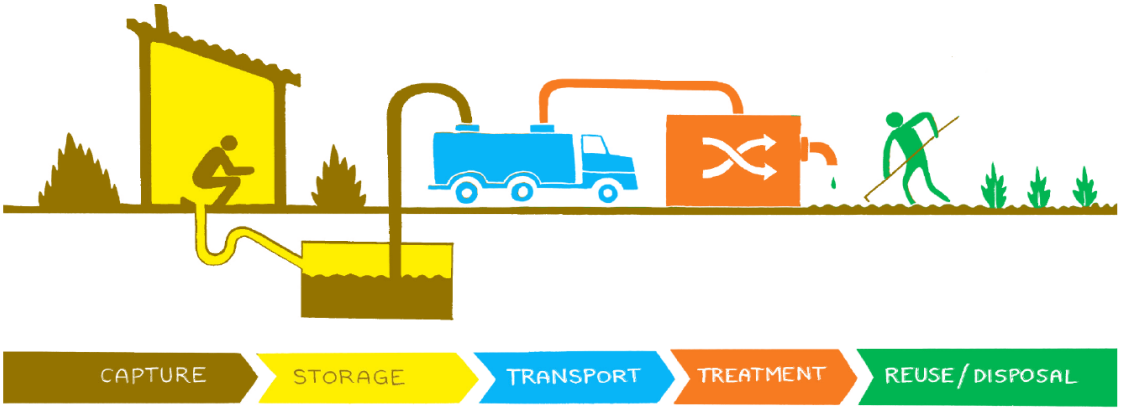


Figure 2.1: The key processes in a complete sanitation service chain (Source: WASH, 2012)

The sanitation service chain from Figure 2.1 shows how faecal sludge moves through the sanitation system (Repon *et al.*, 2015). Sanitation value chain contains five major components of the sludge management. These are containment of sludge, emptying, transportation, treatment and finally reuse or disposal of FS (Repon *et al.*, 2015). Elements of the chain may reach their capacity limits, equipment or infrastructure may malfunction, the service may even become temporarily unavailable, but the chain may still cope with demand. A sanitation system is complete when it has a defined flow stream for each of the products (Tilley *et al.*, 2010). However, during an emergency, regular processes tend to break down because of the cumulative impacts on the sanitation service chain (WASH, undated). Onsite technologies can represent viable and more affordable options, but only if the entire service chain, including collection, transport, treatment and safe end use or disposal, is managed adequately.

The entire sanitation delivery chain (containment, emptying, transport, treatment, and disposal/reuse) must be examined in order to ensure a separation of human contact from human excreta within and beyond the household premises (Peal *et al.*, 2014). The main purpose of sanitation is to prevent the transmission of faecal-borne disease and reduce the risk of environmental contamination **(**Repon *et al.* 2015).

2.2 Faecal Sludge Management

Faecal Sludge Management (FSM) includes the storage, collection, transport, treatment and safe enduse or disposal of FS that means all five component of the sanitation value chain (Singh *et al.*, 2017). FSM deals with on-site sanitation systems and appropriate FSM have significant impacts on human and environmental health (Strauss *et al.*, 2002). Effective management of FS systems entails transactions and interactions among a variety of people and organizations from the public, private and civil society at every step in the service chain, from the household level user, to collection and transport companies, operators of treatment plants, and the final end user of treated sludge (Islam, 2016). Till now FSM coverage is low and problematic, causing environmental and public health threats (Tilley *et al., 2010*).

2.2.1 Overview of Global Fecal Sludge Management

The sanitation needs of 2.7 billion people worldwide are served by on-site sanitation technologies, and that number is expected to grow to 5 billion by 2030 (Thye *et al.*, 2011). A large number of people in urban areas of low and middle-income countries use onsite sanitation technology because there is no proper management of FS (Dodane *et al.*, 2012). FSM is important because although over a billion people in urban and peri-urban areas of Africa, Asia, and Latin-America are served by on-site sanitation technologies, FS is not well managed in many cities (Murungi and Peter, 2014). It is important that the management of FS is a critical need and must be addressed and that it will continue to play an essential role in the management of global sanitation into the future (Islam, 2016).

In urban areas, it has been demonstrated that, depending on local conditions, the cost of FSM technologies are five times less expensive than conventional sewer-based solutions (Dodane *et al.*, 2012). Without an FSM structure in place, when the containment structure fills up, the untreated FS most likely ends up directly in the local environment (Murungi

and Peter, 2014). This results in the prevalent contamination of the environment by pathogens and is not providing a protective barrier to human contact and hence protection of public health. For example, in Dakar, only 25% FTP (Chowdharyand Kone, 2012) of FS that accumulates in onsite facilities is being collected and transported to legitimate FTP. A very successful example of this management model is in Japan where the systems successfully co-exist in urban areas (Gaulke, 2006).

A large portion of the thousands of tons of sludge generated daily from onsite sanitation systems in the developing countries is not well managed (Strande *et al*., 2014). The FS from un-sewered family and public toilets and septic tanks are disposed of untreated indiscriminately into lanes, drainage ditches, onto open urban spaces as well as into inland waters, estuaries and the sea (Strauss and Montangero, 2002). This improper practices of FS disposal are growing environmental and sanitary concern since many water-borne diseases are transmitted from feces to humans through water and soil pollution (Kone *et al*., 2007). The problems and challenges in FS management rest with all the components of the faecal sludge stream, namely pit/vault emptying, haulage, storage or treatment, and use or disposal. (Strauss and Montangero, 2002). In many developing countries, FSM has been neglected (Strande *et al*., 2014). In recent years, an encouraging number of initiatives towards improved FSM, including appropriate FS treatment schemes, have been developed, particularly so in several West African countries, in South East Asia (Kone *et al*., 2007).

In Sustainable Development Goals (SDG), there are some goals on sanitation as

- Goal 6: Ensure availability and sustainable management of water and sanitation for all
- Target 6.2 by 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.
- Target 6.3 by 2030, improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

2.2.2 Fecal Sludge Management in Bangladesh

Bangladesh is one of the world's most densely populated countries with a total area of 147,570 km^2 and a total population of 1.53 million (BBS, 2011). Though Bangladesh has achieved significant progress in sanitation; however, it needs special attention to manage this huge amount of fecal generated every day that results in ground and surface water pollution with significant environmental, public health and economic impacts. Some progress has been also made in Bangladesh to improve the total FSM sector (Islam, 2016). However, the management of OSS remains neglected with a large quantity of fecal sludge generated in these facilities inappropriately managed to lead to significant environmental, health and economic challenges.

People living in high-density urban slums and low-income communities depend entirely on OSS facilities shared by multiple families (Rahman *et al.*, 2015). As a result, the pits or septic tanks are filled up quickly with fecal matter and without de-sludging services, the toilets become unusable. Thus, in absence of effective emptying, a part of the FSM system, sanitation in these communities is becoming unsustainable. A root cause for lack of FSM services in these cities and towns is that there is no clear assignment of responsibilities with regard to FSM among the utility service providers, City Corporations, Municipalities and City Development Authorities in major cities (Kabir and Salauddin, 2014).

The introduction of National Strategy for Water Supply and Sanitation 2014 is an important step for FSM to consolidate and improve the present approach. There are also some talks about FSM in some rules and regulation of Bangladesh and some development organizations have also started to focus on this challenging FSM sector. Sludge treatments plants were also constructed for managing this FS. Some other organizations like WaterAid, Bill & Melinda Gates Foundation, UNICEF, Practical Action, etc. also manage several projects on FSM. SNV Netherlands Development Organisation has started to take the different initiative to manage the faecal sludge for the urban context in Bangladesh.

Khulna, the third largest metropolitan city in Bangladesh where the inadequate emptying option was found for FS (Kabir and Salauddin, 2015). In this city, about 628,070 m^3 of FS is produced every year (Islam, 2016). Unfortunately, in Khulna City Corporation (KCC) the entire FSM process is unsystematic and mainly maintained by informal private

service providers (Islam, 2016). City people have lack of awareness on timely and safe emptying of their pits/septic tanks. Inappropriate design of septic also makes the system non-functional (Gunawan *et al.*, 2015). These factors cause overflow/discharge of FS in the drains, water bodies or open dump site.

In 2014, a baseline study was conducted by SNV in three cities (Khulna, Kushtia, and Jhenaidah) that provides the information about existing sanitation situation in these areas. According to this study, open defecation has become a rare phenomenon in Khulna. The majority of toilets have either a septic tank or pit as containment, however, most of them do not have a soak well or, due to the high water table, a soak well does not work. Hence the households are connecting the toilet to a drain. In Khulna city, about 84% of the total have a septic tank (Kabir and Salauddin, 2015) are connected to a drain or surface water. The practice of safe septic tank emptying and conveyance is almost absent in Khulna city. More than half of the total households, irrespective of wealth situation, either use unsafe emptying or do not at all practice fecal sludge emptying. About 81% of the emptying process is manually (Islam, 2016), even though, vacating service was introduced a few years back. Safe disposal and treatment of fecal sludge are mostly absent in Khulna (Kabir and Salauddin, 2015). In a nutshell, Figure 2.2 shows the shit flow diagram (SFD) for FSM of Khulna city.

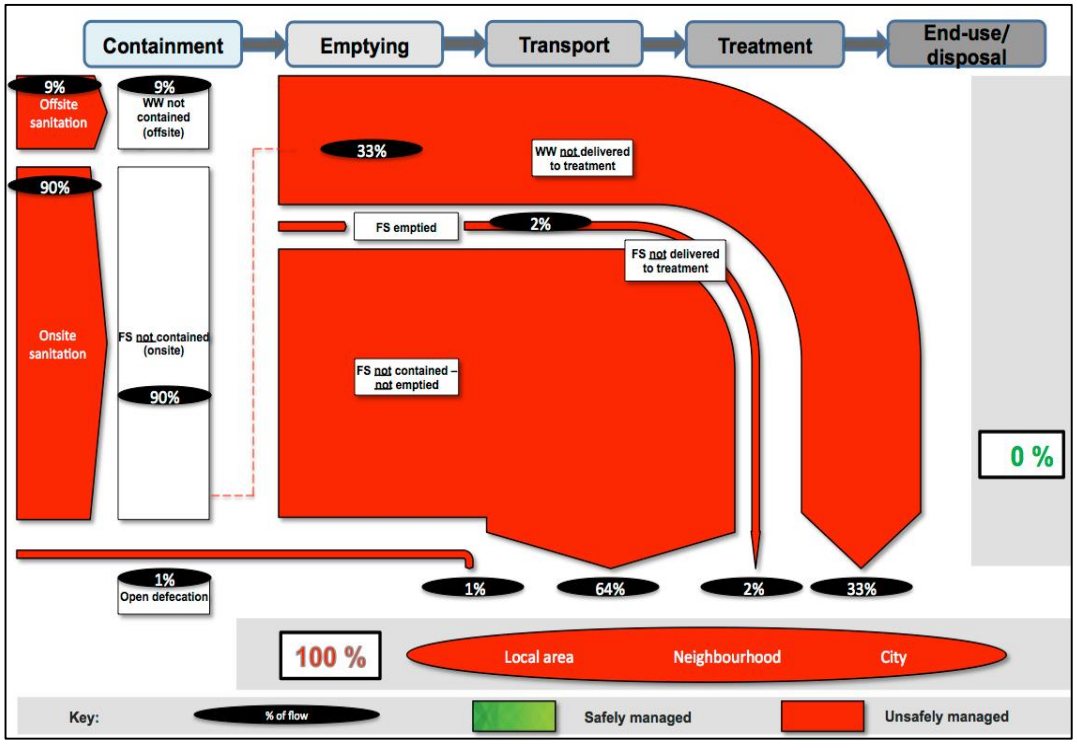


Figure 2.2: Shit Flow Diagram (SFD) of Khulna (Source: Gunawan *et al.*, 2015)

2.3 The Situation and Problems Associated with Faecal Sludge Management

In urban areas of developing countries, several hundred thousand tons of faecal matter from collected from on-site sanitation (OSS) installations are disposed of into the urban and peri-urban environment (Agyei, 2009). In light of this, Bareh (2005) suggested that the best way to provide awareness for environmental problems and promote environmentally responsible behavior is by increasing the access to environmental education. According to Boot (2007); Chaggu *et al*., (2002); Jones (2005) as cited in Nkansah, (2009) points out the problems about the associated with the FSM of the low-income countries as shown in Figure 2.3.

- Containments fill up and overflow without being emptied
- Lack of appropriate equipment and expertise for the emptying resulting in an environmental and aesthetic mess
- Constant breakdown of emptying and transport machines with little or no chance for repair or replacement due to lack of funds and availability of spare parts
- Appropriate policy for emptying and transport is lacking
- Poor settlement and infrastructural which deny vehicular access and unnecessarily increase costs to the users
- Households' poor knowledge and attitude to latrine use safely

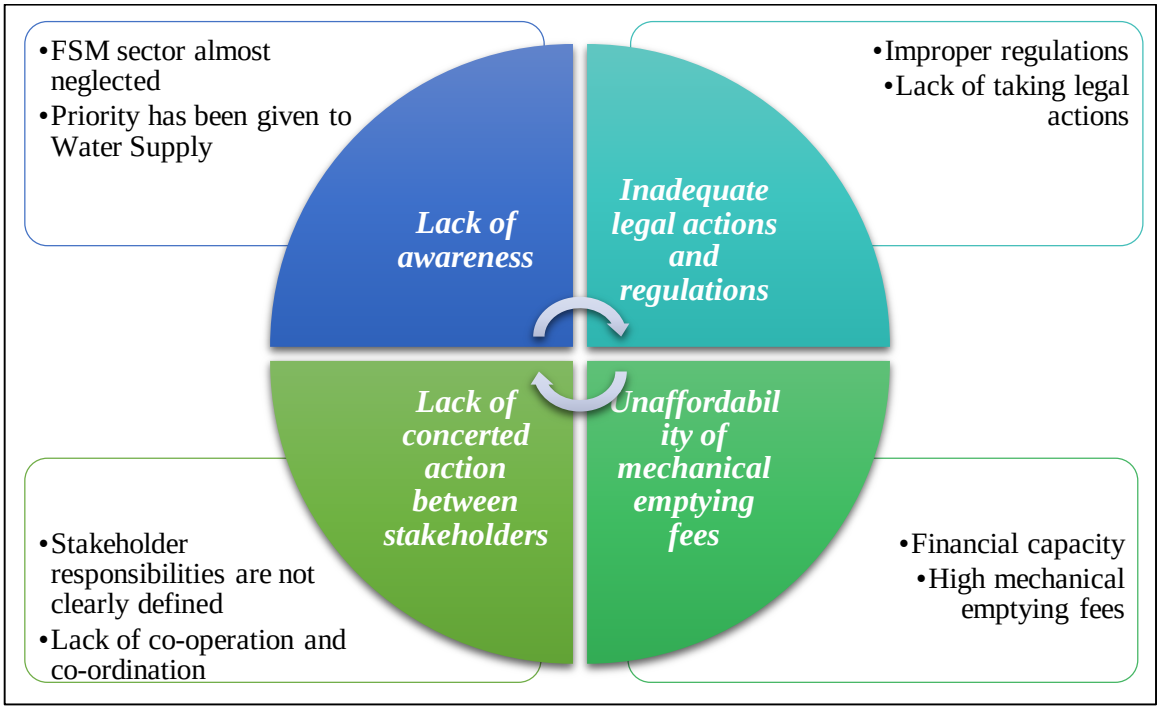


Figure 2.3: Problems associated with proper FSM (Source: Klingel *et al*., 2002)

These issues highlight the following concerns about the idea of storing excreta in on-plot latrines and removing the excreta from the latrines to disposal points of safety in the urban areas according to Nkansah, 2009, Klingel *et al*., 2002, Ingallinella *et al.*, 2002 are given below.

- ✓ On-site sanitation should have good containment are in good condition, regularly emptied are accompanied by hygienic behaviour and the overall good safe excreta disposal behaviour and practice
- ✓ There should be unhindered access to the emptying of the excreta
- ✓ Appropriate equipment and tools should be used for the emptying and transport
- ✓ Once the latrines are emptied, the transport of the pit contents to disposal points should be safely handled and managed

The inadequate and improper management of FSM impacts on environmental pollution and to sustained health risks are tabulated below in Table 2.2 for the urban areas.

Table 2.2: Causes, problems, and impacts of inadequate FSM

Causes	Low Priority on authorities agenda
	Inadequate Legal and Regulatory Basis
	Lack of concentration among FSM stakeholders (Households, Service Provider, Policy regulatory bodies)
	Lack of incentive /sanctioning procedures Difficulty in securing suitably located treatment sites
	Non-affordability of pit emptying fees
	Difficulty of accessing pits for emptying
	Infrequent emptying of on-site installations
Problems	Indiscriminate disposal in urban environment and reuse of untreated FS
Consequences and Effects	Terrestrial and aquatic environment contaminated by excreta
	High risks of transmission of gastrointestinal infections
	Disease and mortality

(Source: Klingel *et al*., 2002)

2.4 National Policies, Strategies, and Frameworks for FSM in Bangladesh

According to SACOSAN, 2016, the political commitment of the Government of Bangladesh (GoB) to sanitation has been the major driving force tor the sanitation movement in the country. The Policy Support Unit (PSU) of LGD with support and

assistance from DPHE and other stakeholders provides technical assistance to the GoB to develop water supply and sanitation-related policies, strategies, and guidelines. The women, children, differently abled people, indigenous communities, disadvantaged, hard-core poor people and floating population have been mainstreamed in the policy documents. The major policies and strategies guiding the sanitation movement in Bangladesh are:

- The National Strategy for Accelerated Poverty Reduction, 2005 & 2008, and the Medium Term Budgetary framework, 2008
- National Water Management Plan, 2004
- The National Sanitation Strategy, 2005
- The Pro-poor Strategy for Water and Sanitation, 2005
- The Sector Development Plan, 2011-15
- The Sixth Five Year Plan (SFYP), 2011
- The National Strategy for Water and Sanitation in Hard to Reach Areas of Bangladesh, 2012
- The National Hygiene Promotion Strategy for Water Supply and Sanitation Sector in Bangladesh, 2012
- The National Cost-Sharing Strategy for Water Supply and Sanitation Sector in Bangladesh, 2012
- Bangladesh National Hygiene Baseline Survey 2014
- National Strategy for Water Supply and Sanitation, 2014
- Institutional and Regulatory Framework for Fecal Sludge Management (FSM) in Bangladesh (draft), 2015

2.4.1 Establishing Fecal Sludge Management as Regulation

According to LGD (2014), The National Water Supply and Sanitation Strategy- 2014 (Final Draft), Strategy 5, it has been stated that sewerage system covers only about 20% of the population of Dhaka City, the remaining population in urban and rural areas of the country use on-site hygienic sanitation technologies like septic tank and pit latrines or none at all. The FS from septic tanks and pit latrines in most cases are not emptied timely or at all causing fecal matters to overflow and often this sludge discharge directly into drains or water bodies, nearby drains and open spaces. This improper management of

fecal sludge is creating severe environmental pollution and putting public health at high risk (Alamgir *et al.*, 2015). The situation is critical in urban low-income communities. Presently only a few small-scale pilots on fecal sludge disposal are being tried in urban and rural areas.

The following strategic direction is to initiate and establish a proper FSM system in the country.

- Give priority to the management of sludge from septic tanks and pit latrines such that all sludge is collected, transported, treated and disposed of safely in an environmentally friendly manner.
- Allocate land by LGIs for fecal sludge treatment and disposal for all urban areas and upazilla headquarters
- Build capacities of LGIs for sludge management
- Promote the use of compost or treated sludge as fertilizer thus recycling nutrients back to nature.
- Encourage use of double pit latrines to enable proper in-situ composting of sludge and for their safe disposal or to be used as fertilizer.
- Make arrangements for regular emptying of septic tanks and pit latrines.
- Establish collection and safe disposal of fecal sludge from trains, launches, and boats.
- Provide technical and business support to the private sector in sludge collection, treatment, disposal and sales of compost.

2.4.2 Bangladesh National Building Code

In Chapter-6 of BNBC (2014) the following subject matters related to FSM are mentioned below.

Liquid waste: The liquid waste is the discharge from any fixture appliance or appurtenance in connection with a plumbing system which does not receive faecal matter.

Septic tank: A septic tank is a water-tight settling tank which receives the discharge of a drainage system or part thereof and is designed and constructed so as to separate solids from the liquid, digest organic matter through a period of detention, and allow the liquids

to discharge into the soil outside the tank through a system of open joint or perforated piping or disposal pit.

Sludge: A settled portion of the sewage or wastewater effluent from a sedimentation tank in semi-solid condition.

Soak pit: A pit, dug into permeable soil lined to form a covered perforated chamber or filled with sand at the bottom and gravel or broken bricks at the top into which effluent from a septic tank or storm water is led and from which these may soak away into the ground. Also known as seepage pit or soak well.

Septic tank discharging into either a subsurface disposal field or one or more seepage pits shall be required for the approval of drainage and sanitation plans for the places where public sewers are not available (BNBC 6.9.12.1). The design of such system shall be on the basis of location with respect to wells or other sources of water, soil permeability, groundwater elevation, the area available and maximum occupancy of the building (BNBC 6.9.12.3). Effluent from septic tank shall not discharge into open water sources (BNBC 6.9.12.5). The septic tank shall have a minimum liquid capacity of 2000 liters, minimum width 1 m and minimum liquid depth 1 m. The minimum length of a septic tank shall be at least thrice its width. It is recommended that the maximum length of a septic tank shall be not more than 4 times its width (BNBC 6.9.12.8).

Again, the maximum size of a septic tank shall be limited to the number of users not exceeding 300 persons for residential buildings (BNBC 6.9.12.9). The volume required for digested sludge and scum may be computed on the basis of 0.04 m^3/capita/year. There shall be a clearance between the top of the liquid level and bottom of the tank cover slab which shall be at least 300 mm (BNBC 6.9.12.10). The liquid retention time of a septic tank shall be at least 1 day (BNBC 6.9.12.11).

It has been clearly stated that the de-sludging frequency of a septic tank shall be at least 6 months interval and maximum once a year. (BNBC 6.9.12.12). It is recommended to use two-chamber septic tank when the capacity of a septic tank exceeds 3000 liters. The inlet compartment of a two-chamber septic tank shall have a capacity not less than two-thirds of its total capacity (BNBC 6.9.12.13). The total description has been summarized in Table 2.3.

Table 2.3: What is in BNBC about septic tank?

Parameter	Stated in BNBC
Minimum liquid depth	1m
Minimum Width	1m
Minimum Length	Thrice of width
Maximum Length	4 times of the width
Person uses	300 Nos.
Minimum liquid capacity	2000 liters
De-sludging frequency	➢ At least 6 months ➢ Maximum 1 year

(Source: BNBC, 2014)

2.5 FSM Stakeholders in Bangladesh

In Bangladesh perspective, there are many actors playing roles in Fecal Sludge Management. These are central government, local government, different departments or agencies of government and CBOs or NGOs (Islam, 2016). The main stakeholders involved in FSM sector in Bangladesh are shown in Figure 2.4.

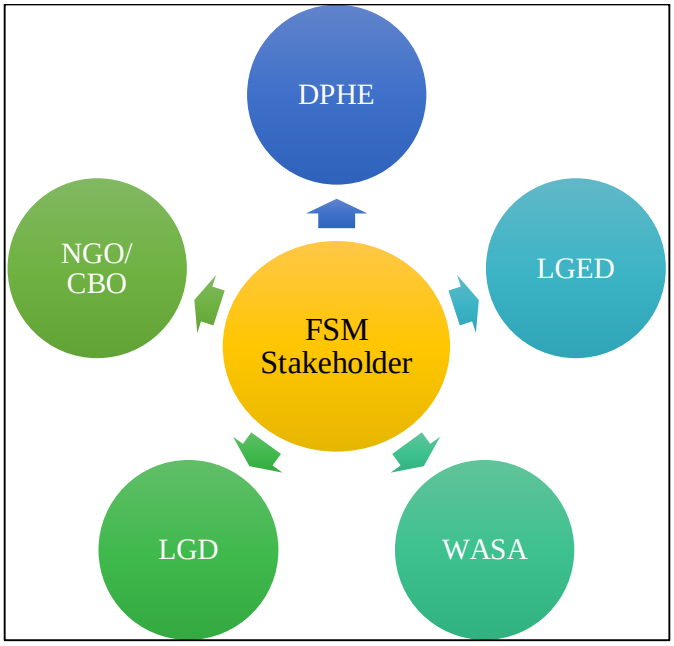


Figure 2.4: FSM stakeholders in Bangladesh (Source: Islam, 2016)

FSM stakeholders are the main regulatory authority to apply rules and also responsible for FSM. Table 2.4 describes the stakeholders associated with FSM sector in Bangladesh with their roles and responsibilities.

Table 2.4: Stakeholders and their responsibilities in Bangladesh

FSM Stakeholders	Responsibilities
LGD	➢ Responsible for different development works including sanitation or FSM
LGED	➢ Responsible for different development projects which includes sanitation program ➢ Provide technical assistance to Pourashavas or city corporations.
WASA	➢ Responsible for water supply and sanitation
DPHE	➢ Responsible for water supply and sanitation ➢ Provides technical assistance to Municipalities
CBO/NGO	➢ Working mainly with the local government doing mainly sanitation or FSM management works

(Source: Islam, 2016)

The Ministry of Local Government Rural Development and Cooperatives is in charge of overseeing the development of water supply and sanitation sectors (Roy, 2014). The Local Government Division is responsible for the implementation of policies, strategies, plans, and regulations, as well as coordination and monitoring (Ahsan *et al*., 2014). Table 2.5 shows the regulatory stakeholders associated with FSM in Khulna. In Khulna, the mandate of sanitation service provision is with KCC, the Khulna Water Supply and Sewerage Authority (KWASA) and the Khulna Development Authority (KDA).

Table 2.5: Stakeholders delivering sanitation services in Khulna

Key Stakeholder	Institutions/ Organizations
Public Institutions	KCC, KWASA, and KDA
Non-governmental Organizations	WaterAid, SNV Bangladesh, Nabolok, Community Development Committee (CDC)
Private Sector	Manual emptying service provider
International financing institution	Asian Development Bank (ADB), Japan International Cooperation Agency (JICA), World Health Organization (WHO), Bill & Melinda Gates Foundation (BGMF).
Others	Khulna University of Engineering Technology and Khulna University (KUET)

(Source: Gunawan *et al.*, 2015)

2.6 Estimation of Faecal Sludge Generation

An estimation and projection of the generation of FS is an important aspect for the proper scheming of infrastructure required for the development of collection and transportation

networks, discharge sites, treatment plants, and end-use or disposal options (Strande *et al.*, 2014). The quantity of faces produced daily can vary significantly based on dietary habits. Quantity also depends upon the type of food (Singh *et al.*, 2017). Generally, high fiber content food produces a high quantity of faces than food with low fiber content (Strande *et al.*, 2014). Due to the variability of FS volumes generated it is important to make estimates based on the requirements specifically for each location and not to estimate values based on literature. However, no proven methods exist for quantifying the production of FS in urban areas (Islam, 2016). There is, therefore, a need, to develop methodologies for providing reasonable estimates (Charles *et al.*, 2015). To obtain a good estimate of FS production, the following data is required: (Strande *et al.*, 2014) number of users; location; types and number of various onsite systems; FS accumulation rates; and a population of socio-economic levels. The faces production rates in low and high-income countries are presented in Table 2.6.

Table 2.6: Reported faecal production rates

Location	Wet Weight (g/person/day)
High-income countries	100-200
Low-income countries, rural	350
Low-income countries, urban	250
China	315
Kenya	520
Thailand	120-400

(Source: Singh *et al.*, 2017)

2.7 Containment

The structure which store the excreta and black water mainly come from the toilet is termed as containment. In the FSM process, the initial parts are the containment of human excreta. Containment is the act or condition of containing. So, containment of human sludge means the containing of human sludge or excreta and the wastewater. While global monitoring currently focuses especially on the type of sanitation technology used by the household, there is a need to understand what happens with human excreta beyond the point of containment (Peal *et al.*, 2014). The aims of containment are to remove the wastewater and excreta from households. It will either combine a technology for collecting excreta only, with a technology for wastewater collection or option for

technologies that collect and treat all wastewater and excreta (Monvois *et al*.., 2010). Generally, two types of containment prevail as shown in Figure 2.5 and which one is a simple pit and another is a septic tank.

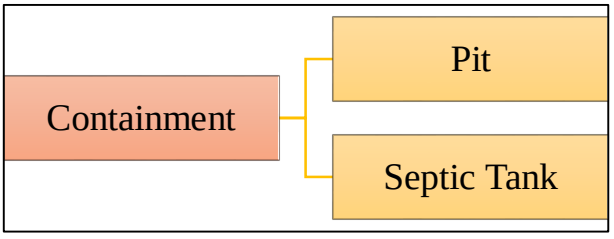


Figure 2.5: Containments Types

2.7.1 Pit

Which is generally built up by the ring slab one after another digging the soil (Howard *et al*., 2003) is known as the pit. Pit latrines are the dominant type of excreta disposal facilities in urban slums in Africa, Asia and Latin America & Carribean (WHO, 2008). Pit latrines do not require water for their functionality, can be built and repaired with locally available materials, have low capital and operating costs and can be modified to serve user preferences. Infiltration of the liquid phase into groundwater and overflows during the rainy season from the excreta collection chamber have made pit latrines major causes of groundwater pollution (Kulabako *et al*., 2007; Mara *et al*., 2008 as cited in Howard *et al*., 2003;). There are two different types (Thye *et al*., 2011) of pit latrine: single pit and a double pit latrine. The single pit latrine is continually in use and will need to be emptied more regularly, whereas the double, or twin, pit latrine technology enables to store more FS and to get a first anaerobic treatment from a full pit, while the second is used, before it needs emptying (Opel and Bashar, 2006).

2.7.2 Septic Tank

The term "septic" refers to the anaerobic bacterial environment that develops in the tank which decomposes or mineralizes the waste discharged into the tank (Nnaji and Agunwamba, 2012). The septic tank system is the most widely used onsite system for wastewater treatment especially in developing countries where the cost of central wastewater treatment facilities is prohibitive. A septic tank is a key component of the septic system, a small-scale sewage treatment system common in areas with no connection to main sewage pipes provided by local governments or private corporations. Effluents from the septic tank are directly discharged into open water bodies, ditches, and drains.

Those connected to pits always overflow. The pits then face the problem of early clogging due to poor design (Ahmed, 2000). In the United States only, over 50 million people use the septic system (Rahman *et al.*, 1999). A properly designed and normally operating septic system is odor-free and, besides others some important issues (Bounds, 1995; Nnaji and Agunwamba, 2012). It should have some requirements which in*d*icate that the septic tank is working well. Figure 2.6 shows the general requirements and quality of a good and working septic tank.

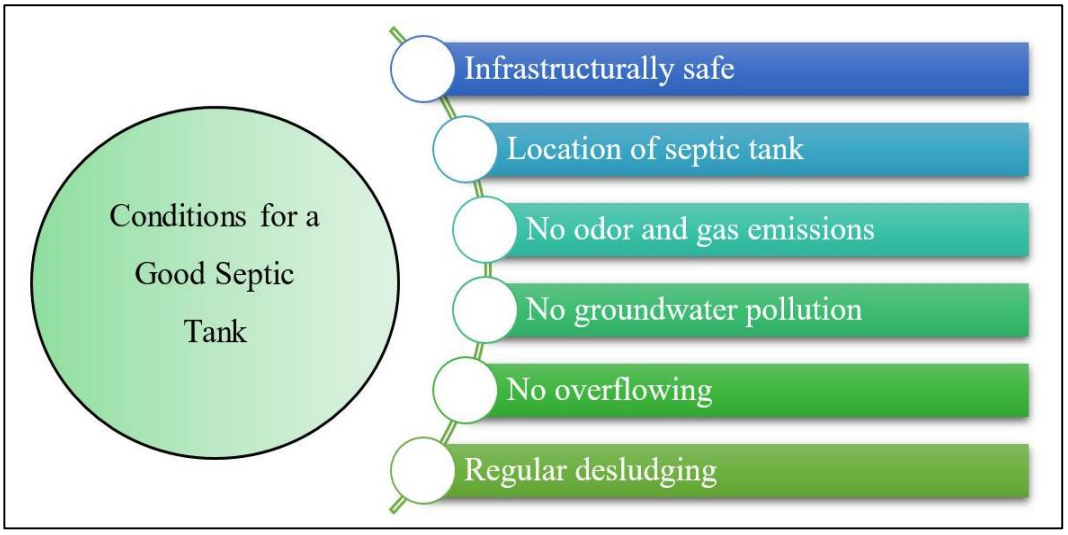


Figure 2.6: Good septic tank requirements (Source: Bounds, 1995; Rahman *et al.*, 1999)

2.7.3 Containment Location and Accessibility Problems

Location and accessibility problems are mentioned as obstacles to successful pit emptying (Montagero *et al.*, 2002). Therefore this section is divided into two subsections to discuss in detail the location and accessibility problems respectively.

2.7.3.1 Location Problems for Containment

The design and maintenance of containment are location specific (Riberio, 1985; Chaggu *et al*., 2002 as cited in Nkansah, 2009). The containment location should be such a place that it could get access easily. Some of these location-specific issues are the location of the containment regarding the available space. Another dimension to the location specific problem is the fact that an inappropriately located containment in an unsuitable soil formation can lead to the collapse of the containment during emptying operations (Mara, 1996). Besides, the physical limitations imposed by the sites at poor peri-urban and slum areas can be a major constraint to FS emptying and transport (Hogrewe *et al*, 1993).

2.7.3.2 Accessibility Problems for Containment

Due to the narrow streets in poor urban settlements, they often cannot access the pits (Strauss *et al.*, 2002). Access is one of the main reasons why manual emptying is so common. Large vacuum tankers are simply unable to traverse the narrow streets in unplanned settlements. Although longer hoses can be used, the maximum length possible is approximately 50 m (Still, 2002). Designs such as the vacutug carry a small sludge tank and a pump and can negotiate narrow pathways. Even the vacutug, designed with accessibility in mind, is unable to access some of the narrower paths in Dhaka, Bangladesh (Graefnitz, 2012). In mainly slums areas, where there are no accessibility for vehicles, local contractors manually empty pit latrines by making a hole in the side wall of FS holes (Montangero *et al.*, 2002).

As could be inferred from the previous section, accessibility problems could stem from the way housing components, the service facilities (electricity poles, water standpipes, and latrines, etc.) and the physical environment interact with each other (Mara, 1996). Lack of proper urban planning and settlement pattern render vehicular accessibility to some latrines almost impossible (Montangero *et al.*, 2002). Therefore in narrowly accessible situations, there is the need for small-size emptying and transport equipment that ought to overcome accessibility limitations placed on it. Available openings to reach the contents of the pit are also an important accessibility factor to consider (Bosch and Schertenleib, 1985). For example, fixed non-removable slabs, as well as the inaccessible superstructure of the containment, may have to be destroyed to allow machines or humans to gain access for emptying. As has been mentioned already, there could be accessibility problems regarding the very steep terrain as well as muddy and geologically unstable environments where the poorest of the poor with land tenure problems live (Hogrewe *et al.*, 1993).

2.8 Faecal Sludge Emptying

After a certain times containment needs to be clean, that is termed as the emptying of faecal sludge. The predominance of on-site sanitation means that pit or tank emptying is required at regular intervals. Household pit and septic tank emptying behavior is not well understood or characterized in the literature (Williams and Overbo, 2015). Many developing countries are struggling to find viable technological and business solutions to

pit and septic tank emptying without which the gains of improved sanitation coverage fail to bring desirable benefits (Opel, 2012; Chowdhry and Kone, 2012). Emptying pits or septic tanks or using untreated sewage for irrigation bring direct health threats, often serious by the workers lack awareness of the way that diseases are transmitted (Bruijne *et al.*, 2014). The pit emptying depends to a large extent on the present climate and weather. During an intensive rainy season period, the pit contents will be more liquid (Graefnitz *et al.*, 2012). Despite the significance of the issue, research about fecal sludge emptying service is both limited and weak. There are considerable knowledge gaps about fecal sludge emptying as a service, and its effectiveness as a component or an integrated part of cities sanitation service provision (Chawdhury and Kone, 2012). It has been clearly stated in BNBC that the pit or septic tank should be emptied between six months to one year (BNBC, 2014).

2.8.1 Emptying Methods of Feacal Sludge

The prevailing methods used around the developing world for emptying septic tanks or pit latrines can be categorized into three main groups: manual, manually driven mechanical system, specifically designed mechanical systems (Kone *et al.*, 2007). It can help to identify the suitable option for septage removal from tanks/pits. The general emptying process or techniques are shown in Figure 2.7.

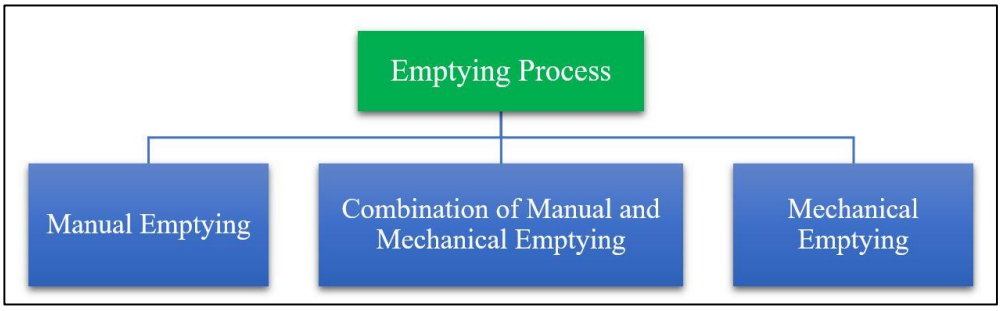


Figure 2.7: Sludge Emptying Method

2.8.1.1 Manual Emptying

Manual emptying means when the sludge is emptied by hand using buckets and shovels or by a portable, manually operated pump system (Islam, 2016). It is generally the easiest and cheapest way (Murungi, 2013) of removing sludge to keep a pit operational, although it is usually the most expensive per unit volume. Manual emptying often involves at least two workers (Kone *et al.*, 2007). One worker has to enter into the pit need to be equipped with ladder, rope, protective clothing and buckets (Mara, 1996). Manual emptying

technologies in low-income countries have included hand tools and accouterments such as hand-operated pumps, bare or gloved hands, brooms, buckets, drums, scoopers, pickaxes, spades, ladders, ropes, and boots (Kone *et al.*, 2007).

Again, manual pit emptying is less effective than the conventional mechanical emptying due to its slow rate of operation and rudimentary tools used (Van der Geest, 2002). Manual emptying is most hazardous (Opel and Islam, 2013) as the emptiers usually do not use anything other than some buckets and a plastic drum to transport sludge and manual sweepers do not even use any gloves or any other protective equipment's to avoid contact with sludge. If a containment is emptied by hand, every precaution should be taken to prevent anyone from accessing the pit. If, for whatever reason, the pit has to be entered, the emptier has to be fitted with adequate protection and safely secured by a rope (Islam, 2016) to the surface in the event he has to be pulled out quickly.

2.8.1.2 Risks Associated with the Manual Emptying

There are no specific records for health and safety issues required for the manual emptiers (Thye *et al.*, 2011). However, digging the FS manually from pits without adequate precaution and protection is risky and can get one infected with bacteria and worms (Scott and Reed, 2006; Nkansah, 2009). Manual emptying has many health risks and hazards. Its positives and negatives aspects are described in Figure2.8.

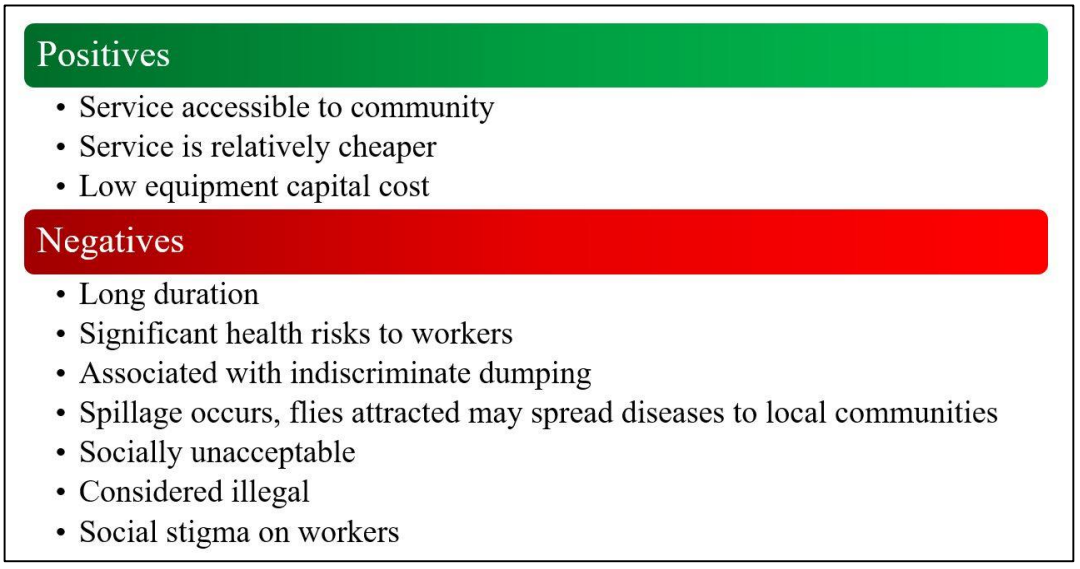


Figure 2.8: Positives and negatives aspects of manual emptying (Source: Still, 2001; Opel and Bashar, 2006; Kone *et al.*, 2007)

In some instances the sludge being emptied spills around the neighborhood of the latrines, on the streets and on the bodies of the emptiers (Van Der Geest, 2002; Muller, 1997) which could get them infected by the pathogens in the excreta. Sometimes the manual emptiers who cannot withstand the disgusting odor and nastiness of the human excreta resort to the use of chemicals like paraffin to control the odour (Scott and Reed, 2006), and this could lead to possible environmental pollution. The risks also imply that the use of rudimentary manual tools for FS emptying could not only expose emptiers and households to diseases but also create an aesthetic mess, contamination and environmental pollution. All the above risks highlight the need for clear health and safety issues meant for excreta or FS emptying.

2.8.1.3 Mechanical Emptying

Mechanical emptying refers to a vehicle equipped with a motorized pump and a storage tank for emptying and transporting FS and urine. Humans are required to operate the pump and maneuver the hose, but sludge is not manually lifted or transported. Mechanical emptying was more prevalent and commonly used in some region (Williams and Overbo, 2015). In these regions and cities, mechanized services are rendered by municipal authorities or by small to medium-sized enterprises. If the household can afford an emptying service then a sewer truck will pump and collect the FS from the pit, transport and landfill it into a dumping site. Table 2.7 shows a comparison of manual emptying and mechanical emptying briefly.

Table 2.7: A comparison of manual emptying vs mechanical emptying

	Manual Emptying	Mechanical Emptying
Advantages	✓ Accessibility ✓ Local job creation and income generation	✓ Fast and generally efficient ✓ Minimizes health risk
Disadvantages	▪ Time-consuming ▪ Health hazards for workers ▪ Hard, unpleasant work ▪ Requires a disposal point or discharge area (< 0.5 km) ▪ Spillage and bad odours	▪ Low accessibility ▪ Expensive, capital and O&M costs ▪ Cannot pump thick, dried sludge (must be manually removed) ▪ Pumps usually only

(Source: Kone *et al.*, 2007)

2.8.1.4 Mechanical Sludge Emptying Devices

1. Large Vacuum Tanker

Most pits/septic tanks, however, are emptied by large vacuum trucks or tankers equipped with a pump and a storage tank. The pump is connected to a hose, which is lowered down into a septic tank or pit, and the sludge is pumped up into the tank. All vacuum tanker systems use a pump to create a vacuum in the tank and suction hose. The vacuum then lifts the sludge into the tanker. Generally, the storage capacity of a vacuum truck ranges between 3 and 12 m^3 (Tilley *et al*. 2014). Large vacuum tanker contains a motorized pump and a storage tank for emptying and transporting FS. Volume can vary from 5 and 10 m^3 operate effectively up to about 60 m and to a depth 2 to 3m (Tilley *et al*. 2014). Most pump trucks are manufactured in North America, Asia or Europe. Therefore, older trucks are often used (Strauss *et al*., 2002). Over time the sludge thickens, with the result that the solid at the bottom becomes harder to suck. Depending on the system, the material to be pumped out can sometimes become so compacted that it cannot easily be removed. In these situations, the solids have to be liquefied with water in order to flow more easily. If water is not available, the waste will have to be removed manually. For this reason vacuum tanker operators try to encourage their clients to empty their septic tanks frequently, and not to wait until they are completely full of solids (Brikke *et al*., 2003).

2. Vacutug

Vacutug is the vacuum mounted on a truck, recent innovations of mechanical devices which can do the job more quickly, safely and efficiently. A suction hose runs from this unit into the pit through the hole. It takes 5 to 10 minutes to fill. Sometimes, the sludge becomes very compacted and it cannot easily be removed (Tilley *et al.,* 2008). In these situations, the solids have to be liquefied with water in order to flow more easily (Tilley *et al.,* 2008). After the liquefaction, vacutug suck it out easily. There are different types of vacutugs. Some are larger and some are smaller. The larger vacutug volume ranges between 4 to 5m^3. Large vacutug often have difficulty accessing the latrines or septic tanks in areas with narrow or inaccessible roads (EAWAG, 2005). The smaller one is named mini vacutug with less powerful pumps could be mounted on a vehicle to access the narrow lanes to empty the FS sludge (Oriordan, 2009) and its volume ranges between 1 to 2m^3. It is completely mechanical and smaller than conventional vacuum tankers

(Issaias, 2006). Mini vacutug are invented due to solve accessibility problem. Where large vacuum tanker or large vacutug cannot get access due to narrow road width, mini vacutug can get access easily there (Strauss *et al.*, 2002). The technologies are only able to empty to a limited depth. A large vacutug can lift a depth of up to 2 to 3m but the mini-vacutug cannot empty pits more than 2 m deep (Issaias, 2006). Frenoux and Tsitsikalis (2013) suggested that septic tanks/pits should not be completely emptied and a small amount of digested sludge should be kept in the bottom.

The Vacutug MK1 and Vacutug MK 2 have been tested in Africa and Asia and a relative comparison has been shown in Table 2.8. They are combinations of a tank with a capacity range of 200 to 500 liter capacity (Thye *et al*., 2011), a small manual or motorized pump for extracting faecal sludge connected to a flexible hose pipe and wheels suited for maneuvering in a congested area. These technologies have low local operation and maintenance cost. Their limitations include weak pit latrine substructure in the case of pumping, depth of less than 2m and inability to remove dry sludge and solid particles like stones and wood from pits (Boot and Scott, 2008; Harvey, 2007).

Table 2.8: A comparison of different vacutug technologies for FS emptying

Technology	Vacutug MK1	Vacutug MK2
First application	Kibera slum, Nairobi, Kenya (1995).	Dhaka, Bangladesh in (1999).
Components of system	500 liter tank, vacuum pump powered by small petrol engine with hose and handcart.	As Vacutug, in two sections with smaller (200 L) tank in one section and a remote 1900 L collection tank
Access width (m)	1.5	>1
Depth (m)	≤ 2	≤ 2
Applying conditions	➢ Areas with a high density of population using pit latrines. ➢ Access corridor of 1.5 m width is adequate. Availability of fuel for the motorized system.	➢ Areas with poor accessibility and narrow corridors between housing units. ➢ Petrol needs to be relatively cheap and easily available.
Current Status	Still in use in Kibera. Largely superseded elsewhere by the MK 2.	In use in more than 10 cities in developing countries.

(Source: Isaias, 2006; Thye *et al*., 2011)

2.8.2 Emptying Practices in Bangladesh

In Bangladesh, both all types of emptying services are privileges that mean manual, semi-mechanical and fully mechanical emptying services (Islam, 2016). A few government offices, such as hospitals, police stations, City Corporation offices, and Municipalities have permanent emptiers who are responsible for pit/septic tank emptying, transportation, and disposal of faecal sludge **(**Repon *et al.* 2015). The emptying, transport and disposal steps of the sanitation service chain are generally conducted by informal workers, with this part of the sanitation sector historically dominated by low caste Hindus, commonly known as 'horijon' or 'sweepers' **(**Repon *et al.* 2015). It has been found that manual emptying of pit/septic tanks is widely practiced but there are few exceptions such as in Khulna City Corporation (KCC) and in Kushtia Municipality (Islam, 2016). There is also manual pit emptying done by sweepers in those areas where the desludging trucks cannot run through the narrow roads (Yousuf and Bashar, 2011). These mechanical systems are funded by international donor/aid organizations for improving the faecal sludge management in the municipalities.

2.8.3 Problems and Difficulties in Emptying and Collection

Pit emptying constitutes a major problem (Frenoux and Tsitsikalis, 2013) in many places, both technically and managerially. FS collection and haulage are particularly challenging (Bosch and Schertenleib, 1985) in metropolitan centers with their often large and very densely built-up, low-income districts. Spillage of faecal sludge during pit or septic tank emptying is prevalent (Frenoux and Tsitsikalis, 2013). Environmental pollution causing health risks is serious. The municipal or private sector service of vacuum trucks to empty septic tanks and pits is often lacking efficiency and reliability and the service costs may be beyond the affordability of the poor knowledge (Muller and Rijnsburger, 1994; Frenoux and Tsitsikalis, 2013).Vacuum-based technologies have experienced difficulties (Harvey, 2007) with various kinds of sludge. Vacuum pumps are unable to deal satisfactorily with dry sludge or solid objects like stones, sticks and other rubbish (Harvey, 2007). This is because the vacuum system depends on the material pumped behaving as a fluid. Thus the density of sludge is an important criterion, though often water is added before emptying starts. Some problems and difficulties are gathered in Figure 2.9.

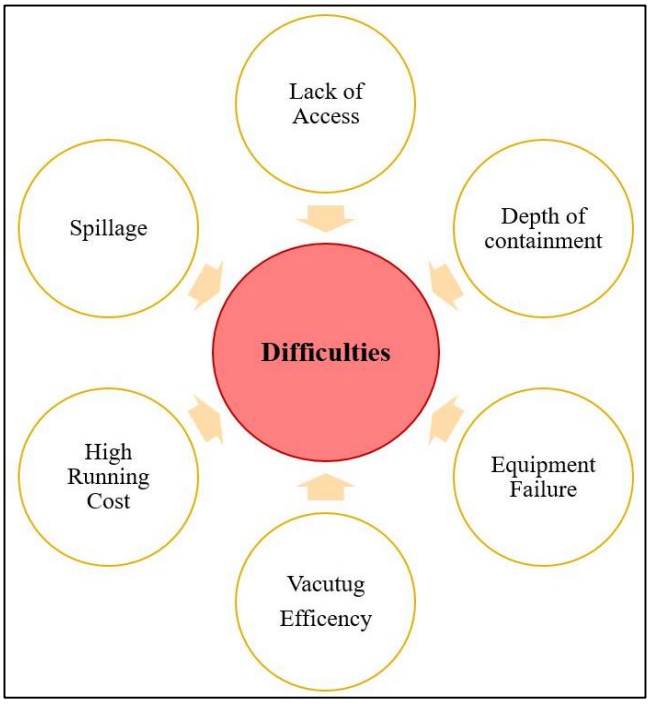


Figure 2.9: Difficulties and possible problems associated with the sludge emptying by vacutug (Source: Harvey, 2007; Montagero *et al*., 2002; Ingelinellina *et al*., 2002)

The inadequate and improper management of FSM impacts on environmental pollution and can cause serious problem both as the people and environment. Table 2.9 shows the current FS emptying practices and its causes, problems, and consequences of Bangladesh.

Table 2.9: Current FS emptying practices: causes, problems and consequences

Current FS Emptying	Causes	Problems	Consequences
Technical	➢ Limited access to pit ➢ Inappropriate emptying equipment ➢ Manual emptying	▪ Overflowing pits ▪ Emptying frequency often very low ▪ Informal or emergency emptying of pits and indiscriminate disposal of FS	At neighborhood level ▪ Health hazards by contamination of water by indiscriminate disposal ▪ Non- functionality of infrequently emptied septic tank
Institutional/ Financial	➢ Poor emptying services ➢ Users low affordability for pit emptying ➢ Lack of information		At emptiers level ❖ Safety issues ❖ Health insecurity ❖ Disposal

2.8.4 Quality of Emptying

Emptying quality is the means the quality of the containment condition and other infrastructures regulations, quality of emptying, always safely for both of workers and environment. Kabir and Salauddin, 2015, classified the emptying quality into five intensive part. These are environmentally safe emptying, safe emptying, partially safe emptying, and unsafe emptying and not ever emptied.

2.8.4.1 Unsafe Emptying

When the environmental pollution (Frenoux and Tsitsikalis, 2013) and a certain health hazard has come to account, then it can be said unsafe emptying. In Bangladesh faecal sludge management is generally provided by individuals or informal private sector operators in an unplanned, unsystematic, unhygienic and poorly regulated way (Repon *et al.*, 2015). The safety of the emptying and collection of sludge was classified according to where the sludge was conveyed after emptying and the type of containment being used. Figure 2.10 shows the point of view for unsafe emptying.

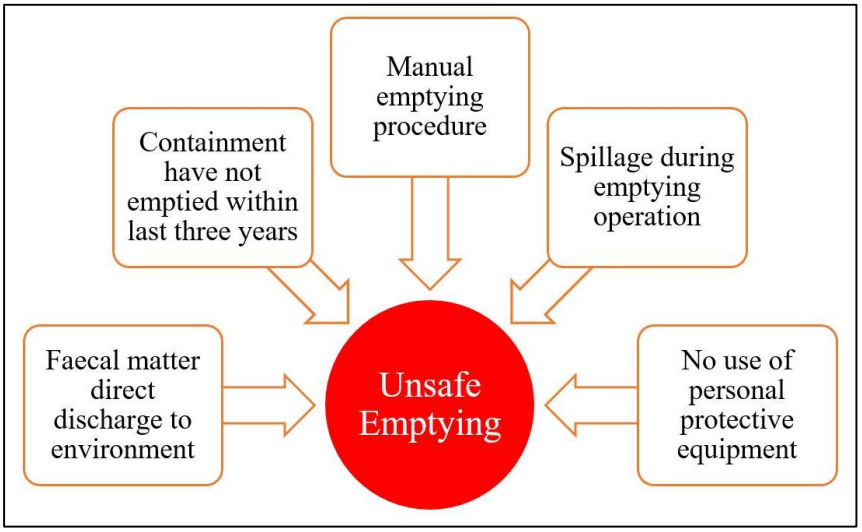


Figure 2.10: Criteria for unsafe emptying (Source: Islam, 2016, Frenoux and Tsitsikalis, 2013)

The lowest level of unsafe emptying or conveyance was recorded when the sludge is directly discharged into the environment (Islam, 2016); pits have not been emptied within the last three years, or emptying is done with someone entering the containment without protective gear. Graefnitz *et al.*, 2012 stated that the willingness to pay is ranging a lot and has been depending on the ability to pay off the pit owner and when the house owner

is unable to high emptying fees, then mainly manual emptying occurs. In Khulna, more than 85% of households practice unsafe faecal sludge emptying and conveyance (Kabir and Salauddin, 2014). The overflow of septic tanks and odor nuisance were reported as other important reasons for de-sludging septic tanks.

Again, fecal sludge management (FSM) has been identified as a major challenge, particularly for the urban areas of Bangladesh. Inappropriate management of fecal sludge is causing environmental pollution and becoming a major health risk. Development of an institutional and regulatory framework for FSM, with clear assignment of responsibilities among the stakeholder organizations/institutions, could be the first major step toward solving the FSM problems (Mujibur *et al*., 2012).

2.8.4.2 Effect of Unsafe Emptying

If a pit is not emptied often enough, FS overflows from the pit and contaminates the household and the surrounding area. It is common for people who do not have enough income to pay for emptying services to carry out the removal by hand, using buckets and limited protection. It is considered to be one of the principal means of breaking the faecal-oral disease transmission cycle (Frenoux and Tsitsikalis, 2013), which is highly associated with the reduction of child mortality (Muller and Rijnsburger, 1994) and a powerful measure to control the transmission of helminth infections (Thye *et al.,* 2011). The risk of faecal matter re-entering the domestic environment remains high, which is a great public health concern (Ingallinella *et al*., 2002; Opel and Bashar, 2006).

2.8.4.3 Safe Emptying

In a development situation, the maintenance of familial latrines often depends on the level of income of a household and whether it can afford private de-sludging services. Safe emptying, transportation, and disposal of sludge are extremely important for public health as well as for the social and environmental benefits it brings (Frenoux and Tsitsikalis, 2013; Thye *et al.*, 2011). The next level, mostly safe, indicates that sludge is not discharged directly into the environment; the containment has been emptied within the last three years (Islam, 2016); someone enters the containment wearing protective gear, or an anaerobic digester was in use. The highest level, environmentally safe emptying, indicates that no one enters the containment; no leakage exists in the sewerage pipe, or

anaerobically digested slurry is disposed of after six months' storage (Frenoux and Tsitsikalis, 2013). Figure 2.11 shows the summarized criteria for the point of safe emptying.

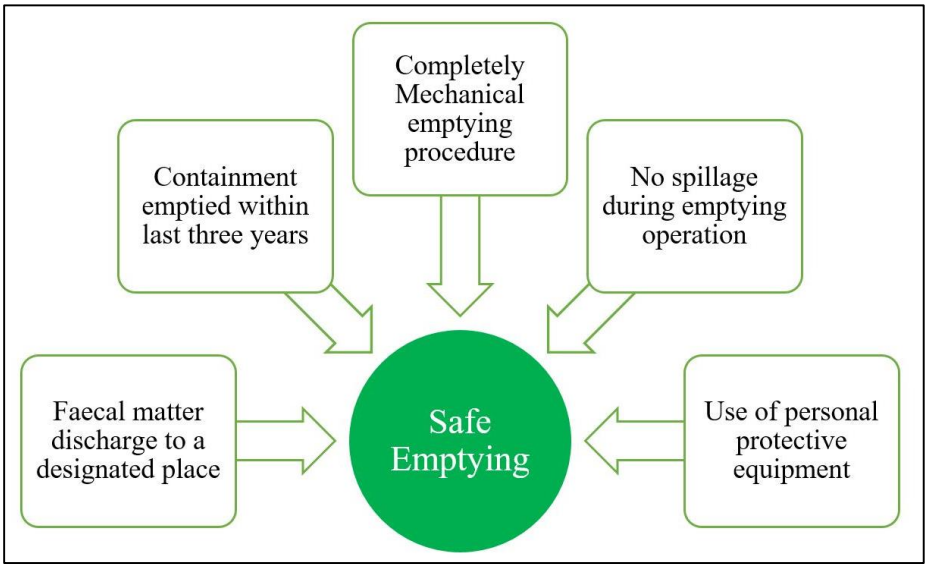


Figure 2.11: Criteria for Safe Emptying (Source: Islam, 2016; Frenoux and Tsitsikalis, 2013)

2.8.4.4 Occupational Health and Safety Issues

FS needs to be considered as a very dangerous substance and therefore requires careful handling. For this reason, health and safety issue during emptying is an important part of FSM. Individuals, small groups of individuals offer manual emptying, traditionally carried out with buckets. Emptiers enter into the pit or septic tank to evacuate the sludge that has generally solidified to be scooped out. Hence, traditional manual emptying is associated with considerable health risks for the emptiers **(**Repon *et al.*, 2015). The general public is also at risk as the emptied sludge is usually deposited into dwelling concessions, nearby surface drains or into lanes (Strauss *et al*., 2002).

Repon *et al.*, 2015 proposed an initiative to develop a guideline on occupational health and safety (OHS) for workers involved in FSM. Its aim was to minimize the risks involved in septic tank/pit emptying. It also explores the issues involved in handling sludge, providing guidance for the protection of workers and the environment, and consolidates knowledge and best practice in this area with regard to limiting disease transmission and contamination.

Despite having some awareness of the dangers associated with their work, the majority of emptiers in Bangladesh work without Personal Protective Equipment (PPE) such as gloves, masks or boots and do not take safety precautions while emptying tanks/pits. Most emptiers work at night to avoid objections from neighbors, while many also drink locally produced alcohol while working, both factors which may further enhance the chances of injury and accidents **(**Repon *et al.,* 2015). If the emptying did by the mechanical emptying device, the Repon *et al.,* 2015 suggested that the containment should typically be no more than 25 meters in linear distance and 4 meters in elevation. In Bangladesh Labour Act, 2006, it has been clearly stated about PPEs mandatory use. However, despite OHS being a key indicator in the maintenance of labor standards and the Bangladesh Labor Act 2006 but the health and safety issues of workers involved in FSM remains broadly ignored.

2.8.5 Responsibilities of Workers Engaged in Emptying and Service Recipients

Repon *et al.* (2015) suggested some proposal for the emptiers about what should be their role in the following;

- Workers engaged in emptying and transportation should be made aware of personal safety and health issues.
- Workers should be encouraged to undertake regular health checks and to always use PPE.
- Workers should be aware of the health impacts of alcohol consumption, and especially the role of alcohol in workplace accidents.
- Sludge discharge into the local environment should be prohibited and workers made aware of its environmental and health impacts.

The responsibilities of service recipients are described below.

- To ensure presence of the head of household or their representative during emptying;
- To practice the emptying twice a year (every six months) or at least once per year as required by the BNBC;
- To teach family members about proper toilet use, with the key message that solid waste should not be disposed of in the toilet;
- To take responsibility to ensure emergency healthcare in the case of an accident during emptying;
- To ensure sludge is disposed of in a designated location selected by the authority.

2.8.6 Alternative Manually Operated Small Mechanical Device

Generally, the emptying of sludge is not possible by vacutug due to some obstacles like that narrow road width, boundary wall etc., that times containment emptying is done by some newly invented alternative technology for emptying. In environments where the streets are too narrow, it is difficult to empty the sludge by large vacuum tankers or simple vacutugs, then the relatively small technologies can be applied that perform better (BRAC, 2015). It is manually operated mechanical devices (Boot *et al.*, 2008). Here it has been discussed three of the most common types of mechanical pumping equipment that has been developed and trialed; namely, the Sludge Gulper, the Manual Diaphragm Hand Pump and the Manual Pit Emptying Technology (MAPET) as shown in Figure 2.12.

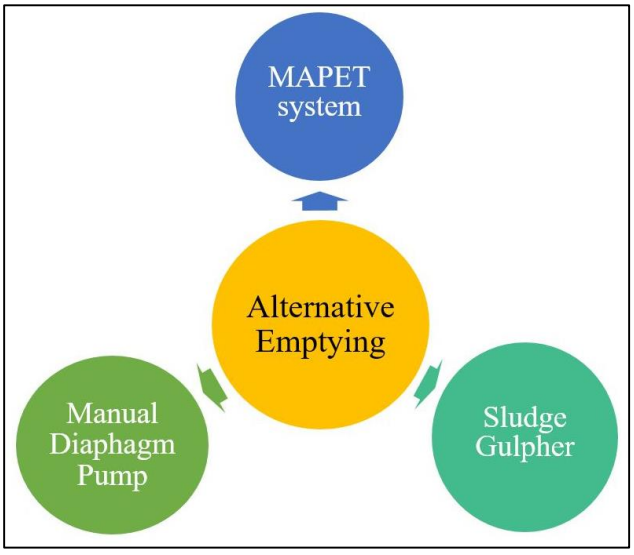


Figure 2.12: Alternative Small Sludge Emptying Device (Source: Boot *et al.*, 2008; Muller and Rijnsburger, 1994)

- ***Sludge Gulper***

Sludge Gulper is a manually driven mechanical system where a hand pump is used lowering down into the pit (Bosch and Schertenleib, 1985) and used to lift the content into a bucket. It was developed by the London School of Hygiene and Tropical Medicine together with Oxfam in Indonesia. The Sludge Gulper appears extremely portable and easily moved around. This is handy, manual and cheap. (BRAC, 2015). The main problem is many plastic and fiber items were in the pits clogging the valves and the screen of the gulper frequently (Graefnitz, 2012).

- ***MDHP (Manual Diaphragm Hand Pump)***

Manual Diaphragm Hand Pump (MDHP) is suitable for pumping low viscosity sludges and maximum flow rate of 100 L/min. Also, the maximum pumping head of 3.5m –4.5m.

❖ ***Manually Pit Emptying Technology (MAPET)***

MAPET is designed and developed by Waste Consultants Netherlands in Nairobi, Kenya (Muller and Rijnsburger, 1994). A MAPET system comprises a hand-pump connected to a vacuum tank mounted on a pushcart. A hose connected to the tank is used to suck sludge from a pit. Depending on sludge consistency, MAPET can pump the sludge from a maximum depth of 3m (Muller and Rijnsburger, 1994; Yarmand, 1998). Table 2.10

Table 2.10: Comparison of manually operated small mechanical equipment

Equipment type	Performance	Purchase/ Operating cost (USD)	Challenges
Gulpher	➢ Suitable for pumping low viscosity sludges ➢ Average flow rates of 30 L/min	➢ Capital Cost: 40-1,400 (depending on design)/ ➢ Operating Cost: Unknown	➢ Difficulty in accessing toilets with a small superstructure ➢ Clogging at high non-biodegradable material content
MDHP	➢ Suitable for pumping low viscosity sludges ➢ Maximum flow rate of 100 L/min ➢ Maximum pumping head of 3.5m –4.5m	➢ Capital Cost: 300 – 850 (depending on manufacturer and model) ➢ Operating Cost: Unknown	➢ Clogging at high non-biodegradable content ➢ Difficult to seal fittings at the pump inlet resulting in entrainment of air ➢ Pumps and spare parts currently not locally available
MAPET	➢ Maximum flow rates of between 10 and 40 L/ min ➢ Maximum pumping head of 3.0m	➢ Capital Cost: 3,000 (1992) ➢ Operating Cost: 175 per annum (1992)	➢ Requires strong institutional support ➢ MAPET service providers unable to recover maintenance and transport costs from emptying fees

(Source: Strande *et al*., 2014)

2.9 Disposal of Faecal Sludge

In low-income developing countries, septic tank and pit latrine sludge is dumped undesignated place and has created a serious environmental problem. The environmental, the economic cost may be substantial in terms of soil, water, and air contamination and pollution, creating health and other risks for aquatic and mammal life (Bosch and

Schertenleib, 1985). If the haulage distance or the traffic congestion is more in the area, it leads to uncontrolled dumping of collected FS at the shortest possible distance from the area of collection (Harvey, 2007). In some instances, the large vacuum tankers also solve the long haulage problem by discharging their contents into the sewer mains (Hawkins, 1982). Where designated discharge sites or treatment schemes are available, a fee is usually charged by private collectors for each FS load delivered to the site. As a consequence, the inhabitants often prefer to dump the waste in non-designated sites to avoid paying the collection fee (Strauss *et al.*, 2002). Table 2.11 describes the best possible impacts and risks caused by indiscriminate disposal of FS.

Table 2.11: Impacts and risks caused by disposal of FS in nature

Impact	Type of Risk
Surface and groundwater pollution	➢ Actual surface water pollution ➢ Potential for groundwater pollution
Transmission of excreta-related infections; occurrence of a high level of pathogens in the urban environment	Potential risk of increased levels of disease prevalence; scientific proof of actual risks attribute to the disposal of untreated FS and high levels of pathogens "floating" within the urban environment
Unpleasant odors and eyesore	Impact felt by those dwelling near the disposal sites and by those passing by

(Source: Hawkins, 1982; Harvey, 2007; Strauss *et al.*, 2002)

The faecal matter is discharged indiscriminately shown in Figure 2.13 as an example into lanes, drainage ditches, onto open urban spaces, into inland waters, estuaries, and the sea, thus causing serious health impacts, water pollution and eye and nose sores (Strauss *et al.*, 2002).

Figure 2.13: Indiscriminate disposal of faecal sludge, Ouagadougou, Burkina Faso (Source: Harvey, 2007)

CHAPTER III

Methodology

3.1 General

The methodology of the study has been described in this chapter. It also represents the steps of the research work process and includes study area selection, sampling procedure, extensive data collection and analysis procedure.

3.2 Methodology

In order to achieve the objectives of the study, the overall methodology being used in this study has been shown in Figure 3.4. According to Figure 3.4, the methodology has been divided into several sections, i.e. study area selection, data collection procedure and data analysis.

3.2.1 Selection and Description of the Study Area

Khulna is the third largest metropolitan city and situated in the south-western part of Bangladesh. Its exact geographical location is 22º 04' 7" to 22º 05' 2" north latitude and 89º 03' 1" and 89º 03' 4" east longitude (KCC, 2017). The area of the total city corporation is 45.65 km^2. The population in this city is about 1.5 million with a density 67994 per km^2 (KCC, 2017).The climate of this city is hot humid during summer and pleasant in winter. The maximum temperature is about 35.5°C during summer and minimum temperature is about 12.5°C during winter (Adhikary *et. al*, 2006). There are two main rivers adjacent to this city, named Bhairab and Rupsha.

Khulna City Corporation (KCC) is the local administrative authority of Khulna city under Local Government Division (LGD). KCC has in total 31 wards with 66,257 holdings (KCC, 2017). In Khulna city on an average, about 49% households are using sanitary water-sealed latrines where average 40% households are using sanitary but non-water sealed latrines (Kabir and Salauddin, 2015). About 10% households on an average have non-sanitary facilities (BBS, 2011).

According to SNV baseline survey statistics in 2014, In Khulna there are only 36.47% households have hygienic sanitation practice, assurance of toilet safety is 34.82% among the residents in Khulna. In terms of functionality, Khulna has 36% residents having functional toilets in use, where 18% have problems in toilet functionality. But from a behavioural perspective, about 43% households are using dedicated hand washing place whereas about 45% households in Khulna have no hand washing station for hygienic sanitation practice. Khulna city corporation area there are 85% of people practice unsafe emptying (Kabir and Salauddin, 2015).

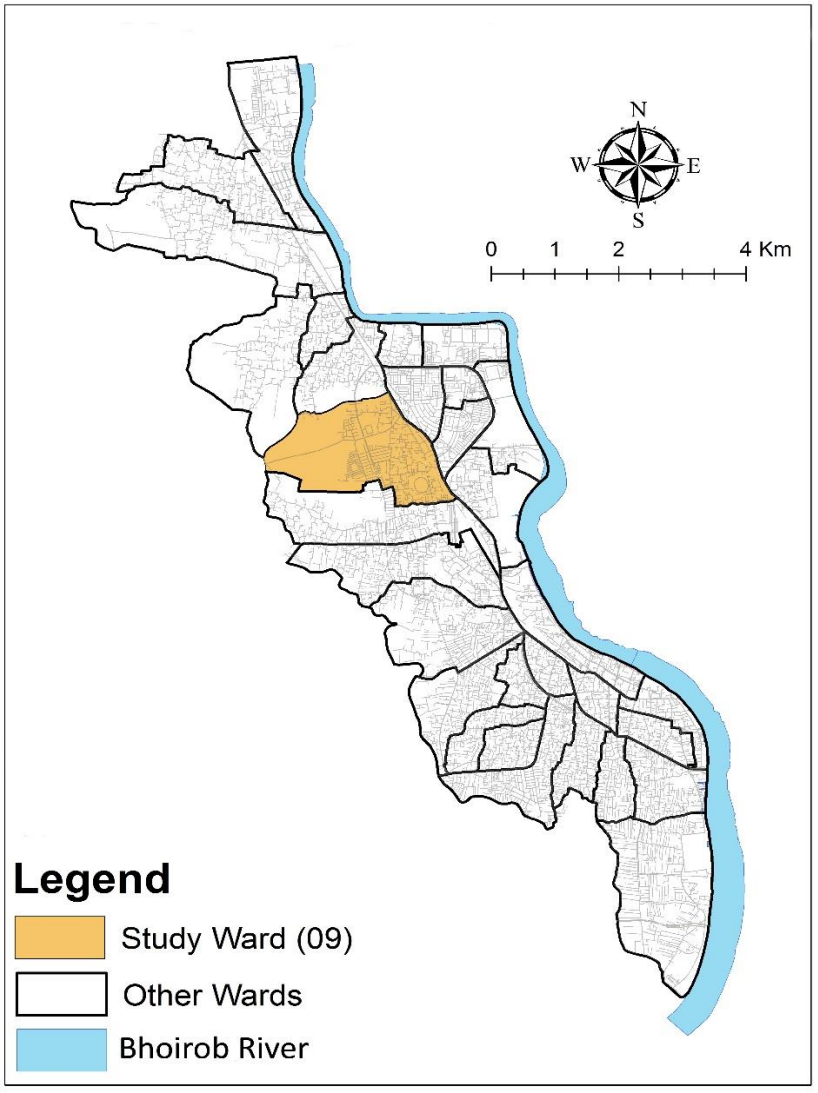


Figure 3.1: Map of Khulna City Corporation (KCC) with study area

Figure 3.1 shows the map of Khulna City Corporation (KCC). This study mainly focuses on the emptying provision and facilities of three different types of settlements. It is the aim to identify the existing containment management practices, also to find the quality of

emptying and finally to propose some respective solutions to achieve safe emptying of three different types of settlements. The first type of settlement is Muzgunni Second Phase as a planned residential area, the second one is Boro Boyra as a mixed-use area and the last one is Rail Junction Bosti as a slum area. This three types of settlements have been found together in Ward No. 09 in Khulna City Corporation as shown in Figure 3.2. For this reason, Ward No. 09 is selected as the study area. According to BBS (2015) and Nabalok (2016), total household of Muzgunni Second Phase, Boro Boyra and Rail Junction slum is 934, 754 and 300 respectively. Also, the population of this area is 3837, 3243 (KCC, 2017) and 300 respectively (Nabalok, 2014).

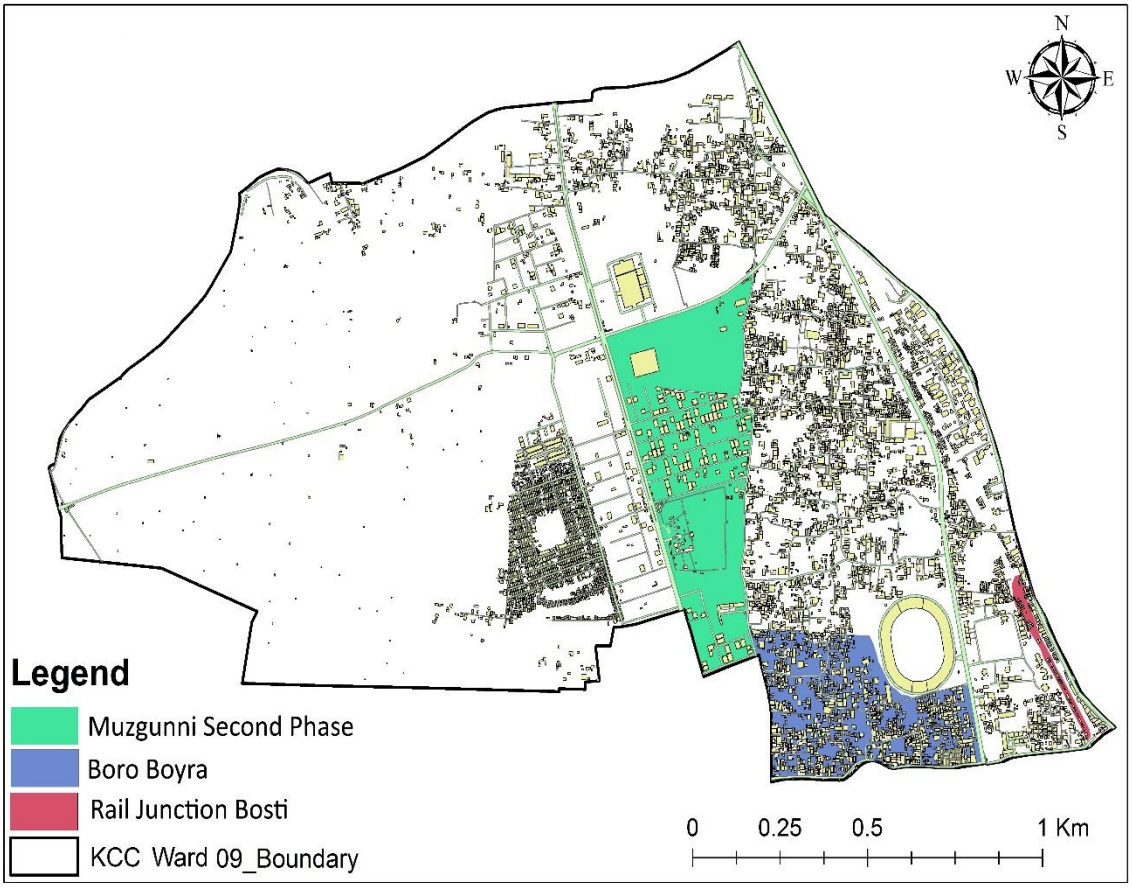


Figure 3.2: Map of Ward No. 09 with specific study areas

Muzgunni Second Phase is a well-planned residential area developed by KDA and people living here are well educated and income level is high than the other two area. According to KCC (2017), approximately 1500 people are living in this area. Again, Boro Boyra is totally unplanned situated beside the Abu Naser Cricket Stadium of Khulna and approximately 5500 people are living in this area (KCC, 2017). And finally, Rail Junction Bosti is situated along the Dhaka-Khulna railway at Boikali and low-income community

are living here. Most of the people are worker, day labour, hawker etc. Currently, 300 households live in this slum (Nabalok, 2014).

3.2.2 Selection Criteria for Emptying Quality and Respective Indicators

SNV baseline statistics in 2014 has been found that the safe emptying does not occur in Khulna city. Therefore, this study aims to find out the quality of emptying. The quality of emptying is divided into five criteria in SNV baseline statistics in 2014. For this study, some modification has been applied to this five emptying quality criteria and further divided into three categories namely unsafe emptying, safe emptying and moderate emptying that means partially safe emptying. The selection criteria for the quality of emptying has been described in Table 3.1.

From the literature, it has been identified that some indicators responsible for the safe or unsafe emptying. It has been mentioned previously that the study area of this research is Ward No. 09 which is sub-divided into three types of settlements named as a well-planned residential area, a mixed-use area, and a slum area. This division is mainly due to identifying what kind of emptying quality exists for this three types of settlements. If unsafe emptying occurs in this settlements, this research will follow up what is the main reason for this unsafe emptying with a respective proposal for its solution. It is the assumption of the research that unsafe emptying is to come for the area.

In this research, the determination the quality of emptying has been linked with containment management section, emptying provision section and the knowledge and perception of the user's section. Some indicators have been selected section-wise to evaluate the existing containment management practices and the quality of emptying of the study area. Again, these indicators have been selected in such a way that it illustrates the risk variables for the users, emptiers, and environment. Some criteria are chosen for each indicator selection like that an indicator must have easily understandable by both literate and illiterate people, easily measurable at the local level, accurately defined, standardized and compatible with data collected elsewhere, scalable.

Table 3.1: Selection criteria for the quality of emptying

Criteria	Description
Safe Emptying	➢ Containment is older than three years have been emptied within the last three years ➢ Totally mechanical emptying procedure and no one entered the containment at any time during emptying ➢ Emptiers used safe emptying devices ➢ Emptiers wore protective gear during emptying ➢ FS is discharged in a designated place or Faecal Sludge Treatment Plant (FTP)
Partially Safe Emptying	➢ Households are aware of the need and frequency (standard) of periodic emptying of FS from the containment ➢ Containment has not emptied within last three years but emptied less than five years ➢ Manual emptying requires someone to enter the containment ➢ No protective gear is worn ➢ Combination use of mechanical and manual procedure to empty the thicken sludge ➢ Containment is accessible by mechanical emptying but lack of willingness to pay for mechanical device ➢ FS does not directly discharge into environment
Unsafe Emptying	➢ Households are not aware of the need and frequency of periodic emptying of FS from the containment ➢ No containment and faecal matter directly discharges into environment ➢ Containment is older and have never emptied or emptied 5 or more years ago ➢ Totally manual emptying procedure without use of Personal Protective Equipment (PPE) ➢ No accessibility of mechanical emptying provision ➢ Spillage during emptying operation

(Adapted from Kabir and Salauddin, 2015; Islam, 2016; Franceys *et al.*, 1992)

Based on the criteria shown in Table 3.1, total fourteen indicators have been selected for the containment management section, emptying section and knowledge and perception of users section. Table 3.2 shows the list of selected respective indicators taken for this research. There are four indicators in containment section, seven indicators in emptying section and three in knowledge and perception section. The research topic mainly deals with emptying part, but when emptying quality is to be determined, emptying part is linked up with containment and user's knowledge and perception.

Table 3.2: Selection of indicators for this research

Sections	Indicators	
Containment (*4 Indicators*)	Containment size	
	Containment condition	
	Containment location & accessibility	
	Containment outlet connection	
Emptying (*7 Indicators*)	Emptying type	
	Emptying service providers	
	Emptying frequency	
	Safety issues	
	Emptying cost	
	Vacutug efficiency	
	Disposal of FS	
Users Knowledge & Perception (*3 Indicators*)	Users Level	Containment infrastructure
		Policy and regulations
		Mechanical emptying provision
	Emptiers Level	Health and safety issues
		Disposal regulations

Table 3.3 shows the detailed illustration of each indicator for which the indicators have been selected. In each section of indicators, the unsafe emptying condition, safe emptying condition as well as partially safe emptying condition has been identified and described. Again the whole concept of the research and how the section wise indicators fulfill the objectives of the research has been shown in Figure 3.3.

Table 3.3: Illustration of indicators

Indicators		Description		
		Unsafe (Score 0)	Partially Safe (Score 0.5)	Safe (Score 1)
Containment	Size	If the FS generation is more than the size of containment, then it is responsible for overflowing and effects on emptying quality. So, size of containment can be an indicator of emptying quality determination. If the containment size less than the user used that containment, termed as unsafe and vice versa is safe. Between this two considered as partially safe.		
	Condition	If the containment is broken, then it is responsible for unsafe emptying. But if the condition of the containment is good, then emptying will be safe from condition perspective.		
	Location & Accessibility	Containment location is somewhere that it is not possible for emptying or very difficult to empty. Sometimes accessibility to the containment during emptying operation depends on the location of containment. Besides, If the containment is not accessible by the vacutug machine then the house owner will go through manual emptying which is mostly unsafe. Accessibility can be meant two things. One is vacutug accessibility to the road or not and another is the distance of the containment from the road.		
	Outlet connection	If the outlet of the containment is connected to the nearby drain or open water body which is responsible for environmental pollution and termed as unsafe. But if the outlet is connected to a soak pit, then in this case emptying is considered mostly safe.		
Emptying	Emptying type	Emptying type affects the emptying quality. If the emptying is done by manual emptying without PPEs, then it is considered unsafe emptying. But emptying is done by vacutug is considered as safe emptying. Emptying by a combination of mechanical (liquid part only) and manual (solid part) is partially safe emptying.		
	Service provider	If the service is provided by mechanical, then it is safe but if emptying is done by private sweepers has been considered as unsafe emptying.		
	Emptying frequency	If the emptying frequency is between 6 months to 1 year according to the BNBC, 2006, it is safe emptying. When emptying frequency is between 3 years then it is moderate emptying and emptying is not done ever or many years ago is considered as unsafe emptying.		

Indicators		Description		
		Unsafe (Score 0)	Partially Safe (Score 0.5)	Safe (Score 1)
	Emptying Cost	Cost of emptying is an important issue for emptying quality. When cost is high for mechanical emptying, then one goes to manual emptying which is cheap and available compared to mechanical emptying. In this indicator, no standard has been made. For this reason, only user's perception is taken into consideration. When the emptying cost is more according to the users, then it will go to unsafe emptying and vice versa. Again if the house owner does not will to pay for improved service, then unsafe emptying occurs.		
	Emptying Efficiency	Emptying quality also depends on vacutug efficiency. If the vacutug is old, mechanical failure occurs during operation and unable to empty solid sludge, then also manual emptying is needed to empty the solid part, is considered as moderate emptying. Again vacutug has limitation to emptying the sludge highest 2m to 3m in elevation. Also if spillage occurs during emptying operation is responsible for unsafe emptying.		
	Safety issues	The safety issue is important for emptying services. If the workers work with PPE is safe emptying but if not is unsafe emptying.		
	Disposal	If disposal occurs at a designated place, then it is safe emptying but if the disposal is done to nearby ponds or drains or river, then it is totally unsafe.		
Knowledge & Perception	User Level	Emptying standard	When the house owner is aware of the regular emptying provision (BNBC, 2006), then it is safe but if house owner doesn't, empty the containment at the serious condition, then unsafe emptying.	
		Policy and regulations	If the house owner knows about the policy and regulations provided by government or stated in BNBC, 2006 or any other rules and regulations in sanitation such that outlet connection of containment, containment infrastructure etc.	
		Mechanical Emptying	If the house owner is aware of the mechanical emptying, then safe emptying otherwise not.	
	Emptiers level	OHS issues	If the emptiers aware of the need of PPEs and use then safe emptying otherwise not.	
		Disposal	If the emptiers are aware of the effects of illegal disposal, then it is safe but if he doesn't then unsafe emptying.	

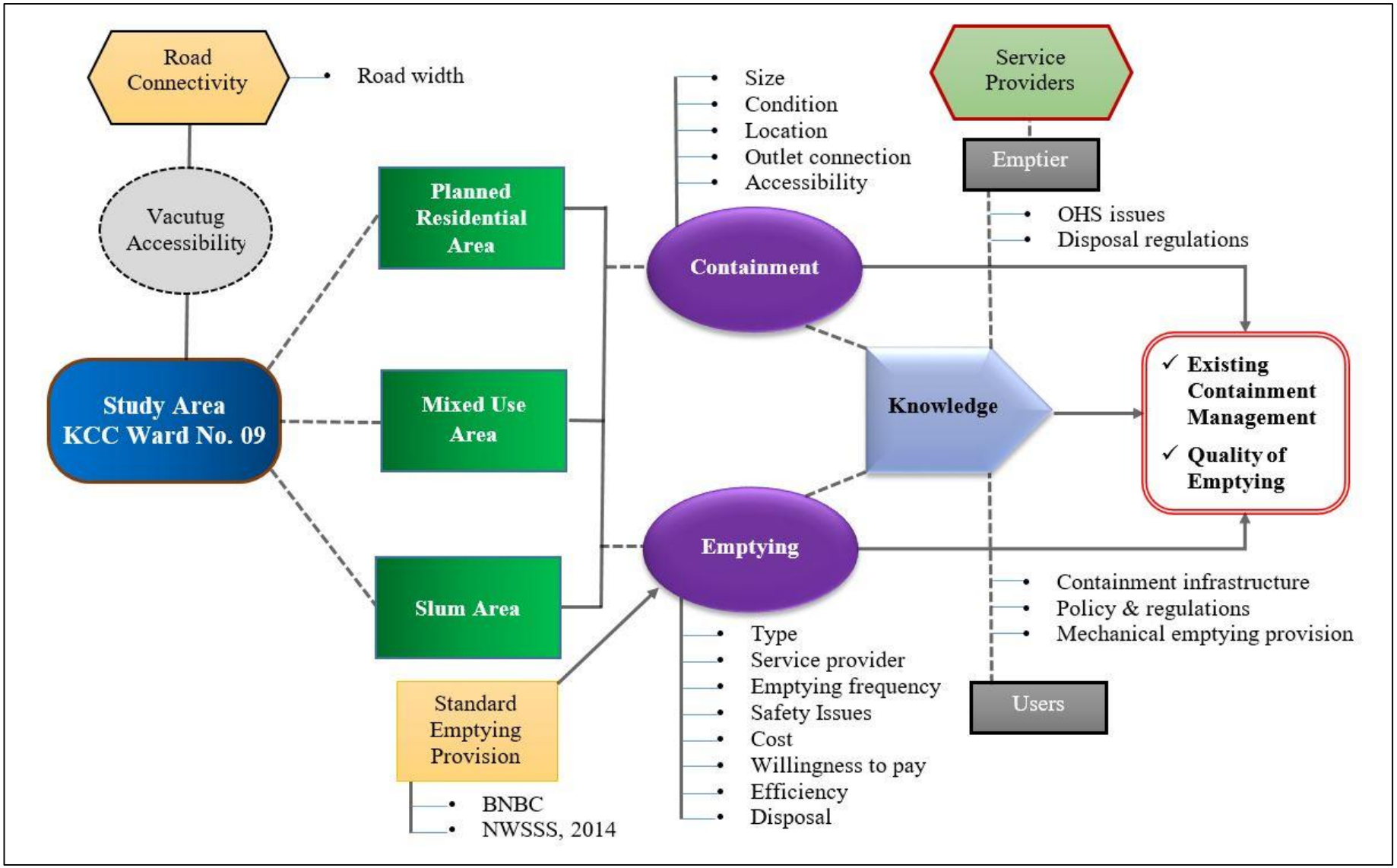


Figure 3.3: Conceptual framework of the research

3.2.3 Analysis Procedure of the Research

The research has been conducted as a mix method research. Because both types of data that mean qualitative and quantitative data have been collected and analyzed in this research. Qualitative data have been gathered from several Key Informant Interviews (KII) from the stakeholders of KCC and Group Discussion (FGD) to the emptiers. Quantitative data have been collected by a series of household surveys by preparing a questionnaire in the study area. The questionnaire has been prepared based on the indicator. The objective wise data collection and methodology adopted has been shown in Table 3.4.

Table 3.4: Research objectives and methodology matrix

Objectives	Data collection and analysis methods
1. To identify the existing on-site containment management practices and emptying process in the study area.	➢ Visual inspections and observations of containment facilities ➢ Quantitative analysis by questionnaire survey ➢ KII to KCC, KDA, and CDC
2. To identify the quality of emptying in the study area by categorizing unsafe emptying, partially safe emptying or safe emptying	➢ Qualitative analysis from KII, FGD ➢ Quantitative analysis by questionnaire survey
3. To find out the problems related to emptying and to propose a respective probable solution.	➢ KII to KCC, KDA, and CDC ➢ FGD with manual and mechanical emptiers

The step by step or the flow diagram of the methodology of this research has been shown in Figure 3.4. This Figure shows how the whole study will be done and after data collection how it has been processed to find the outcomes of the study.

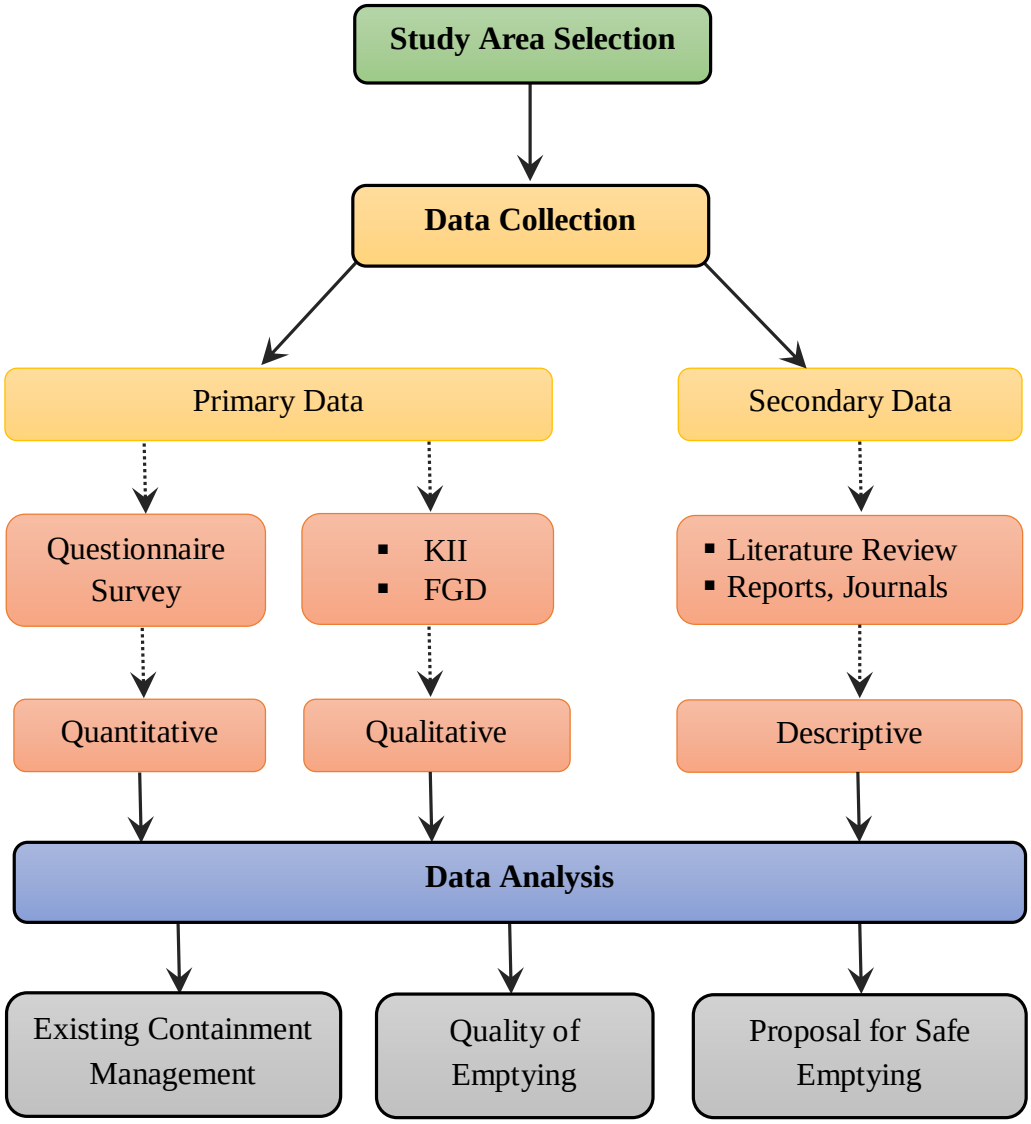


Figure 3.4: Typical steps adopted in this research

3.2.4 Sample Size Determination and Questionnaire Administration

To assess the emptying quality, a questionnaire survey has been conducted based on some indicators of containment, emptying and knowledge, and perceptions of users in the study area. The questionnaire has been prepared in such a way that there are three portions i, e; unsafe emptying, partially safe emptying and safe emptying for each parameter under each indicator. That's why the questionnaire has been prepared into three sections for each question. The first portion of the question is for totally unsafe emptying and will get score 0, then the middle part of the answer is moderate which means partially safe emptying and will get score 0.5. And the last one is for safe emptying which gets score 1. Actually, the households have asked questions with respect to these

parameters. The questionnaire target is the house owner who can give the extensive information about the containment. During the survey, the observation has also made to match the respondent answer and real-world scenarios. Then the answers are validated. Each indicator has several parameters and each variable consists of some indicators. The questions have repeated sometimes to check the consistency of the answers. A sample questionnaire has been appended in Appendix A. Data from questionnaire survey has been analyzed by Microsoft Excel and Standard Package for Social Science (SPSS) software.

The sample size has been calculated based on the total number of containment of the study area. According to SNV, 2016, 141 nos. of septic tank and 18 nos. of pit available for the Muzgunni Second Phase, there are 154 nos. of septic tank and 178 nos. of pit available for the Boro Boyra and 17 nos. of septic tank and 85 nos. of pit available for the Rail Junction Bosti. So, total containment no. of the study area is 593. A stratified random sampling method has been adopted for this study and sample size has determined to assume 95% confidence level and 5% confidence interval. According to Sudman *et. al*, (1982) and www.research-advisors.com, the sample size calculation formula for the whole study area has been shown in Equation No.–1.

$$\textit{Sample Size, } n = \frac{Z^2 pqN}{e^2 (N-1) + Z^2 pq} \qquad \text{---------- } (Eq^n\ 1)$$

Where,
N= Number of household
Z= The nominal variants and which has 1.96 for 95% confidence level
p=0.5
q=0.5
e= 0.05

$$\textit{Total sample size, } n = \frac{1.96^2 * 0.5 * 0.5 * 593}{0.05^2 * (593-1) + 1.96^2 * 0.5 * 0.5}$$

$$n = 234$$

The sample size is adjusted for three types of settlements using that formula. For Muzgunni 2nd Phase as planned residential area, the sample size is

$$\textit{Distributed sample size, } n = \frac{141+18}{234} \times 593$$

$$n = 62$$

Similarly, for Boro Boyra and Rail Junction Bosti, the total sample size is 131 and 41 respectively. The sample size is adjusted for three types of settlements using that formula

and distributed according to the total number of containment of each area. The distributed sample size for each area has been shown in Table 3.5.

Table 3.5: Sample size for each selected area

Area name	Number of containment	Calculated sample size	Distributed sample size
Muzgunni Second Phase	156*	234	62
Boro Boyra	330*		131
Rail Junction Bosti	105**		41

(Source: *****SNV, 2017; ******Nabalok, 2016)

3.2.5 Key Informant Interview and Focus Group Discussion

To collect the emptying service qualitative data, Key Informant Interview (KII) has been done to get the qualitative data for the study area. At first, it is identified the stakeholder who is mainly involved and providing emptying service in Khulna city. KII has been done to KCC, Khulna Development Authority (KDA), Community Development Committee (CDC) and local NGOs. One is KCC conservancy officer, town planner of KDA and managing director of CDC. The main focus of KII of this two stakeholder is to get data about their resources, logistics etc. related to emptying. Also, KII is done to an NGO, SNV Netherlands Development Organization because they are working with FSM for 4 years in Khulna city. They are not connected to directly to emptying service but they provide support to the local authority to help in emptying service. They also organize different types of program i.e.; This KII is done to get knowledge about the ongoing program such as awareness building, demand creating etc.

Simultaneously, Focus Group Discussion (FGD) has been done to both manual emptiers (who emptied the sludge manually) and mechanical emptiers (who emptied the sludge by vacutug). FGD has been done with manual emptiers mechanical emptiers at the sweeper colony at the Ward No. 21. The total respondents are 12 where the number of manual emptiers is 8 and mechanical emptiers are 4.

3.2.6 Data Entry and Analysis Procedure

Two types of data have been gathered during data collection phase of the research. After collection of 234 household information, the data have been firstly processed in Standard Package for Social Science (SPSS) software. The variables have been selected and

identified for the preparation of data input. After completing data input, the data have been transferred to a Microsoft Excel spreadsheet for further analysis. From this extensive data, the percentage of containment, containment suitability, containment overall condition, containment outlet connection, emptying ever or not, emptying type, service providers, frequency, cost, knowledge about regulations etc. have been found. This data covers the first objective of the research.

In the second objective, emptying quality parameters (unsafe, partially safe and safe emptying) have been determined. Emptying Quality has been determined by two way based on indicators of containment, emptying and knowledge, and perception of the users. Firstly, safe emptying, partially safe emptying and unsafe emptying have been identified specifically. This specific emptying quality for each area has been calculated by summing all the unsafe responses, partially safe responses, and safe responses. Again, an overall emptying quality score has been derived by some several steps and by applying priority to each indicator and based on this score according to the priority index table 3.5. And also from this table, the overall emptying quality has been identified based on this score obtained.

This research used the simple colour method to point out the emptying quality intensity (Red, Yellow and Green). The scores have been given accordingly within value 0-1. For category 'Red' the score is given 0 points which indicated unsafe emptying, for category 'Medium' it's 0.5 for partially safe emptying and for 'Green' it's value is 1 point for safe emptying. Actually, for the easiness of the research, such kind of scale is these research indicators are valued using the 0 and 1. Now, the weighted value has been identified by following Equation No.-2.

Level of weighted value for each parameter = (No. of responses for Red × Score 0) + (No. of responses for Yellow × Score 0.5) + (No. of responses for Green × Score 1) divided by a total number of responses for that particular parameter

$$Weighted\ Value\ (WV)_{(n)} = \frac{Res\ (Unsafe)\times 0 + Res\ (Partially\ Safe)\times 0.5 + Res\ (Safe)\times 1}{Nj} \text{ --- } (Eq^{n}\ 2)$$

Where,

$WV_{(n)}$ = *Score of N parameter*

Res = Number of respondents

N_j = *Total number of responses under that parameter* ***'j'***

After determining the weighted value (WV) score for each parameter, then average weighted value (AWV) score for each indicator can be found using the following Equation No.-3.

$$Average\ Weighted\ Value\ (AWV) = \frac{\sum Weighted\ Value\ (n)}{Np} \text{ ---------- } (Eq^n\ 3)$$

Where,

$_n AWV^i_{ind}$ *= Emptying quality score of* N^{th} *indicator*

N_p *= Number of parameter under* i^{th} *indicator*

After determining the average weighted value (AWV) for each indicator, the value has multiplied by prioritizing value 0, 0.5 and 1 according to the table. Then further averaging the value of indicators the final emptying quality score has been found. Since the emptying quality score is being determined using average score of the response and points, the total emptying quality score is thus interpreted as an average emptying quality score. The emptying quality scores are interpreted according to a rule of thumb used by Campos *et. al*. (2015) and Vera (2007). According to these authors emptying quality level 'Unsafe/Partially Safe/Safe' will happen if average weighted value (AWV) score stays between the range ≤ 33 whereas Partially safe level takes score between >33 - ≤67 and finally 'Safe' level possesses to >67 average score.

Table 3.6: Emptying quality priority indexing value

Emptying Quality	Average Weighted Value	Prioritizing Value	Colour Code
Unsafe emptying	0 - ≤ 33	0	Red
Partially safe Emptying	> 33 - ≤ 67	0.5	Yellow
Safe emptying	> 67 - 100	1	Green

Giving priority to each indicator average weighted value, the obtained termed named as prioritized weighted value (PWV). Finally, the individual emptying quality score for each area can be derived by the following Equation No.-4.

$$EQ_{(i)} = \frac{\sum PWV_{ind}}{N} * 100 \text{ ---------- } (Eq^n\ 4)$$

Where,

$EQ_{(i)}$ *= Emptying quality score of 'i' variable*

N = Total number of indicator under

An example can make it easy to understand the whole calculation process. Suppose, a study area has 50 number of households. Then the total response number will be 50. Assuming that the respondents have used the all 50 responses (not exactly necessary to respond all 50 all time) to identify the quality of a parameter. Suppose, 21 people told about Green, 13 people used Yellow and 16 people told about Red to describe the specific parameter. So, the emptying quality for this parameter is 0.55 found from Equation 2.

$$\frac{(16\times 0)+(13\times 0.5)+(21\times 1)}{50} = 0.55 \text{ or } 55\%$$

Suppose, containment size indicator has four parameters (four questions) and value for this four parameters comes at 0.55, 0.42, 0.31 and 0.35. Then the next step is to average this four parameter score according to Equation No.-3. The results then come

$$\frac{0.55+0.42+0.31+0.35}{4} = 0.41$$

Then the priority of the indicators is given to each indicator value according to the Table 3.6. Suppose, in containment section, the average weighted value (AWV) for four indicators are found 0.41, 0.26, 0.59 and 0.78 respectively for containment size, condition, accessibility, and outlet connection. Then the overall emptying quality score has been found by prioritizing and further averaging by a total number of parameters.

$$\frac{0.41*0.5+0.26*0+0.53*0.5+0.72*1}{4}*100 = 29.75$$

The result has been found as 29.75 which indicates unsafe emptying according to Table 3.6. The total process follows to evaluate emptying quality for each area which indicates what kind of emptying prevails for the area.

3.2.7 FSM Situational Assessment Tool

Situational Assessment is a systematic process of assessing the present situation of faecal sludge management in order to identify the problems and possible solutions with the aim of better FSM situations in the future. This includes identification of the key factors causing the problems, recognition of possible solutions and establishment of baseline information for prioritizing goals and objectives. Thus, the assessment helps to identify the conditions that need to be addressed in order to obtain more effective planning in the future (AIT, 2016).

FSM situational assessment tool is a tool of FSM toolbox which is developed by AIT team of Thailand. The Situational Assessment Tool in the toolbox is moderately data intensive and has been designed to analyze the existing FSM practices and to plan for better FSM by addressing the needs of 'informed users'. This tool is an Excel-based data entry form with 9 tabs, labeled as Introduction, General, Containment, Emptying, Transportation, Treatment, Reuse, Dashboard and monitoring aspects of FSM for the entire FSM chain. The tool is applicable to areas where households are installed with On-site Sanitation Systems (OSS) and it is not applicable to areas which are totally sewered or are provided with centralized sewage treatment plant.

The tool not only allows users to assess the overall situation of FSM in a designated area but also helps users assess any specific FSM chain component depending upon users' interest and/or problems in their interested area. In a nutshell, the Situational Assessment Tool has three main objectives:

- Identify and recognize problems in present FSM situations
- Assess present FSM situations and report the status of FSM along with the service delivery pathway
- Identify each service component's situation or performance level in the form of colored indicators

This tool follows the weighted average to calculate the results. The weighted average is an average resulting from the multiplication of each quantity which is averaged by certain weight reflecting its relative importance or significance. The average result is summed, and the total is divided by the sum of the weights as shown in Equation No.-5.

$$Weighted\ Average = \frac{\Sigma(Score \times Weight)}{Total\ Weight} \text{---------- } (Eq^n\ 5)$$

To provide a score of each question, it follows open-ended questions. The score of 1, 0.5 or 0 is chosen for three-option answers based on the literature reviews. For three-option answers, the score of 1 is given to the option 'Yes' ('best possible answer'), the score of 0 is given to the option 'No' ('with considerable scope of improvement') and the score of 0.5 is given to the option 'In-process' ('with a moderate scope of improvement'). Therefore, finally, overall results will be shown on the dashboard by the color chart.

CHAPTER IV

Results and Discussion

4.1 General

This chapter describes the output and findings of the research. It also reveals elaborately the existing containment management practices, emptying process investigation, emptying quality determination and finally identifying the problem associated with the containment management with probable solutions. Also, the comparison has been shown for among the three study areas based on the objectives of the study.

4.2 Sanitation Characteristics of the Study Area

The Ward No. 09 of Khulna City Corporation (KCC) has been selected as the study area. This Ward is selected due to the three different types of settlements i.e. residential, mixed-use and slum area have found in this ward in combined. It helps to compare the existing containment management practices, emptying quality score as well as lacks among these areas.

A total 234 households have surveyed during the data collection of this research where the household head is the main target. The respondents are mostly women compared than the male during survey time. In most of the cases, the respondents are free-flowing to give the answers but some of the respondents are unwilling to give information.

Table 4.1 shows a summary of the responses against each indicator of this research collected from the questionnaire. Based on this table, further analyses have been made. The values represent the number of respondents given responses to the particular questions including the observation answers. Not in every case, the 234 households have responded. There are missing values which means either the households are unable to answer those questions or observation did not find anything matching like that. But in these cases, the other corresponding answers are taken into count which made all the questions answered in anyways. Hence, the total number of respondents or responses is not equal in every section.

Table 4.1: Basic sanitation information of the study area

Study Area Name				***Muzgunni Second Phase***	***Boro Boyra***	***Rail Junction Bosti***
Types of Data				***No. of Respondents***		
Section: Containment						
Indicator 1: Containment Size						
1	Type of containment	Pit	Single pit	0	16	23
			Twin pit or more	0	20	8
		Septic tank		62	95	10
2	Number of chambers	1 Chamber		0	16	1
		2 Chambers		17	42	3
		More than 2 chambers		45	37	6
3	Containment size	Size is less than needed		1	8	4
		Size is optimum		11	25	20
		Size is suitable and enough		50	98	17
4	Permission for construction of the septic tank	No		14	33	5
		Neutral		8	18	0
		Yes		40	44	5
5	Design of septic tank	No		16	39	5
		Neutral		8	20	0
		Yes		38	36	5
Indicator 2: Containment Condition						
6	Leakage	Yes		10	15	3
		Neutral		5	31	14
		No		47	85	23
7	Overflow	Regularly overflow at any season		0	4	9
		Overflows during rainy season		9	51	13

Study Area Name			*Muzgunni Second Phase*	*Boro Boyra*	*Rail Junction Bosti*
Types of Data			*No. of Respondents*		
		Don't overflow at any time	53	76	19
8	Type of problem	Major problem	0	21	4
		Minor problem	12	18	19
		No problem	50	92	18
9	Frequency of problem faced	Regular	0	0	0
		Often	1	28	15
		Never	61	103	26
10	Condition of cover slab	Broken	0	2	12
		Partially broken	2	57	13
		Good	60	72	16
11	Frequency of checking	Not check ever	51	129	39
		Check sometimes	11	2	2
		Regular check	0	0	0
Indicator 3: Containment Location & Accessibility					
12	Road type	Katcha	0	0	41
		Semi Pucca	6	84	0
		Pucca	56	47	0
13	Road width	< 10 ft	0	84	41
		≥ 10 ft - < 20 ft	43	47	0
		≥ 20 ft	19	0	0
14	Distance of containment from road side	> 25m	4	41	41
		≥ 25m	58	92	0
15	Containment position from the road side	Rear	0	62	25
		Side	8	64	16
		Front	54	5	0
16		Yes	1	79	24

Study Area Name			*Muzgunni Second Phase*	*Boro Boyra*	*Rail Junction Bosti*
Types of Data			*No. of Respondents*		
	Any obstacles to get the containment off the road	Neutral	8	7	16
		No	53	45	1
Indicator 4: Containment Outlet Connection					
17	Soak well	No	58	91	10
		Yes	4	4	0
18	Outlet connection	Outlet is connected to stagnant water body	5	7	2
		Outlet is connected to drains	53	84	8
19	Material go through the outlet	Water + FS	10	39	4
		Only water	52	52	6
		Nothing goes through the outlet	0	0	0
20	Knowledge about regulations of outlet connection	Don't know	47	89	10
		Neutral	14	2	0
		Yes	1	4	0
Emptying					
Indicator 5: Emptying Type					
1	Ever emptying of containment	Doesn’t emptied more than 5 years	7	21	17
		No	29	34	4
		Yes	26	76	20
2	When emptied last time	Containment was full	23	64	20
		Containment was nearly full	2	7	0
		Containment was not full	1	5	0
3	Understanding that containment was full	Overflowing/Spreading foul odor	24	72	20
		Because of regularly check	2	4	0
4	Action taken	Nothing to do/Close the pit	0	2	2

Study Area Name				*Muzgunni Second Phase*	*Boro Boyra*	*Rail Junction Bosti*
Types of Data				*No. of Respondents*		
		Empty if have money		3	5	3
		Empty immediately		23	69	15
5	Containment emptying process	Manually		18	65	20
		Mechanically		8	11	0
6	Time was taken to get the service	Service did not provide within 24 hours		6	3	18
		Service was provided within 24 hours		20	73	2
Indicator 6: Emptying Service Provider						
7	Emptying service provider	Manually	Private sweepers	15	60	17
			Self	0	2	3
			KCC manual boggy service	3	3	0
		Mechanically	KCC Vacutug service	2	3	0
			CDC Vacutug service	6	8	0
8	In future, depending on which service provider	Manually	Private sweepers	32	87	38
			Self	0	2	3
			KCC manual boggy service	6	13	0
		Mechanically	KCC Vacutug service	5	10	0
			CDC Vacutug service	19	19	0
9	Facing problems from the emptiers	Yes		10	61	3
		No		16	15	17
Indicator 7: Emptying Frequency						
10	Emptying frequency	More than 3 years		17	47	7
		Equal or less than 3 years		2	8	3
		Once in a year		0	2	6

Study Area Name			*Muzgunni Second Phase*	*Boro Boyra*	*Rail Junction Bosti*
Types of Data			*No. of Respondents*		
Indicator 8: Emptying Cost					
11	Approximate emptying cost (BDT)	Manually	1700-2000	1500-1700	700-1000
		Mechanically	3000-3500	2500-3000	N/A
12	Satisfaction level	Dissatisfied	12	21	7
		Neutral	0	0	4
		Satisfied	14	55	9
Indicator 9: Safety Issues					
13	Entering into the containment	Yes/Don't know	11	29	2
		Neutral	0	0	0
		No	15	44	1
14	Enforcing to the emptiers to enter into the containment for solid part extraction	Yes	0	2	0
		Neutral	0	1	0
		No	26	72	3
15	Using of PPE during emptying	No/Don’t know	24	74	20
		Use but not sufficient	2	2	0
		Yes	0	0	0
16	Spillage during emptying	Yes/ Don't know	17	60	15
		Partially	1	7	3
		No	8	9	2
17	Harmfulness of spillage	No/ Don't know	11	2	17
		Neutral	0	13	1
		Yes	15	61	2
Indicator 10: Vacutug Efficiency					
18	Emptying by vacutug	No	1	4	0
		Yes	7	7	0

Study Area Name			*Muzgunni Second Phase*	*Boro Boyra*	*Rail Junction Bosti*
Types of Data			*No. of Respondents*		
19	Vacutug failure during emptying	Yes	0	0	0
		No	8	11	0
Indicator 11: Sludge Disposal					
20	Designated place for sludge dumping	Disposed to nearby river/ponds/drain	24	69	19
		Buried in HH plot	0	4	1
		Disposed to FTP	2	3	0
21	Final disposal place of FS	No	53	121	41
		Don’t know	0	0	0
		Yes	9	10	0
22	Knowledge about FTP in Khulna	No	55	129	41
		Yes	3	2	0
23	Reusing of FS	Don’t know	41	122	39
		Not sure but having a little bit knowledge	6	4	1
		Yes	15	5	0
Users Knowledge and Perception					
Indicator 12: Containment Infrastructure					
1	Necessity of taking permission from the authority	No	4	8	16
		Neutral	16	13	6
		Yes	42	110	19
2	Containment is structured properly	No	5	15	0
		Yes	57	116	10
3	Regulations of outlet connection	Don't know	47	89	10
		Neutral	14	2	0
		Yes	1	4	0

Study Area Name			*Muzgunni Second Phase*	*Boro Boyra*	*Rail Junction Bosti*
Types of Data			*No. of Respondents*		
Indicator 13: Emptying Standard					
4	Importance of emptying the containment in due time	No	3	11	40
		Yes	59	120	1
5	Harmfulness of manual emptying	No	7	5	16
		Yes	55	126	25
6	Regulations of emptying frequency BNBC (6 months to 1 year)	No	62	131	41
		Yes	0	0	0
Indicator 14: Mechanical Emptying Services					
7	Knowledge about the vacutug service in Khulna	No	33	108	40
		Yes	29	23	1
8	Safety of mechanical emptying	No	1	3	31
		Yes	61	128	10
9	Eagerness to empty by mechanical emptying device	No	5	12	19
		Yes	57	119	22

4.3 Existing Containment Management Practices at the Study Area

To evaluate the existing containment management practices in the three types of study areas, extensive data collection and analysis has been conducted. Different management types issues i.e. containment types, containment suitability, containment outlet connection, ever emptied or not, emptying types, emptying service providers, emptying cost, emptying frequency, safety issues, disposal facilities and also the knowledge and perception of the users etc. component of the research have been revealed and compared among the three study areas in this section.

At first, the containment types have been shown in Figure 4.1. About 62 No. household have been surveyed in the residential area and found that all the containment is the septic tank. On contrary, both the septic tank and the ordinary pit has been found in the mixed-use and the slum area. In the mixed-use area, total 131 respondents have been surveyed where the number of septic tanks is more than the pit latrine. About 73% of containment is septic tanks and remaining 27% is pit latrine in this area where the single pit is 12% and the twin pit latrine or more is 15%.

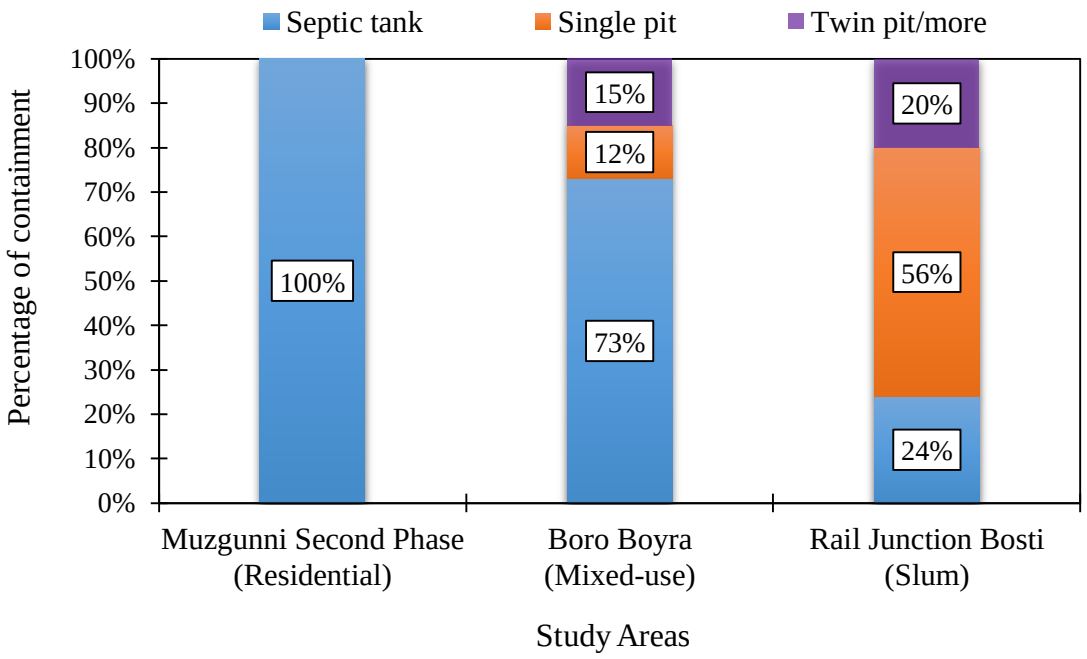


Figure 4.1: Containment types of the study areas

In the slum area, total 41 households have been surveyed and found that where the number of pit latrine is higher than septic tank. About 76% of containment has been found as pit

and only 24% is septic tank. In pit latrine, the single pit is 56% and twin pit is 20%. In slum area, the low-income community is living here and most of the people are day labour. They live in a house like a hut and have not the ability to construct a septic tank. For that reason, the number of pit latrine is more than the septic tank. Only ten septic tank has been found among total 41 respondents in the slum. But in this 10 septic tanks, 5 of them have been built personally and the rest 5 are community-based toilets which are built by a local NGO Nabalok in 2015. There are three toilets per septic tank in this community-based toilets and users per septic tank are 40-45 persons.

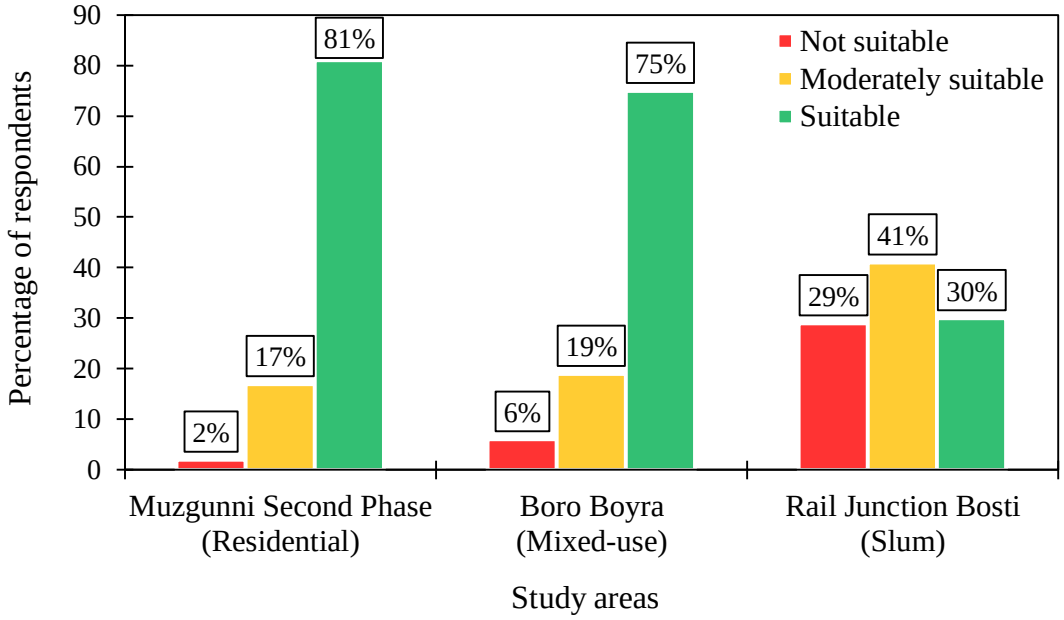


Figure 4.2: Containment size suitability of the study areas

Figure 4.2 represents the containment suitability of the study area and it is classified into three categories namely suitable, moderately suitable and not suitable. When the containment size is less than the size needed according to the number of users is termed as not suitable containment. But when the size of containment is optimum, termed as moderately suitable and if the containment has enough according to users said to be suitable. Containment size is determined by the field observations. Where theoretically the size is found by the number of users multiplying by the per capita accumulation rate and then matching with the previous one.

Finally, the containment size suitability is calculated by the combined scoring of no. of the user, permission was taken from the authority, proper design and faultiness from the containment size indicator (Indicator No.-1) in Table 4.1. From the Figure 4.2, it has been

seen that the majority of the containment is suitable where only 2% of containment is not suitable. Almost same criteria have been found in the mixed-use area where about 75% of containment is suitable, 19% is in moderately suitable and 6% is not suitable. Similarly, 49% of containment is suitable, 41% is in moderately suitable and rest 10% is not suitable for the slum. In the slum, the percentage of containment unsuitability and moderate is more than other two area.

Figure 4.3 represents the containment condition of the selected study area. It is found by the combined scoring of leakage of containment, overflow of containment, the frequency of facing a problem, types of the problem, the condition of the cover slab of containment from the containment condition indicator (Indicator No.-2) in Table 4.1. To describe the containment condition, it has been classified into three categories e.g. good, moderate and poor. Containment is in good condition means the containment is structurally safe, have not any leakage, doesn't overflow during any season, no problem faced, etc. which can be considered as safe. Containment is in poor condition means the containment is structurally unsafe, the cover slab is open and broken, having leakage, overflowing in all season, frequently problem faced, etc. which can be considered as unsafe. And finally, containment is in moderate condition means the containment is between in good and poor condition.

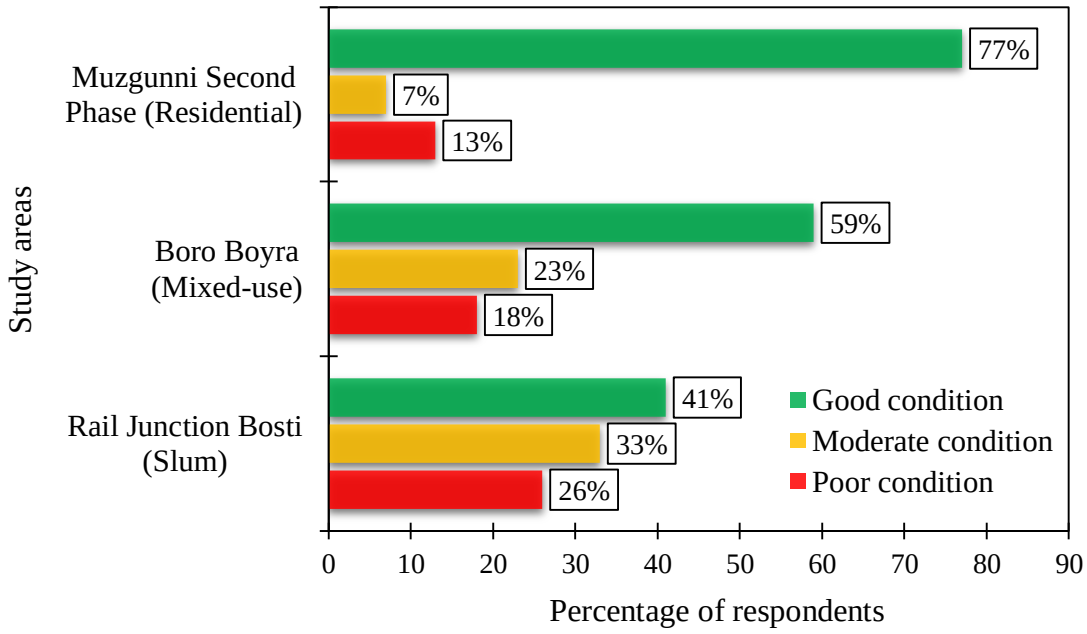


Figure 4.3: Containment condition at the study areas

From the Figure 4.3, it is seen that containment condition is found good in most of the household in almost all three types of area. About 77% of containment are in good condition, 10% are in moderate and 13% are in poor condition in the residential area. Similarly, it shows that 59% of containment are in good condition, 23% are in moderate and 18% are in poor condition at the mixed-use area. And in the slum area, it has been shown that 41% of containment are in good condition, 33% are in moderate and 26% are in poor condition. It is obvious that the condition of containment is better in Muzgunni Second Phase and worst in Rail Junction Bosti.

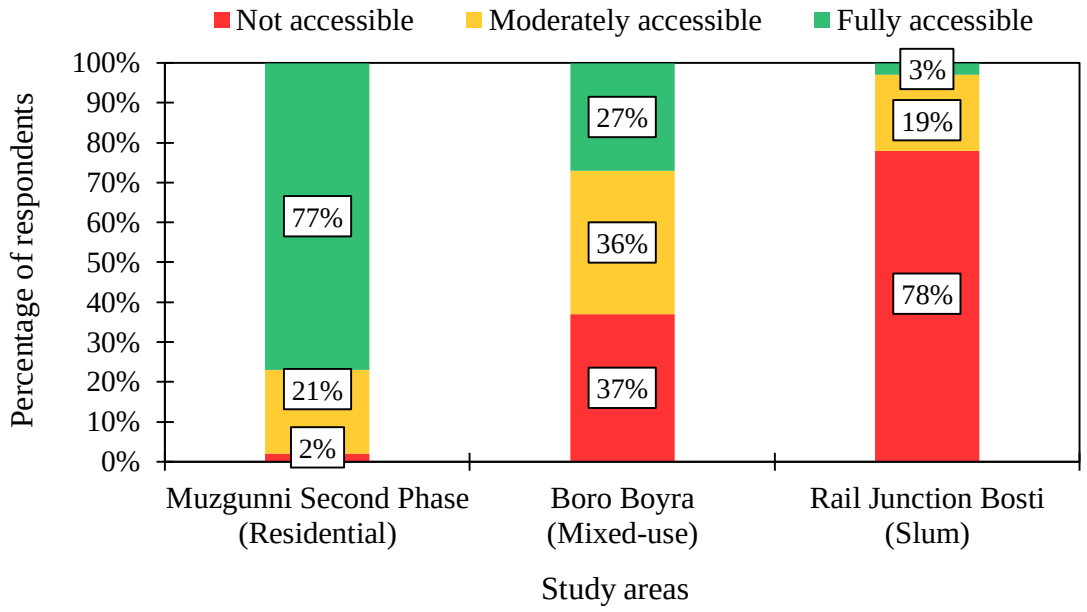


Figure 4.4: Containment accessibility for mechanical emptying at the study areas

Figure 4.4 represents the containment is accessible or not for the mechanical emptying operation of the study area. It is determined by the combined scoring five variables i.e. types of road, road width, the distance of containment from the road, the location of containment of the building and any obstruction to get the containment during emptying. From this Figure 4.4, it has been found that most of the containment are accessible for emptying operation both manually and mechanically at the residential area where 77% of containment are easily accessible, 21% of containment are moderately accessible or partially accessible that means containment is accessible by removing some removable obstacles and around 2% of containment are not totally accessible for emptying operation. The main cause for not accessible is narrow road width or the long distance from the roadside or the non-removable obstacles to get the containment.

Similarly, for the mixed-use area, it is observed that 37% of containment is not totally accessible for emptying where 36% and 27% of containment are accessible moderately and easily accessible respectively. The AB Siddique road and Jhurivita road in the mixed-use area is not fully accessible for vacutug entry due to its narrow road width and some of the containment is situated long distance from the roadside. For this reason, the percentage of accessibility has been decreased. In the slum, 81% of containment is not totally accessible because this slum is situated beside a rail line and the people use rail line as their road. A small portion of the slum beside a road in which a vacutug can get an entry. For this reason, most of the containment are inaccessible for mechanical emptying. About 19% of containment are moderately accessible and 3% are fully accessible.

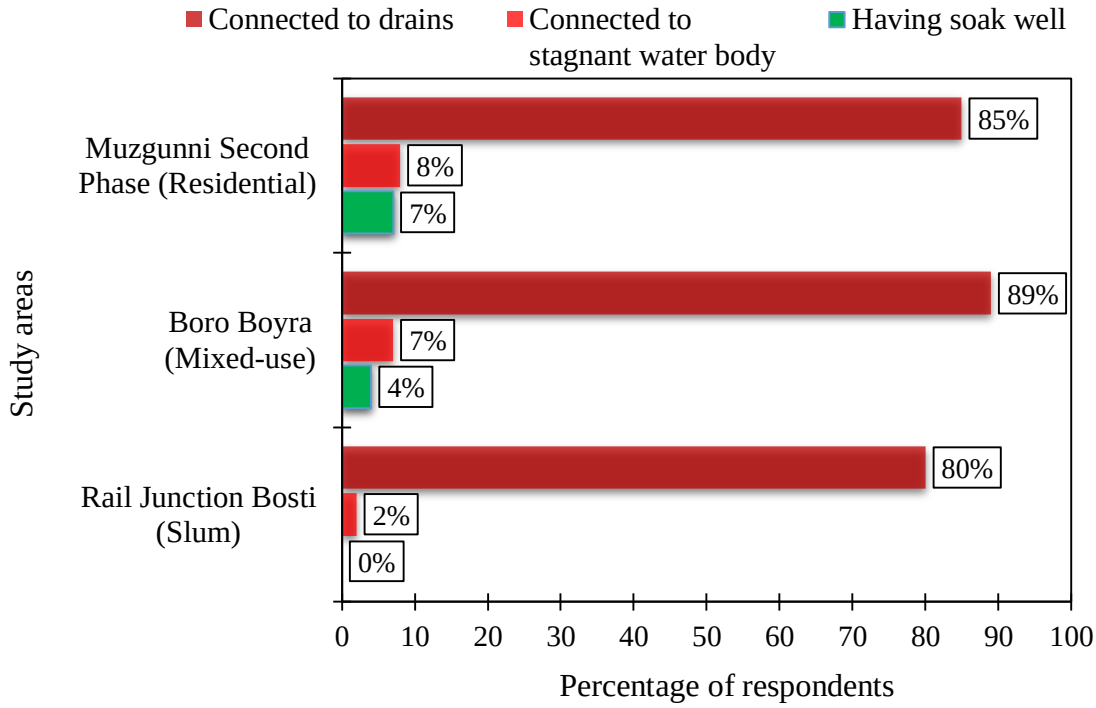


Figure 4.5: Septic tank outlet connection at the study areas

One of the main issues of containment management indicators is outlet connection of septic tank and Figure 4.5 shows for the same of the study area. There is no sewerage facility in Khulna City. For this reason, most of the containment is connected to nearby drains or stagnant water body. There are 85% of containment connected to drain and 8% to ponds or stagnant water body in the residential area. A small number of the septic tank has soak well and its quantity is only 7%. On contrary, a total 131 respondents are surveyed and found that most of the septic tanks (89%) are connected to roadside drains and about 7% of the septic tank is connected to stagnant water body as shown in Figure

4.5. Like as the residential area, a small number of the septic tank have soak well and it is only 4%. For Rail Junction Bosti area, it has been found that no septic tank have soak well except the community-based toilets septic tank. Similarly, as the residential and the mixed-use area, most of the septic tank is connected to nearby drains and it is about 80%.

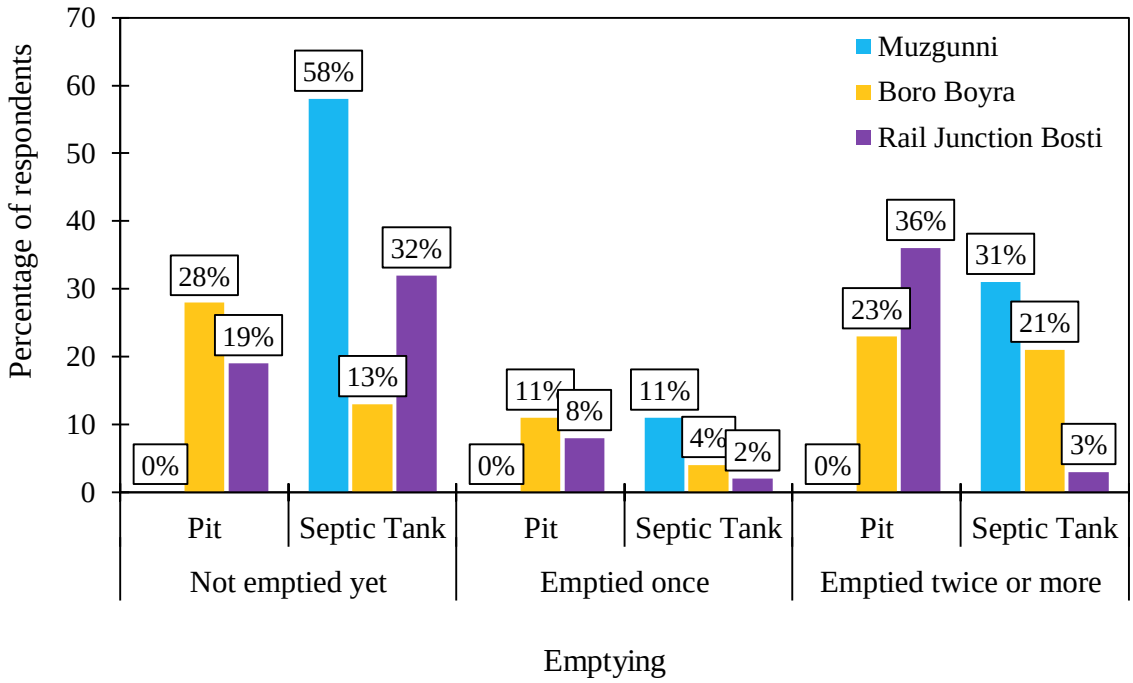


Figure 4.6: Containment emptied ever or not in the study areas

Figure 4.6 represents the containment emptied ever or not for the study area. About 58% of respondent have emptied their containment yet where 11% are emptied once and 31% are emptied twice or more times at the residential area. In this area, most of the septic tank is big and suitable according to the number of users. For this reason, it takes a long time to fill up and the respondent do want to empty until it completely fills. Again, some user linked their septic tank to nearby drain in such a way that they do not need to empty ever because all of the sludge go to drain through the outlet connected pipe. But in the mixed-use area, emptying percentage has slightly increased and it is 44%. Similarly, in the slum area, 51% of respondent have not taken emptying service ever, 10% are emptied once and 39% are emptied twice or more times.

Emptying types of containment have been shown in Figure 4.7 and it is seen that most of the containment have emptied manually emptying process in all of the three types of the study area. It also shows that a big portion of people are not emptied their septic tank in

the residential area and its quantity is 58%. This cause is most of the respondents building is new and age of these building is about 6-8 years. On contrary, 42% of the septic tank is emptied. The manually emptying process is 29% and the mechanical process is 13%.

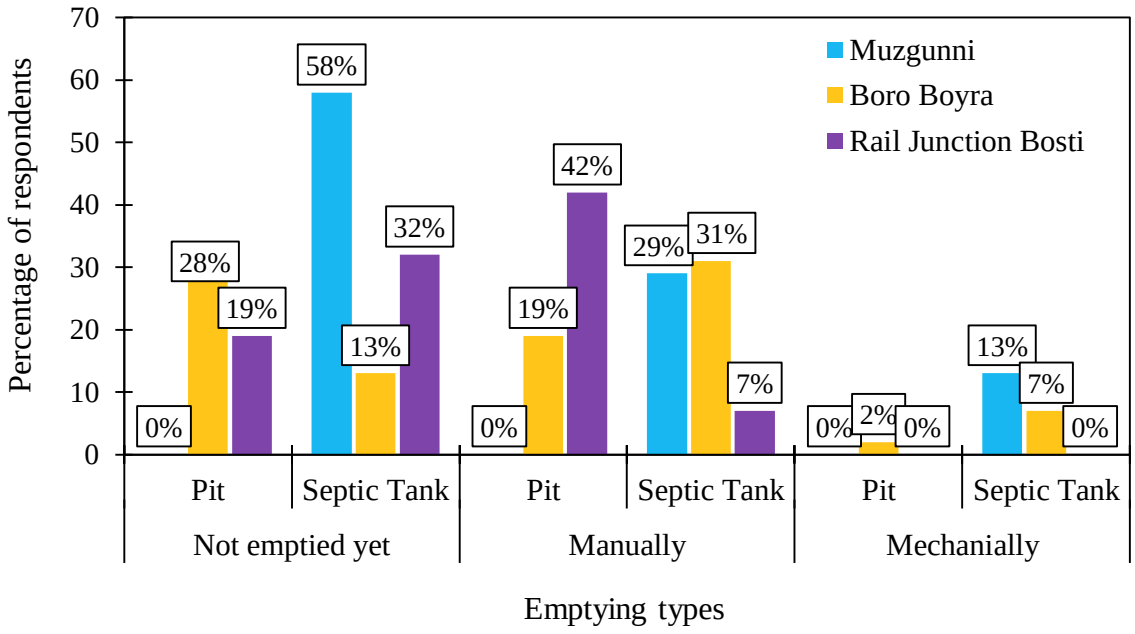


Figure 4.7: Emptying types of containment in the study areas

In the residential area, about 47% of people know about the mechanical service of emptying but the respondent is not willing to empty their septic tank by a mechanical process. It has been also identified that the average cost for manual emptying process and mechanical emptying process is approximately 1700-2000 BDT and 3000-3500 BDT respectively. Again, from the Figure 4.7, at the mixed-use area, 41% containment have not emptied yet where 19% of the pit and 31% of the septic tank have emptied manually. Again the percentage of mechanical emptying is very low in this area and 2% of the pit and 7% of septic tank emptied mechanically. The average cost for manual emptying process and mechanical emptying process is found approximately 1500-1700 BDT and 2500-3000 BDT respectively. Table 4.2 shows the average emptying cost at the study areas.

Table 4.2: Approximate cost of emptying at the study areas

Emptying types	Approximate cost of emptying (BDT)		
	Muzgunni Second Phase	Boro Boyra	Rail Junction Slum
Manual emptying	1700-2000	1500-1700	700-1000
Mechanical emptying	3000-3500	2500-3000	N/A

Similarly, at the slum area, 51% containment have not emptied ever where 42% of the pit and 7% of septic tank emptied manually. No mechanical emptying is occurred in this area due to vacutug inaccessibility. It has been mentioned that this slum is situated beside a rail line. There is no road by which a vacutug can get an entry. For this reason, mechanical emptying is not possible. Again, 5 nos. of the community-based septic tank is built by Nabalok in 2015 in this slum and the size of the septic tank is large, so it is not required emptying till now. The average cost for manual emptying process and mechanical emptying process is found approximately 700-1000 BDT as shown in Table 4.2. Safety issues during the emptying operation are almost neglected. During manual emptying, sweepers do not wear the safety protective gear i.e. dress, gloves, gumboot, mask etc.

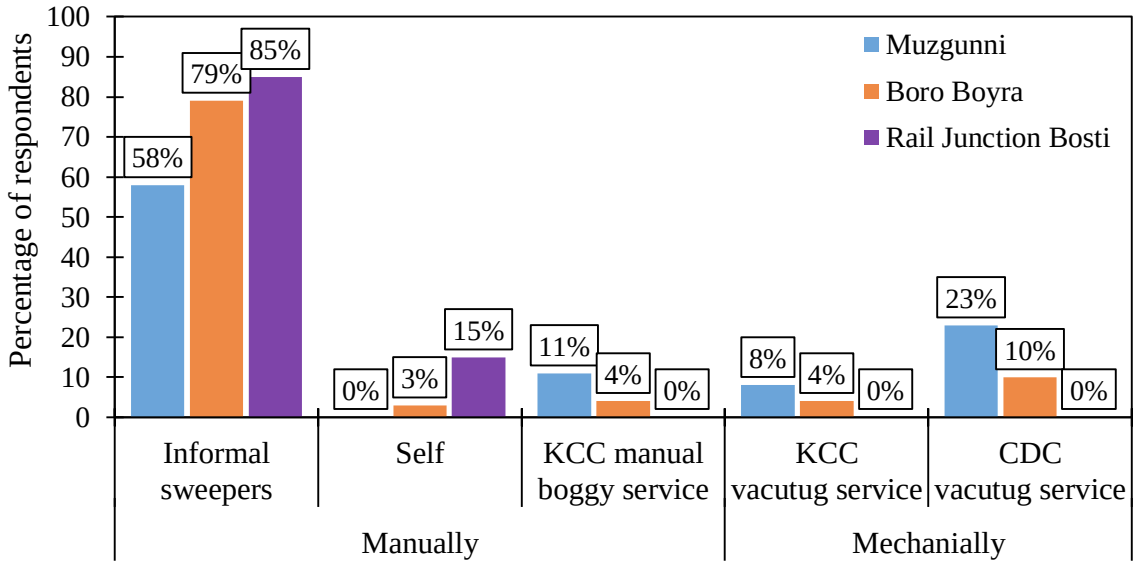


Figure 4.8: Emptying service providers at the study areas

Figure 4.8 represents the existing emptying service providers who currently provide the emptying service at the study area. There are total four types of emptying service providers in the study area. They are the private sweepers who empty the containment by manual process, manual boggy (700L circular tanks which are hauled by a tractor) service by KCC (manually emptied but transport to a disposal site by boggy) and two mechanical service providers. KCC and CDC provide the mechanical vacutug service at the study area. In the residential area, greater than half of the total respondents who emptied the containment at least one service taken by private sweepers and its amount is 58% where

11%, 8% and 23% of respondents have taken the service from KCC manual boggy, KCC vacutug and CDC vacutug service respectively.

Again, at the mixed-use area, about 86% of containment have emptied by manually and 14% of containment have emptied mechanically. In manual emptying, 79% of respondents have emptied their containment by private sweepers where only 3% by themselves and 4% by KCC manual boggy service. And in mechanical emptying, 4% of containment have emptied by KCC vacutug service and 10 % by CDC vacutug. In slum area, about 85% of respondents have emptied the containment by private sweepers and only 15% of respondents by themselves. No mechanical emptying have occurred in this area. It has been previously shown that most of the containment is not accessible due to long distance from the roadside and also inaccessibility. Again, most of the living in slum area are low-income people, they do not want to expense for emptying purpose. For that reason, they are directly involved in the emptying process.

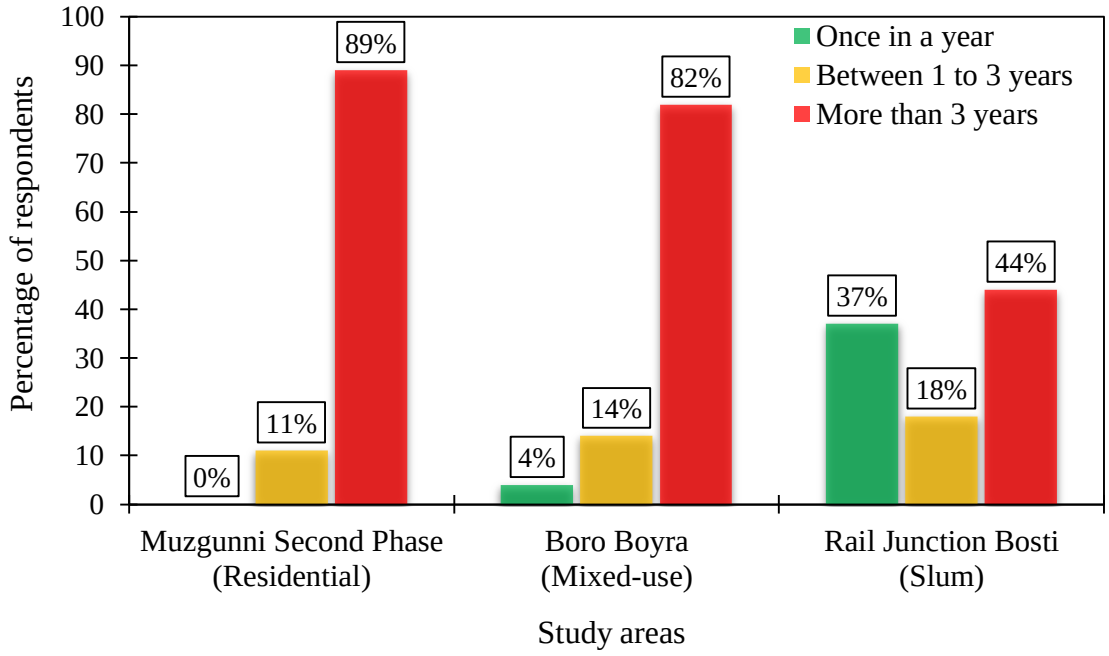


Figure 4.9: Emptying frequency of containment at the study areas

The containment emptying frequency of the study area has been shown in Figure 4.9. Emptying frequency of containment has been categorized into three types i.e. more than 3 years, equal or less than 3 years and at least once in a year. At residential area, total 26 respondents have emptied their septic tank and 19 respondents have emptied twice or more times and only 7 respondents have emptied once. In this 19 respondents, 17 of them

that means 89% respondents have emptied their septic tank by 3 years or more and rest of them have emptied their septic tank by less than 3 years as shown in Figure 4.9. However, there is no septic tank found in all of the three study areas that are emptied at least once in a year. But, it has been clearly stated in Bangladesh National Building Code (BNBC) that containment should be emptied at least once in a year. It has been cleared that, the rules stated in BNBC, is not properly followed by the users. Only some pit latrine has been found in the mixed-use and the slum area that is emptied once or twice in a year due to its low capacity or higher number of users.

At the mixed-use area, about 82% of respondents have emptied their containment by 3 years or more and 14% of respondents have emptied their containment by less than 3 years. But only 4% of respondents have emptied the containment once in a year. Similarly, at the slum area, 44% of respondents emptied their containment by 3 years or more and 18% emptied their containment by less than 3 years. But 37% of respondents have emptied the containment once in a year.

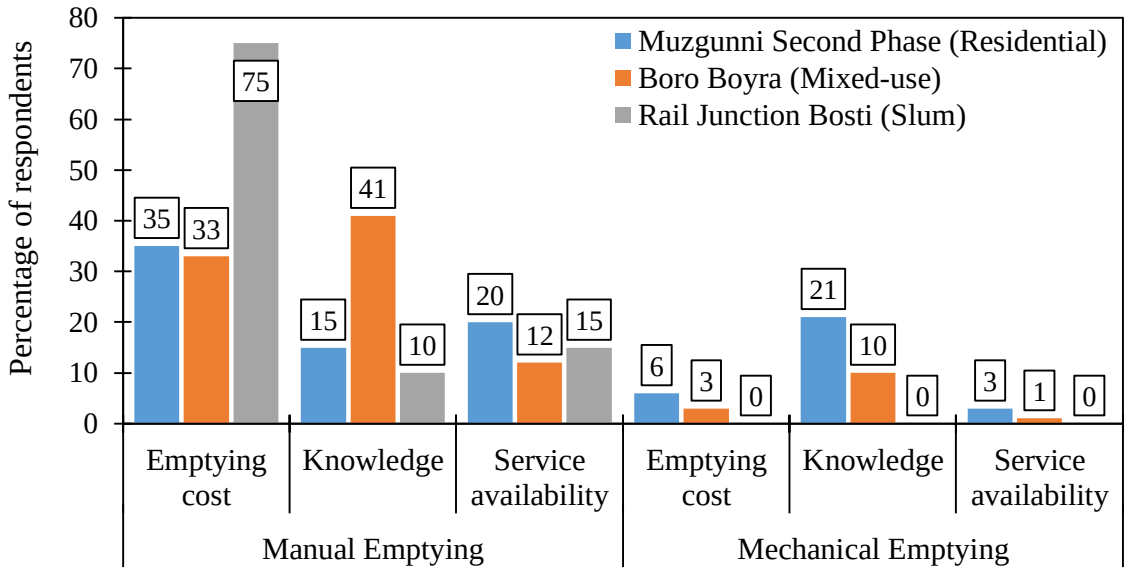


Figure 4.10: Reasons for choosing emptying types

The reason for choosing of emptying types has been shown in Figure 4.10. Reasons are classified as emptying cost, knowledge about the service and also the availability of the service. It shows that low emptying cost is the main factor for choosing manual emptying and maximum as 75% at the slum area. However, majority people know about only

manual emptying where maximum as 41% at the mixed-use area. The responses about the availability of the manual emptying service are almost same for all of the three study areas.

Again, in mechanical emptying, knowledge about the mechanical service is the main reason for choosing the mechanical emptying. Maximum 21% of respondents at residential and 10% at mixed-use area shows the reason for the same.

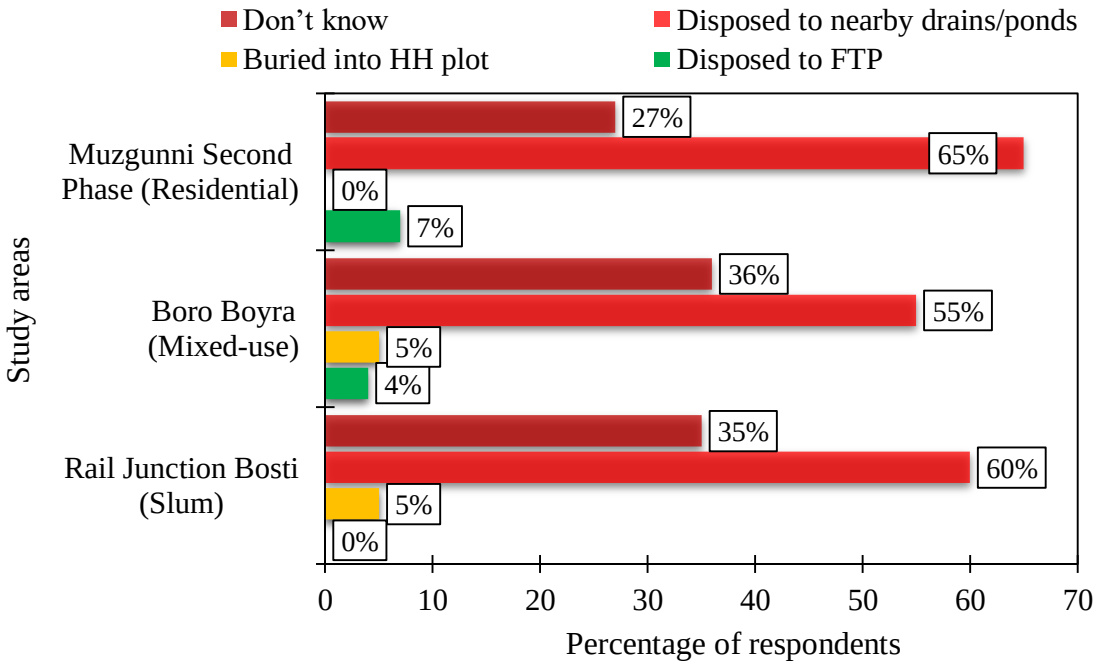


Figure 4.11: Sludge disposal at the study areas

Figure 4.11 shows the sludge disposal facilities of the study area. At residential area, it is seen that about 65% of emptied sludge is disposed to nearby drains or stagnant water body or rivers which is harmful to the surrounding environment where only 7% of emptied sludge is disposed to the faecal sludge treatment plant (FTP). A big portion of respondents nearly 27% do not know where the emptied sludge finally being disposed. On the other side, at the mixed-use area, about 55% of emptied sludge is disposed to nearby drains where only 4% of emptied sludge disposed to FTP. Similarly, at slum, 35% of respondents have not any idea about the sludge disposal, 60% of respondents septic tank connected to drains or ponds or another water body. 5% of sludge buried in the household plot at both the Boro Boyra and Rail Junction Bosti area.

Previously the emptied sludge had being disposed to the KCC solid waste dumping trench ground at Rajbondh-2 if emptying operation is done by the KCC or CDC emptiers .But recently a new FTP has been constructed beside the solid waste dumping site and sludge is being dumping there currently.

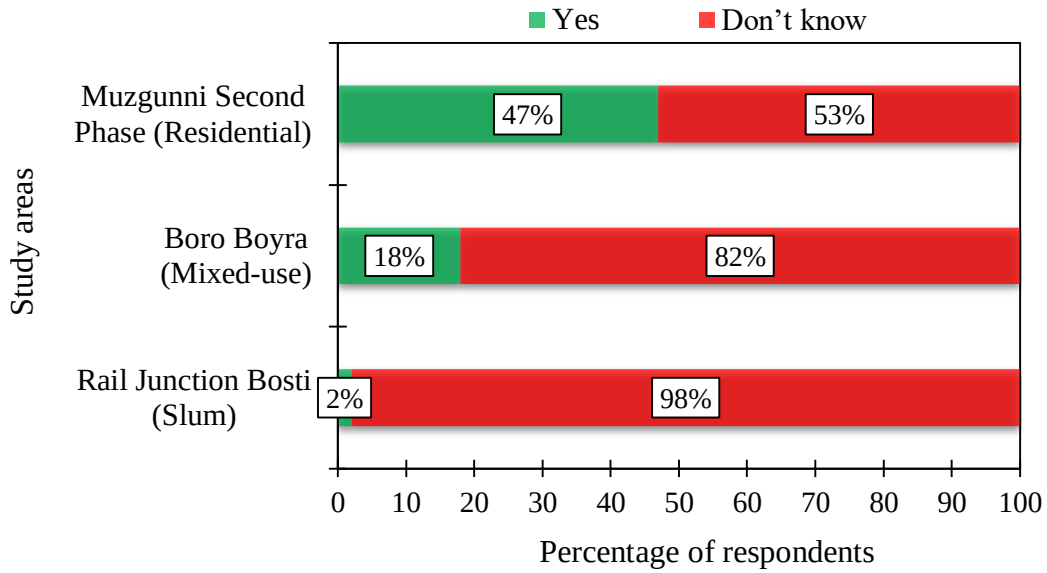


Figure 4.12: Knowledge about mechanical service at the study areas

Figure 4.12 represents the knowledge and perception of users about the mechanical service (Vacutug service) at the study area. About 10 to 11 years ago, the mechanical service is being provided by KCC. On contrary, mechanical service is being provided by CDC since 2012. But the local people don't much aware about this mechanical service. About 47% of respondents at residential area do know the mechanical service is ongoing in Khulna city as shown in Figure 4.12. However, most of them don't want to get the service because they don't know the process to get the mechanical service. They also think that only the sweepers do the emptying job. Again, 82% of respondents at mixed-use area and 98% of respondents at slum area do not aware about the mechanical service.

4.3.1 Containment Emptying Process

In this section, it has been described about the ongoing emptying process in the study area. It has been found that, only two types of emptying techniques are going on at the study area. There are manual emptying and mechanical emptying.

4.3.1.1 Manual Emptying

Manual emptying is provided by the traditional sweepers. The sweeper's live at Ward No. 21 and 17 named sweeper colony in Khulna city. The sweepers are easily available only by a phone call. For this reason, people want to get service by sweepers instead of mechanical emptying service providers. While emptying, they dig a ditch nearby the containment where land is available, otherwise they dispose it to the drains or water bodies. Most of the people think that the sweepers are the only professionals who can empty the containment as they are not aware regarding the mechanical service. Individual sweepers are playing an important role along with the municipality, especially in the suburbs where municipal services have not reached. In some cases people also took it upon themselves to clean. Sometimes, they use drum carrying with van. Khulna city has two types of emptying devices. On the other hand, KCC also provides manual emptying by a fixed charge. KCC manual emptiers emptied the containment manually but transport this manually emptied sludge to the disposal place by boggy (700L circular tanks like boggy of the train which is hauled by a tractor). This is actually manual emptying. The sweepers empty the pit/septic tank with a bucket and the tank of the boggy or trailer is filled-in. Then the boggies are carried with the engine and dumped elsewhere. The capacity of one boggy is 300 liters only and the charge for one boggy is BDT 300.

4.3.1.2 Mechanical Emptying

Vacuum tankers or vacutugs are being used as a mechanical device in the city. Khulna is largely dependent on the services of individual sweepers even though Khulna City Corporation (KCC) provides service. Mechanical service is provided in this area by both KCC and a local authority Community Development Committee (CDC). The percentage of mechanical emptying is relatively very low comparing manual emptying in this city is very low. Awareness gap and cost of mechanical emptying are the main issues for lower percent of mechanical emptying. There is two mechanical emptying service provider in this city. Mechanical service is provided by both Khulna City Corporation (KCC) and Community Development Committees (CDC) in the city. There are two 4000 liters capacity vacutugs in KCC. Which one is functioning, a tanker is carried by a tractor. The vacutug is large and needs a wide road to access. One has to apply and then pay a bank fee and deposit to KCC to get vacutug services from KCC. Table 4.3 shows a comparison

of mechanical services between KCC vacutug service and CDC vacutug service from different perspective.

Table 4.3: A comparison of mechanical services between KCC and CDC

Vacutug Information	Khulna City Corporation (KCC)	Community Development Committee (CDC)
Total no. of vacutug	2 (1 is not functioning)	3
Investment cost (lac)	30-40	40-45
Investment provided by	KCC	UPPHR
Establishment year	2005	2011
Capacity of vacutug	4000 liters ($4m^3$)	1000 liters ($1m^3$)
Pipe length	30 ft	50 ft
Access road width	Wider road (12-15 ft)	Narrow road (8 ft)
Service time	Daytime	Day and night both time
Fuel needed	10 lit.	3.5 lit.
Service area	KCC area	KCC and adjacent area
No. of vacutug labour (per vacutug)	2 (1 driver and 1 sweeper)	3 (1 driver and 2 sweepers)
No. of working day per month (avg.)	3-5 nos.	5-8 nos.
Income per vacutug service	3000 tk. +15% vat = 3450 tk.	1000 tk. per trip
Service getting process	By KCC conservancy department	By only a phone call
Disposal site	Rajbandh FTP	Rajbandh FTP

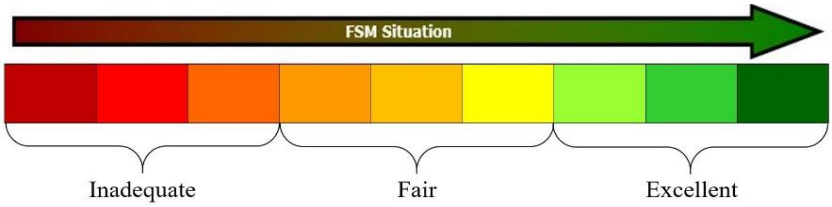
Again, mechanical service is also provided by a local authority CDC. CDC has three vacutags. The operator of these vacutugs is the cluster CDCs based at Ward No. 03, 17 and 22, respectively. They are providing service in the entire city also outside of the city. They do service on-call basis and quickly.

The emptied sludge are generally disposed at Rajbandh-2 which is the KCC solid waste dumping site. Previously, there are two trenches which were dug by the KCC authority about four years ago and the sludge was disposed of in this trench. But, a fecal sludge treatment plant (FTP) has been constructed in 2016 at Rajhbadh-2 beside the solid waste dumping site. This FTP is 10 kilometers away from city center. Sludge emptying by KCC and CDC vacutugs and also KCC boggy service is dumping currently in this FTP.

4.3.2 Existing Containment Management by FSM Situation Assessment Tool (SAT)

FSM situational assessment tool (SAT) is used in this research to identify the existing situation of the study area. Table 4.4 represents the existing condition of containment and emptying of these three areas specifically according to the SAT. The data required for this assessment have been used from the questionnaire survey and some data gathered from the KCC officials and SNV Netherlands Development Organization. From the Table 4.4, it is clear that the containment and emptying of all three areas are inadequate as nearly same to this study described previously. Also, the colour code indicates the intensity of the inadequacy.

Table 4.4: Existing situation assessment by FSM SAT

	Colour Code		
Area Name	Muzgunni Second Phase (Residential)	Containment	Fair
		Emptying	Fair
	Boro Boyra (Mixed-use)	Containment	Fair
		Emptying	Inadequate
	Rail Junction Bosti (Slum)	Containment	Inadequate
		Emptying	Inadequate

4.4 Quality of Emptying at the Study Area

The main aim of this research is to identify the emptying quality of the three types of settlements. It has been mentioned previously that, emptying quality has been categorized by unsafe emptying, partially safe emptying and safe emptying. When the environmental pollution and a certain health hazard has come to account during emptying operation, then it can be said unsafe emptying. Unsafe emptying is regarded as the lowest level and safe emptying is regarded as the highest level of emptying quality. The safety of the emptying and collection of sludge is classified according to where the sludge is emptied by a well-

known process with maintaining legal way and transported and disposed of in a safe place after emptying.

Emptying quality has been determined by quantitative analysis in this study based on the questionnaire survey. It is calculated by linking up the containment management section and knowledge of users with the emptying part. Containment management and knowledge about containment, emptying standards, mechanical emptying service, safety issues etc. are important and involved with the emptying of containment. It helps to identify the actual quality of emptying of each study area. Three types of emptying quality have been evaluated for this research. Firstly, by counting and checking all the unsafe, partially safe and safe emptying answers from the questionnaire, emptying quality score has been determined specifically for each the study area as shown in Table 4.5.

Table 4.5: Specific emptying quality of the study area

Area Name	Emptying Category	Percentage
Muzgunni Second Phase (Residential Area)	Safe Emptying	56.00%
	Partially Safe Emptying	12.77%
	Unsafe Emptying	31.23%
Boro Boyra (Mixed-use Area)	Safe Emptying	44.48%
	Partially Safe Emptying	14.24%
	Unsafe Emptying	41.28%
Rail Junction Bosti (Slum Area)	Safe Emptying	24.73%
	Partially Safe Emptying	13.74%
	Unsafe Emptying	61.53%

For Muzgunni Second phase area as the residential area, emptying quality has been found safe emptying as 56%, partially safe emptying as 12.77%, and unsafe emptying as 31.23%. Most of the containment type in the residential area is the septic tank, most are suitable in case of size. For this reason, the percentage for safe emptying has been found more than the others two. Besides, the percentage of unsafe emptying also higher for this area. It is due to some of the factors such as high emptying frequency, lack of knowledge about mechanical service etc. The respondent who knows for mechanical emptying but goes for manual emptying due to emptying cost, availability of the service. For Boro Boyra as the mixed-use area, emptying quality has been found safe emptying as 44.48%, partially safe emptying as 14.24%, and unsafe emptying as 41.28%.

Again, for Rail Junction Bosti as the slum area, emptying quality has been found safe emptying as 24.73%, partially safe emptying as 13.74% and unsafe emptying as 61.53%. Most of the containment type in slum area is an ordinary pit, most of them are not suitable in case of size according to users. Again, there is no such containment that is accessible for mechanical emptying. The slum situated beside Dhaka-Khulna rail line and long distance from the roadside. For this reason, the percentage for unsafe emptying has been found more than the others two.

Table 4.6: The overall emptying quality of the study area

Area Name	Emptying Quality Score	Emptying Quality
Muzgunni Second Phase	42.14	Partially Safe Emptying
Boro Boyra	35.57	Partially Safe Emptying
Rail Junction Bosti	17.35	Unsafe Emptying

Finally, the overall emptying quality is evaluated for each type of settlements and found that what kind of emptying is going on in that area. The overall emptying quality score as shown in Table 4.6 has been calculated by prioritizing of each indicator of containment, emptying and knowledge and perception of the users according to the Table 3.6. The overall emptying quality score for Muzgunni Second phase, Boro Boyra, and Rail Junction Bosti has been found 42.14, 35.57 and 17.35 respectively. According to this score and from Table 3.6, partially safe emptying is going on both Muzgunni Second phase and Boro Boyra where totally unsafe emptying for Rail Junction slum. In this slum, most of the containment inaccessible, containment are in worst condition. For that reason, emptying quality score comes to very low and unsafe emptying.

4.5 Proposal for Safe Emptying

FSM services in Khulna city is an almost new issue or sector. There have many constraints, problems, limitations. Among these, some have been founded and respective proposals have been recommended for its solution.

4.5.1 Containment

In containment management practices, some problems have been identified in respect of containment unsuitability, poor containment condition, and septic tank outlet connection to drains, the dominance of manual emptying rather than mechanical emptying, rudimental disposal of faecal sludge after emptying, lack of knowledge about the rules, regulations, and standard. In the study area, there are a septic tank and pit latrines. In some cases, the containment size according to the user is not suitable and most of the septic tanks out are connected to nearby drain correctly. Septic tanks in this study area are not constructed as per design of BNBC and also there is no inspection mechanism during septic tank construction and after construction. In the study area, there are septic tanks have not constructed by maintaining proper design criteria. So, BNBC must be followed during septic tanks design and construction. It should be mandated that none connect their septic tank outlet to drains, so the house owner has to go to the make soak well. But sometimes due to limited space, the people do not want to construct a soak well. Also due to the high water table, it does not work. So up-gradation of the septic tank is necessary.

In Khulna city, Khulna Development Authority (KDA) in case of Khulna City is the approval authority of building and responsible to design buildings as well as the septic tank. So, in that cases, KDA should be stricter about the permission tanking from the authority, proper checking of the septic tank during construction as well as adequate law enforcing. Building code must be followed and inter-cooperation in between relevant institutions (KCC, KDA, KWASA, etc.) is necessary and joint efforts are essential to sustain and safe sanitation.

4.5.2 Emptying

In the emptying part, KCC is the main regulatory authority to provide service where CDC also provide the service by commercially. Many house owners has not emptied their septic tank for many years. Also, they have not known yet that the containment can be emptied by the mechanical way. In BNBC, it is clearly stated that septic tank should be emptied at least once in a year, but there is no house owner found that he or she knows the regulation about the emptying standard. Again, they think that only the horizon (private sweepers) do the job manually. During emptying operation, they ignore the safety issues.

Most of the cases they don't wear the safety gears for their safety. They also do not feel comfortable with this gears.

Few people know about the mechanical emptying service, but also they do not want to get the service for the unavailability of the mechanical process, difficulty of getting service and sometimes high cost of mechanical service. Both KCC and CDC have lack of logistic supports, manpower, equipment and instrument to provide the service. The private sweepers are doing the cleaning of the toilet, emptying the containment traditionally for many years ago. They support their family with this income. So, they cannot be stopped. But they should be trained regarding the use of protective gear and to be proper health concerned. Proper enlistment of the manual sweepers should be done in which they can provide the service by unity so that only they can provide the service. They are trained sometimes by SNV Netherlands Development Organization, but it is not adequate. More training should provide them with assistance with KCC.

Sometimes, in case of mechanical emptying, vacutug does not have access to narrow road width. It also cannot extract the hard solid part of the bottom of the septic tank due to not emptying since many years. So, after extracting a liquid part from the septic tank, the emptier go down of the septic tank and clean the solids manually. So, the respective authority should be focused on the high proficiency vacutug to empty the total sludge. Khulna is a big city and there are many narrow roads where no vacutug can enter the septic tank. So where the small vacutug cannot get access to entry, the alternative small emptying device should be implemented. There are many small emptying devices such as sludge gulpher, manual diaphragm hand pump (MDHP), manual pit emptying technology (MAPET) etc.

The gulper has low capital and operational costs and is effective for cleaning pits containing sludge. It also requires special transportation, and its operation is complicated in comparison with other tested options. The manual diaphragm hand pump is light in weight and easy to use. It has low energy and maintenance costs, requires few workers and it is unlikely to cause damage to the latrine. The MDHP is able to empty a pit latrine 30% faster than manual emptying. However, it has high capital costs, with a pump costing BDT 30,000. By proper evaluation of these alternative emptying devices sustainability in

our country, it should be implemented where the mechanical emptying is not possible for the accessibility problem of any other obstacles.

Table 4.7 represents such a comparison of these three alternative small emptying devices under various parameter. The vacutugs which are providing the service to the whole city are not registered and moving illegally in the city. So it should be tried to get a license from the license giving authority Bangladesh Road Transport Authority (BRTA). In all of the three areas of the study area, emptying quality came to unsafe emptying or partially safe emptying. So it is clear that overall safe emptying is not occurring. So by proper steps taken by the respective authority, safe emptying is possible.

Table 4.7: A comparison among three alternative small emptying devices

Parameter	Slugde Gulpher	Manual Pit Emptying Technology (MAPET)	Manual Diaphragm Hand Pump (MDHP)
Capital costs	Low	Medium	High
Energy costs (per pit)	Low	High	Low
Maintenance costs	Low	High	Low
Handling	Difficult	Difficult	Easy
Ease of use in rural areas	Difficult	Difficult	Easy
Labour requirements (per pit)	Medium	Medium	Low
Need for transportation (per pump)	Yes	Yes	No
Extraction pit depth (foot)	3-5	10-15	3-10
Pit emptying charges (BDT per pit)	800-1500	1500-2000	700-1500
Health and environmental risks	High	Medium	Low
Probability of damaging latrine	High	Medium	Low
Preparation time (minutes)	15-20	20-30	10-15
Pit emptying time (minutes)	20-30	5-10	15-20

(Adapted from Strande *et al.*, 2014; BRAC, 2015, Islam, 2016)

During emptying operation, they ignore the safety issues. Most of the cases they don't wear the safety gears for their safety. They also do not feel comfortable with this gears. Both KCC and CDC have lack of logistic supports, manpower, equipment, and

instrument to provide the service. The private sweepers are doing the cleaning of the toilet, emptying the containment traditionally for many years ago. But they should be trained regarding the use of protective gear and to be health concerned with the assistance of KCC. Proper enlistment of the manual sweepers should be done in which they can provide the service by unity so that only they can provide the service. They are trained sometimes by SNV Netherlands Development Organization, but it is not adequate. More training should provide them with assistance with KCC.

4.5.3 Knowledge and Perception of Users and Emptiers

In this study, it has been found that most of the house owner have lack of knowledge about the proper FSM. They do not aware of the septic tank outlet connection, emptying frequency. By proper law enforcing by the authority and organizing effective awareness program, it can be minimized. To create demand and gather knowledge among the people, some awareness building program can be arranged by KCC. This can be an advertisement on television, by supplying leaflet. KCC has already started the awareness buildup program Ward by Ward of whole KCC area by a tagline “Emptying of the septic tank, once in a year”. KCC is continuing the job by playing a drama with the assistance of SNV Netherlands Development Organization. Also, sludge emptiers should have proper knowledge about the use of safety gears and ensure the personal health and safety. If the limitations, constraints, problems associated with emptying can be overcome, then safe emptying is possible. Finally, a model for safe emptying has been proposed considered by respective authority’s duties and responsibilities as shown in Figure 4.13.

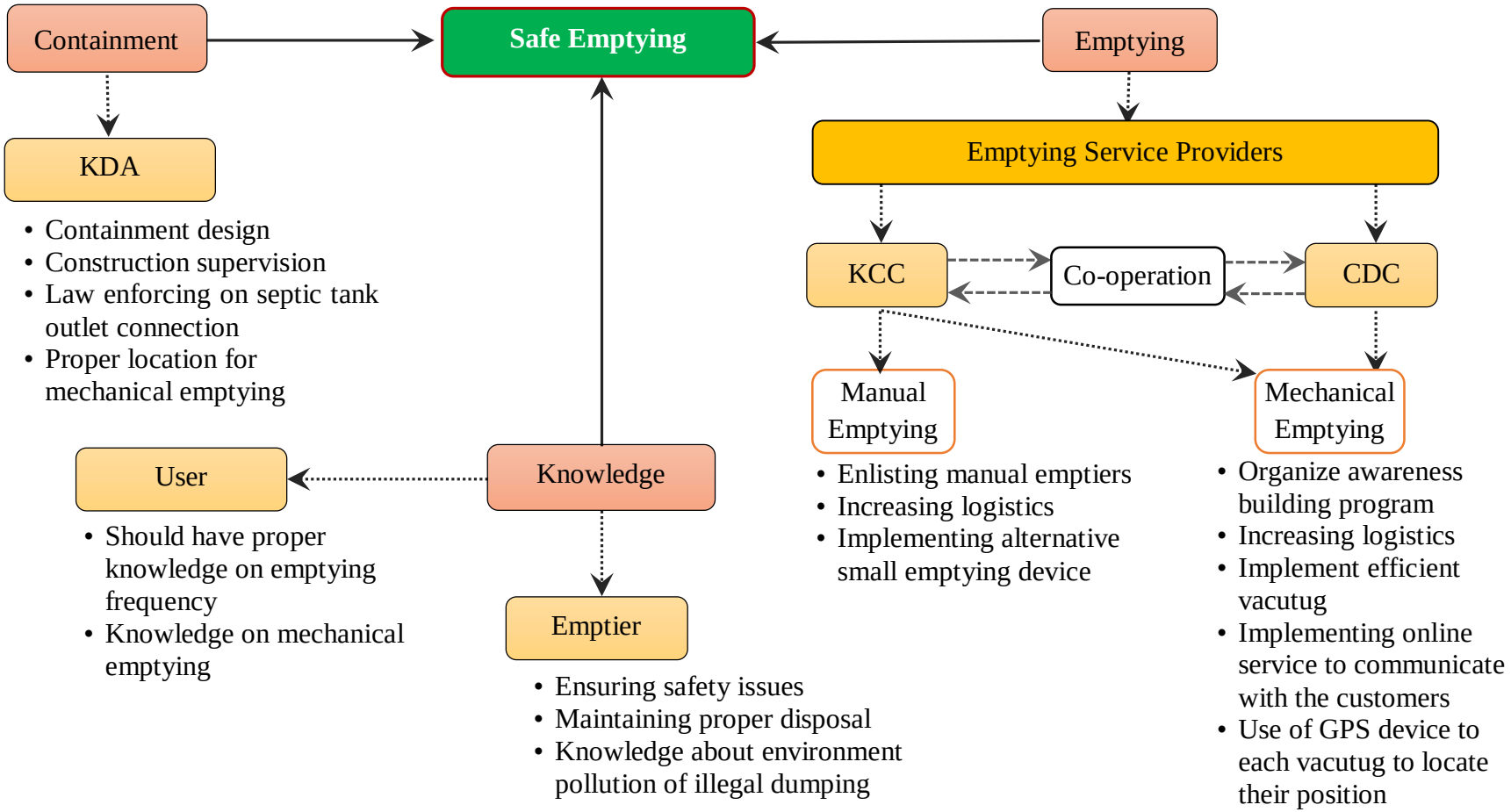


Figure 4.13: Proposed model for safe emptying

CHAPTER V

Conclusions

5.1 General

This chapter is the final part of this research and contains the summarized portion of all finding of the research introducing the existing containment management, quality of emptying of the study area and some major challenges with some probable recommendations.

5.2 Conclusions

The main conclusions are drawn from the study in the followings.

- In this study, it has been found that 81% of containment are suitable at the residential area where this value reduced to 75% and 30% respectively for the mixed-use and slum area. Also, most of the containment is in good condition except the slum. Highest 77% of containment is in good condition at the residential area where 26% of containment at slum is in poor condition.

- In the residential area, 77% of containment are accessible for mechanical emptying operation where 78% of containment is not totally accessible at the slum. Most of the septic tank at all three area is connected to the nearby roadside drains or stagnant water body where only 7% and 4% of containment have soak well respectively for the residential and the mixed-use area.

- In all of the three areas, a large number of containment have not emptied yet. Again about 31%, 44% and 39% of containment have emptied twice or more times for the residential, the mixed-use and the slum respectively. All the emptiers both manual and mechanical ignore the safety issues during emptying operations. Mechanical service has taken more in the residential area than the other two area.

- Emptying frequency is more in this area and it is 89% of more than three years. But the emptying frequency at once in a year is very low in this area except for the slum.

In the residential area, about 47% of respondent are aware of the vacutug service but only 18% and 2% of respondent aware of that at the mixed-use and the slum respectively. Most of the emptied sludge disposed to nearby sewerage drains or stagnant water body and the value is 65%, 55%, and 60% respectively for the residential, mixed-use and slum.

- The study also reveals that the specific emptying quality of the residential area has been found safe emptying as 56%, partially safe emptying as 12.77%, and unsafe emptying as 31.23%. Again, for the mixed-use area, safe emptying has been found as 44.48%, partially safe emptying as 14.24%, and unsafe emptying as 41.28%. And similarly for the slum area, safe emptying has been found as 24.73%, partially safe emptying as 13.74%, and unsafe emptying as 61.53%.

- Finally, the overall emptying quality score has been found as 42.14 for the residential and as 35.57 for the mixed-use area which represents partially safe emptying practices in both two areas. Where the score for the same has been found as 17.35 in the slum which indicates unsafe emptying practices.

- To achieve safe emptying, high proficiency vacutug should be implemented to extract the solid sludge at the bottom of the containment. Safe disposal of emptied sludge is possible to FTP by using GPS devices in each vecutug and proper monitoring.

- Also, there are some small emptying devices such as sludge gulpher, MDHP, MAPET etc. can be implemented by proper evaluation mainly where mechanically emptying is not possible. The knowledge regarding the proper FSM among the people can be increased by organizing different types of the effective awareness program extensively.

5.3 Recommendations

The following recommendations are suggested.

- The study has been conducted in small scale and only the three selected areas of Ward No. 09. The further study can be conducted on the whole Ward wise as well as the total Khulna City Corporation area.

- There are 14 indicators of containment, emptying and user's knowledge and perception have been taken into account to conduct the study. More effective indicators can be adopted for more accurate results.

- A study also can be undertaken to develop a forecasting tool for the emptying demand, emptying quality determination based on the selected indicators in future.

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Appendix A: Questionnaire Sample

Questionnaire Sheet for Household Head

(All information will be collected only for research purpose and right reserves to the Dept. of Civil Engineering, KUET)

Road Name	:	Household Head Name	:
Name of Area	:	Education Level of HHH	:
Holding No.	:	Years of Living	:
Date of Inspection	:	Main Occupation (HHH)	:

Containment

❖ *Containment Size*

1	Type of containment**		☐ Pit	☐ Septic tank
2	Total number of people in this house: ……. Number of children below 5 years: ……. Number of people using toilet facility: …… Volume of containment required: ……			
3	If pit, types of pit? **	☐ Single pit	☐ Twin pit	
	Total number of rings: ……../……..	Depth: …….	**Diameter: ……	Volume: …….
4	If septic tank, number of chambers?	☐ 1 Chamber *<3000 Liters *Don't know	☐ 2 Chambers* > 3000 Liters	☐More chambers
	Septic tank, **Length: ….	**Width: …….	Depth: ……	Volume: ……
5	Is the containment size is suitable for this house?	☐ Size is less than needed *Overflowing occurred	☐Size is optimum *Overflowing occurred during rainy season	☐ Size is suitable and enough
6	Containment Construction	☐ Containment is poorly constrcuted *No containment maintenance	☐ Containment has some construction faults	☐ Containment is well-constructed
7	Did you take any permission for construction of the septic tank?	☐ No *Houseowner did not take any permission *Haven't any knowledge *Don't know	☐ Neutral	☐ Yes *Houseowner take permissions from the authority like KDA

❖ *Containment Condition*

8	Leakage of pit/ septic tank	☐ Yes * Leakage occurs regularly * Don't know	☐ Neutral * Leakage is occurred rarely and solved by house owner	☐ No Containment has not any leakage
9	Overflow of pit/septic tank	☐ Regularly overflow at any season and overflow is visible	☐Overflows during rainy season	☐Don't overflow at any time
10	What type of problem you faced?	☐ Pit damage Pit overflow Or any other major	☐Minor problem *Problem occurs that can be solved	☐ No problem

		problem	by the house owner	
11	Do you ever face any problem related to the pit or septic tank?	☐ Regular	☐ Often	☐ Never
12	Is the cover of the pit open? **	☐ Yes *Totally broken for that reason it is open	☐ Partially broken *A portion of cover slub is open	☐ No *Cover slub is constructed well and not open
13	Do you check your containment?	☐ Not check ever	☐ Check sometimes	☐ Regular check *Checking at regular interval
	❖ *Containment Location & Accessibility*			
14	Is the septic tank adjacent to the building? **	☐ No		☐ Yes
15	Containment position from the roadside**	☐ Rear *Totally impossible to collect FS by vacutug	☐ Side *Some uncertainty in FS collection by vacutug	☐ Front *Easy to collect FS by vacutug
16	Road type**	☐ Katcha or Dirty * Not accessible	☐ Semi Pucca or muddy *Poorly accessible	☐ Pucca * Easily accessible
	Road width**	☐ < 10 ft	☐ ≥ 10 ft - < 20 ft	☐ ≥ 20 ft
17	Containment distance from the roadside**: ……..			
	Distance	☐ > 25m		☐ ≤ 25m
18	Are there any obstacles to get the containment from the road? **	☐ Yes *Obstacles are fixed and nonremovable *Boundary wall, Building etc. *FS collection is impossible	☐ Neutral *Obstacles can be removed during emptying by vacutug	☐ No *No obstacles to collect FS
	❖ *Containment Outlet Connection*			
19	Is there any soak well connected to the containment?	☐ No *Don't know	☐ Neutral *House owner have a little bit knowledge but not clearly	☐ Yes
20	Outlet connection of pit/ septic tank	☐ Outlet is connected to stagnant water body	☐ Outlet is connected to drains	☐ Outlet is connected to outside but safe
21	What type of material goes through the outlet?	☐ Water + FS * Don't know	☐ Only water	☐ Nothing is go Through the outlet
22	Are you know about the regulations of outlet connections?	☐ No *Don't know about the regulations	☐ Neutral *Knows partially but not clearly	☐ Yes *Knows about the regulations

	Emptying			
	❖ *Emptying Type*			
2	Age of containment: ……			
3	Have you ever emptied your pit/septic tank?	☐ No *Don't know		☐ Yes
1	When the containment is full, what action you take?	☐ Nothing to do * Close the pit	☐ Empty if have money	☐ Empty immediately
4	If yes, why you emptied last time of the containment?	☐ Containment was full	☐ Containment was nearly full	☐ Containment was not full
5	If full, how did you understand that containment was full?	☐ Containment was overflowing *Spreading foul odor	☐ Emptying at regular interval	☐ Because of regularly check
6	What was the containment emptying process?	☐ Manually *Self	☐ Combination of mechanical (liquid part) and manual (Solid part)	☐ Completely mechanically
7	How much time was taken to get the service?	☐ Service did not provide within 24 hours * Didn't remember		☐ Service was provided within 24 hours
	❖ *Emptying Service Provider*			
11	If not empty, in future by whom you depend for the services?	☐ Private sweepers * Self	☐ KCC manual Boggy service	☐ KCC/ CDC Vacutug service
12	Who was the service provider for emptying?	☐ Not emptying yet *Manual emptying *Private sweepers *Self	☐ Manual emptying But having PPEs etc. *KCC manual boggy service	☐ Mechanical Emptying ☐ KCC ☐ CDC
13	Have you faced any problems from the emptiers?	☐ Yes *Claim excess charge *Septic tank/pit clean partially		☐ No
	❖ *Emptying Frequency*			
14	How many days before you last emptied your containment?			
15	How long does it take for your pit/tank to require re-emptying?	☐ Once in a year	☐ Equal or less than 3 years	☐ More than 3 years
16	Are you know about the regulations of emptying frequency? **BNBC (six months to 1 year)	☐ No		☐ Yes
	❖ *Emptying Cost*			
17	How much paid for the last emptying?	☐ Manually BDT:	☐ Combination of mechanical and manual BDT:	☐ Completely Mechanical BDT: .....
18	What was the paying system?	☐ Don't know	☐ Per trip basis *Depending on volume of pit/ST	☐ A fixed fee was charged by the authority

19	What do you think about the mechanical emptying fee?	☐ High *If cost is high, house owner go for the manual emptying or not ever empty	☐ Medium	☐ Low *If cost is low, the fees allocated by the service provider is affordable by the house owner
20	What do you think about the manual emptying fee?	☐ High *If cost is high, house owner would not tend to empty the containment	☐ Medium	☐ Low *If cost is low, the house owner can empty the containment frequently.
21	How satisfied are you with the cost of emptying?	☐ Dissatisfied	☐ Neutral	☐ Satisfied
	❖ *Safety Issues*			
22	Did anyone enter the containment for empty the sludge?	☐ Yes *Didn't know	☐ Neutral	☐ No
24	Are the emptiers use PPE during emptying?	☐ No * Don't know	☐ Use but not sufficient	☐ Yes
25	Was any spillage occurs during emptying beside the containment?	☐Yes/ Didn't know *Spillage is risky for both of the emptiers and environment	☐ Partially	☐ No
26	Do you think spillage during emptying is harmful to both of you and emptiers?	☐ No * Don't know	☐ Neutral	☐ Yes
	❖ *Vacutug Efficiency*			
27	Are the vacutug empty the containment completely?	☐ No * Vacutug empty the containment partially		☐ Yes * Vacutug empty the containment completely but a small amount of sludge remains at the bottom
28	Any vehicular (vacutug) failure during operation?	☐ Yes *Didn't remember	☐ Neutral *Vacutug failure occurred but they solved it quickly	☐ No
	❖ *Sludge Transport and Final Disposal*			
30	Do you know about the designated place for sludge dumping?	☐ No		☐ Yes
31	What was the final disposal place for FS?	☐ Didn't know *Disposed of out of HH but to river/ponds/drain	☐ Buried in HH plot	☐ Disposed to a safe place *Rajbandh Disposal place
32	Do you know the newly constructed faecal sludge treatment plant in Khulna?	☐ No		☐ Yes **Rajbandh Treatment Plant
33	Do you know the sludge is reused or recycled?	☐ No *Don't know	☐ Not sure but having a little bit knowledge	☐ Yes

	Knowledge and Perception of Users				
	❖ *Containment Infrastructure*				
1	Are you think that your containment is structured properly?	☐	No	☐	Yes Why.....
2	Are you aware of the regulations of outlet connections?	☐	No	☐	Yes
	❖ *Emptying Standard*				
3	Do you think, is it important for emptying the containment in due time?	☐	No	☐	Yes
4	Do you know the manual emptying process is harmful to the workers?	☐	No	☐	Yes
5	Do you think the need to empty pit/septic tank timely?	☐	No need	☐	Yes
6	Are you aware of the regulations of containment emptying standard? (BNBC emptying standard- between 6 months to 1 year)	☐	No	☐	Yes
7	If yes, do you empty obeying this emptying standard?	☐	No Why?..... ..……	☐	Yes
	❖ *Mechanical Emptying Services*				
8	Dou you aware of mechanical emptying in Khulna City (Vacutug Service)?	☐	No	☐	Yes
9	Do you think, mechanical emptying is safe?	☐	No	☐	Yes
10	Are you want to pay for mechanical emptying?	☐	No	☐	Yes
	** *Two stars represents these indicators should be assessed by observation and should be cross-referenced with that of questions*				
	Thank You for your Cooperation……				
	Surveyor Name_____ Mobile Number_____				

Appendix B: Emptying Quality Calculations

B-1. Muzgunni Second Phase (Residential Area)

Sections	Indicators	Weighted Value (WV)	Average Weighted Value (AWV)	Emptying Quality (EQ)
Containment (*4 Indicators*)	Containment size	0.83	82.58	42.11
	Containment condition	0.82	82.26	
	Containment location & accessibility	0.88	87.90	
	Containment outlet connection	0.27	0	
Emptying (*7 Indicators*)	Emptying type	0.51	25.50	
	Emptying service providers	0.62	30.77	
	Emptying frequency	0.05	0	
	Safety issues	0.40	19.87	
	Emptying cost	0.50	25.19	
	Vacutug efficiency	0.94	93.75	
	Disposal of FS	0.19	0	
Users Knowledge & Perception (*3 Indicators*)	Containment infrastructure	0.64	32.06	
	Policy and regulations	0.61	30.65	
	Mechanical emptying provision	0.79	79.03	

B-2. Boro Boyra (Mixed-use area)

Sections	Indicators	Weighted Value (WV)	Average Weighted Value (AWV)	Emptying Quality (EQ)
Containment (*4 Indicators*)	Containment size	0.67	67.33	35.57
	Containment condition	0.70	70.18	
	Containment location & accessibility	0.44	22.03	
	Containment outlet connection	0.21	0	
Emptying (*7 Indicators*)	Emptying type	0.50	25.41	
	Emptying service providers	0.19	0.19	
	Emptying frequency	0.11	0.11	
	Safety issues	0.53	26.35	
	Emptying cost	0.75	75	
	Vacutug efficiency	0.82	81.82	
	Disposal of FS	0.08	0	
Users Knowledge & Perception (*3 Indicators*)	Containment infrastructure	0.59	29.82	
	Policy and regulations	0.63	31.29	
	Mechanical emptying provision	0.69	68.70	

B-3. Rail Junction Bosti (Slum Area)

Sections	Indicators	Weighted Value (WV)	Average Weighted Value (AWV)	Emptying Quality (EQ)
Containment (*4 Indicators*)	Containment size	0.63	31.59	17.35
	Containment condition	0.58	28.77	
	Containment location & accessibility	0.08	0	
	Containment outlet connection	0.18	0	
Emptying (*7 Indicators*)	Emptying type	0.25	0	
	Emptying service providers	0.85	85	
	Emptying frequency	0.47	23.44	
	Safety issues	0.63	31.25	
	Emptying cost	0.33	0	
	Vacutug efficiency	0	0	
	Disposal of FS	0.01	0	
Users Knowledge & Perception (*3 Indicators*)	Containment infrastructure	0.51	25.46	
	Policy and regulations	0.21	0	
	Mechanical emptying provision	0.27	0	

Appendix C: Key Informant Interview (KII)

C-1. KII to Khulna City Corporation (KCC) Personnel

Checklist for KII of Faecal Sludge Emptying Service Provider							
(All information will be collected only for research purpose and rights reserves to the Dept. of Civil Eng., KUET)							
Organization Name	:	Khulna City Corporation (KCC)		Org. Type	:	☑GOVT.	☐NGOs
Name of the informant	:	Anisur Rahman	Stakeholder Type	:	Emptying Service Provider		
Designation	:	Conservancy Officer	Date	:	09 July 2017	Time: 1.15 pm – 2.15 pm	
Name of the interviewer	:	Sabok Mondal & Irfan Shakil					

1. How long you involved in FSM sector? What role you play as an FSM stakeholder

   Answer: *I involve in FSM sector during 2011. So it would be 6 or 7 years. We know that there are five components of FSM. These are containment, emptying, transportation, treatment, and disposal or reuse. So as a stakeholder, we, the conservancy department managing the middle three elements of FSM in Khulna city.*

2. In which area you provide the service? What is the service approval process to get emptying operation? Which type of emptying service you provided?).

   Answer: *We provide our service only in the City Corporation area. Service approval process is slightly complex. One who needs the service has to come to our office and have to apply by filling a form with payment of 3885 BDT (with VAT). A supervisor from city corporation goes to see the customer's containment for pre-assessment. Pre-assessment means what is the actual septic tank size, the vacutug is accessible or not accessible to the containment, the approximate amount of trip etc. We provide both manual service and mechanical service. We have enlisted formal emptiers but the informal emptiers do the job on-call basis by other emptiers.*

3. What are the resources you have manage for manual process services?

   Answer: *For manual emptying, we have three boggy (a small tanker) and a tractor (which can haul the boggy). The volume of each boggy is 750L. Two drivers and 4 helpers do the job as a city corporation member but sometimes they call other informal emptiers based on their work volume. Generally, they charge 1000 BDT per boggy. Sometimes they contract with the customers based on pit or septic tank volume.*

4. What are the resources you have to manage for mechanical process services? Can you give me with details information (Vacutug Size, Pipe length, minimum road width to entry) about vacutug?

   Answer: *For mechanical emptying, we have two large vacutug (a vacuum tanker). The volume of each boggy is 5000L. Recently a new 7000L vacutug has been provided by SNV. But this vacutug will be worked as an intermediate transfer station. This work is not started till now. Two permanent vacutug drivers and 4 helpers do the emptying job. The length of the pipe is 120 ft and at least 10-12 ft road width is needed to the entry of vacutug. A customer who wants to empty the septic tank, at first he/she has to pay a fixed amount of BDT to city corporation*

office, then the service is provided by pre-assessment. We have not so much expertise according to emptying demand, we need more.

5. What about the emptying demand and service provided? Do you provide the service in between 24 hours as per request? Generally, which time (day, night, season) you provide the service?

   Answer: *The emptying demand of customers has been increased than previous few years. But we cannot provide the service mainly mechanical service according to customer demand. Sometimes the service is provided within 24 hours, sometimes not. Most of the time it is not possible to provide emptying service in 24 hours. Both at day and night time, we provide the service. But the percentage of the night is more than a day.*

6. Do you maintain any records/registers (income and expenditures) of sludge management services? What is the average monthly income and expenditures to manage the services?

   Answer: *Yes, the conservancy department has the log book (which can keep records) of the emptying operation and also keeps records of income and expenditures. It is difficult to say how much expenses per month for providing the service. But the salary of drivers, emptiers, fuel cost, mobil cost, operation, and maintenance cost is the expenses sector. For example, we have two drivers (both for manual and mechanical) and 4 helpers. The salary for a driver is 13500 BDT. Fuel cost is generally 10 liter per trip. Otherwise, the vehicle operation and maintenance cost is bear by the transport department. Till now, the emptying job is in the loss. It is difficult to say accurately how much loss occurred per month. The government has to a subsidy per year in this sector.*

7. Do you provide sufficient health and safety equipment to the emptiers? Do they use PPEs during emptying operation? If not, why? What is your perception of the necessity of using PPEs?

   Answer: *Yes, we have provided sufficient health and safety equipment to the emptiers. We provided gumboot, dress, mask, gloves, glass etc. as safety equipment. But the emptiers does not feel comfortable to use this safety equipment. Because they are not habituated to use it. They use when any officer come to visit or any other critical time. But all time they are not using it. I think it is very necessary to use PPEs during emptying operation.*

8. Have you organized any training for safe sludge emptying, health and safety issues to the emptier? Do you have any guideline for manual and mechanical emptying? If yes, do the emptiers follow the guideline? If they do not follow, why?

   Answer: *Yes, we have organized training 3 to 4 times for safe sludge emptying, health and safety issues to the emptier and also the driver. We have manual and guideline for both of manual and mechanical emptying. To make this guideline SNV have worked hard.*

9. How is sludge transported to dumping site? Where is the emptying sludge dumped/disposed of currently? Are you aware of illegal dumping of sludge?

   Answer: *If the emptying operation is done by the manual process. Then the manual boggy is poured by sludge and hauling by a mounted tractor, the sludge is transported to the dumping site. The sludge is being dumped at Rajbandh FTP. And if the operation is done by the vacutug. Then vacutug directly transports the sludge to the treatment plant. Mainly, manual informal emptiers are responsible for illegal dumping. They do their job at night and dump the sludge at the nearby drain or water body which is harmful to the environment.*

10. What are the limitation/lack (technical, financial) for that you cannot do your job properly?

Answer: *We have not so much expertise, manpower, equipment financial problem etc., for that reason, we cannot do our duty properly. If the international and local NGOs come forward with co-operation of govt., then the total problem can be minimized.*

11. What are the existing and future plan for awareness program in creating emptying demand?

Answer: *The demand has been increased recently. I think, In future, demand will increase more. Some programs for creating demand, knowledge, and awareness are continuing at present like that mikeing, by cable TV, leaflet and a campaign (pot gan). Training of the emptiers has already been done recently. In future, KCC wants to hand over this emptying service to entrepreneurship. We want to give it to a non-govt. organization but we supervise all time. Already the proposal has been made.*

C-2. KII to Khulna Development Authority (KDA) Personnel

Checklist for KII of Faecal Sludge Emptying Service Provider

(All information will be collected only for research purpose and rights reserves to the Dept. of Civil Eng., KUET)

Organization Name	:	Khulna Development Authority (KDA)		Org. Type	:	☑ GOVT.	☐ NGOs
Name of the informant	:	Tanvir Ahmed		Stakeholder Type	:	Building design	
Designation	:	Town Planner	Date	:	11 July 2017	Time: 2.30 pm – 3.15 pm	
Name of the interviewer	:	Sabok Mondal & Irfan Shakil					

1. What role do you play as an FSM stakeholder?

Answer: *Actually, we don't deal with FSM directly. But we are involved in septic tank design part. A few years back, the house owner didn't take design for the septic tank. Only the location and position of the septic tank was selected. But now the regulations have been changed. The customer has to take permission and detailed design during taking building design.*

2. What do you say about the containment outlet connection?

Answer: *In most cases, containment is connected to the nearby drain. But the house owner has to make a soak well. We are the regulating authority to inspect it. But all times it not possible to inspect it due to some unavoidable circumstances. Now the government is making a rule for this for the law enforcement in which the new building cannot connect their outlet pipe to the drain.*

C-3. KII to Community Development Committee (CDC) Personnel

Checklist for KII of Faecal Sludge Emptying Service Provider

(All information will be collected only for research purpose and rights reserves to the Dept. of Civil Eng., KUET)

Organization Name	:	Community Development Commity (CDC)		Org. Type	:	☐ GOVT.	☑ NGOs
Name of the informant	:	Rokea	Stakeholder Type	:	Emptying Service Provider		
Designation	:	Acting Manager	Date	:	09 July 2017	Time: 1.15 pm – 2.15 pm	
Name of the interviewer	:	Sabok Mondal & Irfan Shakil					

1. In which area you provide the service? What are the resources (manpower, expertise, equipment's, tools, vehicles, logistics) you have to manage the services?

   Answer: *We provide our service only in the City Corporation area with the suburbs. We provide only mechanical service. We have 3 vacutugs. It is small than the city corporation vacutugs. It can get entry 5-8 ft road width. Its volume is 1000L. And the manpower is 1 driver and two helpers worked per vacutug.*

2. What about the emptying demand and service provided? Do you provide the service in between 24 hours as per request? Generally, which time (day, night) you provide the service?

   Answer: *The emptying demand of customers is not so much good and has been increased than previous few years. Sometimes the service is provided within 24 hours, sometimes not. We provide the service within in 24 hours. We provide the service only night time due to spreading bad odor during emptying.*

3. Do you maintain any records/registers (income and expenditures) of sludge management services? Have you any record (log book) of the emptying operation? Currently, this emptying job is in profit/ loss? How much profit or loss per month?

   Answer: *Yes, the conservancy department has a log book of the emptying operation and also keeps records of income and expenditures. The business is not so good for profit. Monthly income is about 20000 BDT. But after giving the salary to driver, helper and fuel cost, mobil cost, operation, and maintenance cost, it has no more in hands.*

4. Do you provide sufficient health and safety equipment to the emptiers? Do they use PPEs during emptying operation? If not, why? What is your perception of the necessity of using PPEs?

   Answer: *Yes, we have provided sufficient health and safety equipment to the emptiers. We provided gumboot, dress, mask, gloves, glass etc. as safety equipment. But the emptiers does not feel comfortable to use this safety equipment. Because they are not habituated to use it. They use when any officer come to visit or any other critical time. But all time they are not using it. I think it is very necessary to use PPEs during emptying operation.*

5. Have you organized any training for safe sludge emptying, health and safety issues to the emptier?

   Answer: *Yes, we have organized training 3 to 4 times for safe sludge emptying, health and safety issues to the emptier and also the driver.*

6. How is sludge transported to dumping site? Where is the emptying sludge dumped/disposed of currently? Are you aware of illegal dumping of sludge?

   Answer: *If the emptying operation is done by the manual process. Then the manual boggy is poured by sludge and hauling by a mounted tractor, the sludge is transported to the dumping site. The sludge is being dumped at Rajbandh FTP. And if the operation is done by the vacutug. Then vacutug directly transports the sludge to the treatment plant. Mainly, manual informal emptiers are responsible for illegal dumping. They do their job at night and dump the sludge at the nearby drain or water body which is harmful to the environment.*

Appendix D: Focus Group Discussion (FGD)

Focus Group Discussion with Faecal Sludge Emptiers

(All information will be collected only for research purpose and right reserves to the Dept. of Civil Engineering, KUET)

Title for FGD	:	Faecal Sludge Management in Khulna City: An Approach for Safe Emptying			
Number of Participants	:	Mechanical Emptiers: 2 Mmnual Emptiers: 8			Vacutug Drivers: 2
Place	:	Office of the Community Development Committee (CDC)			
Date	:	13 July, 2017	Time	:	11.30 am
Name of Interviewer	:	Sabok Mondal, S. M. Tafsirul Islam & Irfan Shakil			

1. What types of work you usually do as a sweeper and describe your responsibility? Are you enlisted as sweeper of any organization?

   Answer: *As cleaners, all of the respondents are by birth sweepers. They were talking about the responsibilities of their respective works. The pattern of the cleaning is different in many cases but the type or main theme of the work is cleaning the toilets. They also said that they have to clean the septic and pit latrines also. They work in various organizations as well as in government offices. Many of them have mentioned about the cleaning of personal toilets of officers' house and their offices and hospital toilets as well as cleaning of the staircase. They have also mentioned that they usually clean the toilets with proper materials daily which is one of the most important duties of their work. They clean toilets, clean septic tanks, clean room, wall etc. as their professional responsibilities. One of the respondents has told about his specific responsibilities in work like cleaning company's toilet with own hands, washing the floor of the fish market. One of the respondents has told that he has to work from morning to evening cleaning toilets and washrooms including the walls and floor.*

2. How long you involved in the emptying job of septic tank/pit? Is it your primary job? Which type of emptying service you provided? In which area, you provide the service (both manual & mechanical)?

   Anwer: *As a sweeper, they are working this emptying job many years ago. When the vacutug did not come to Khulna city, some participants, who work in a hospital, commercial buildings or as a shop assistant, have pointed out their absence in going out for extra work after working in their fixed paid monthly employment. Manual emptying service was the main profession previously, but now they are permanent emptier by vacutug. They provide the service not only the inter Khulna city but also the adjacent area or cities of Khulna.*

3. What types of the customer have you got more? (Pit/Septic tank) (House/Office/Institutions)

   Answer: *Talking about the customers, they all have told that they get a call from the pit latrines users through a substantial quantity of calls come from also the septic tank users. The household is the main customers for cleaning their toilets. The respondents have told that they get a call from the adjacent area of Khulna city.*

Appendix E: SAT Tool Calculations

E-1. Muzgunni Second Phase (Residential Area)

Containment

FSM Situational Assessment Tool

Note: This sheet includes the assessment questions on the first component of FSM service chain i.e. Containment. However, the users can either assess the entire FSM chain by answering all the question or assess any of the FSM service chain component by answering individual sheet of the tool- depending upon their interest and/or the problems in their area; and can view the snapshot of the FSM situation accordingly in the dashboard section.

CONTAINMENT

1. Are the permits required for the construction of on-site sanitation systems (OSS) in existing or new buildings? ◉ Yes ○ In-process ○ No

1.1 Which institutional organization issues the permits for construction of OSS?

Khulna Development Authority (KDA)

2. Are the specifications for construction of OSS clearly identified in the national building code or other similar documents? ○ Yes ○ In-process ◉ No

3. What are the types of toilet in the area? Write percentage of selected toilet types.

☐ Dry Toilet	%
☐ Urine Diversion Dry Toilet (UDDT)	%
☐ Urinal	%
☑ Pour Flush Toilet	70.00 %
☑ Cistern Flush Toilet	30.00 %
☐ Urine Diverting Flush Toilet (UDFT)	%
☐ Others, please specify	%

4. What percentage of containment area is: flood prone and non flood prone — Flood prone area % ; Non flood prone area %

5. What is the groundwater table in the containment area? ○ High (pit bottom <1.5m from Groundwater table) ○ Both ◉ Low (pit bottom >1.5m from Groundwater table)

5.2 What percentage of containment area has low groundwater table? 100.00 % area with low GWT

6. What are the soil types in the containment area? Write percentage of selected soil types.

☑ Clayey	75.00 %
☑ Silty	10.00 %
☑ Sand	15.00 %
☐ Gravel	%
☐ Rocky	%
☐ Others, please specify	%

7. Coverage of On Site Sanitation (OSS)

7.1 % of household with :

a) Septic tanks (watertight chamber with inlet and outlet pipe)	100.00 %
b) Single pit latrine (a sinlge pit dug into the ground which is used to contain excreta)	%
c) Twin pit latrine (double pits dug into the ground which is used to contain excreta)	%
d) Cesspool (leaching pools/pits which is used to contain sewage/excreta)	%
e) Without any connection i.e. public/community toilet	%

(Note: "Household OSS" includes septic tanks as a lined containment & single pit latrine, twin pit latrine and cesspool as an unlined containment)

7.2 % of commercial establishments with :

a) Septic tanks	%
b) Others	%

(Note: "Commercial OSS" includes septic tanks which is a lined containement)

7.3 % of institutional establishments with :

a) Septic tanks	%
b) Others	%

(Note: "Institutional OSS" includes septic tanks which is a lined containment)

8. Average volume of OSS

8.1 For Household:

a) HH septic tanks	75.00 m^3
b) HH single pit latrine	m^3
c) HH twin pit latrine	m^3
d) HH cesspool	m^3

8.2 For Commercial establishments:

a) Commercial Septic tanks	100.00 m^3

8.3 For Institutional establishments:

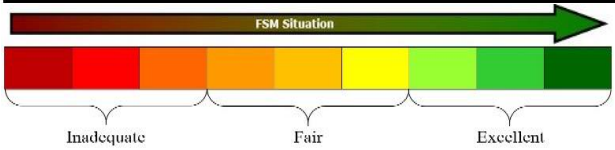
a) Institutional Septic tanks	m^3

9. Are there subsidies for households to construct proper OSS? ○ Yes ○ In-process ◉ No

10. Are people aware of the proper use and maintenance of septic tanks? ○ Yes ○ In-process ◉ No

11. Are there enough FSM advocacy materials available on septic tanks? ○ Yes ◉ In-process ○ No

11.1 Please select the type of available advocacy materials ☐ Publications ☐ Audio ☐ Video ☑ Multimedia ☐ Others, please specify



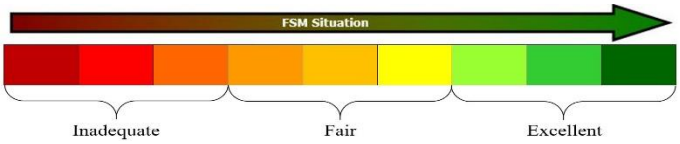
Fair

Emptying

FSM Situational Assessment Tool

EMPTYING

1. Is there a mandate in desludging? (*Note:Desludging is a process of removing FS by emptying the containment)	◉ Yes	○ In-process	○ No		
1.1 Are the households aware of mandatory desluging?	○ Yes	○ In-process	◉ No		
2. Frequency of desludging	◉ 3 years	○ 4 years	○ 5 years	○ Other, please specify:	
3. % of Desludging					
3.1 a) % of household septic tank that can be desludged	42.00	%			
b) % of household single pit latrines that can be desludged	0.00	%			
c) % of household twin pit latrines that can be desludged	0.00	%			
d) % of household cesspool that can be desludged	0.00	%			
3.2 % of commercial septic tank that can be desludged		%			
3.3 % of institutional septic tank that can be desludged		%			
4. % of Accessibility					
4.1 % of household OSS that are accessible	77.00	%			
4.2 % of commercial OSS that are accessible		%			
4.3 % of institutional OSS that are accessible		%			
5. Are permits and license required for emptying?	○ Yes	○ In-process	◉ No		
6. What is the most common method of emptying fecal sludge?	○ Manual	○ Mechanical	◉ Both	○ Other, please specify:	
6.1 (If Manual) Are the safety standards clearly defined in the FSM operators manuals?	◉ Yes	○ No			
6.1.1 What is the current fee for manual emptying?	40.00	Local currency/m^3 for households			
		Local currency/m^3 for slums			
6.1.2 Who checks the compliance of these safety standards?	None				
6.1.3 Are there penalties for non-compliance?	○ Yes	◉ No			
6.2 (If Mechanical) Are the safety standards clearly defined in the FSM operators manual?	◉ Yes	○ No			
6.2.1 What is the current fee for mechanical emptying?	33.00	Local currency/m^3 for households			
		Local currency/m^3 for slums			
6.2.2 What is the % collection efficiency of FSM tariff?		%			
6.2.3 Who checks the compliance of these safety standards?	None				
6.2.4 Are there penalties for non-compliance?	○ Yes	◉ No			
7. Is there any awareness program on the desludging process?	◉ Yes	○ In-process	○ No		
8. Are there any FSM advocacy materials on desludging?	○ Yes	◉ In-process	○ No		
9. Are there any advocacy programs for service providers/workers about the health risks of Fecal Sludge?	○ Yes	◉ In-process	○ No		
10. Are there any FSM advocacy materials targeted at FSM workers involved in Fecal Sludge collecting and emptying?	◉ Yes	○ In-process	○ No		



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E-2. Boro Boyra (Mixed-use Area)

Containment

FSM Situational Assessment Tool

Note: This sheet includes the assessment questions on the first component of FSM service chain i.e. Containment. However, the users can either assess the entire FSM chain by answering all the question or assess any of the FSM service chain component by answering individual sheet of the tool- depending upon their interest and/or the problems in their area; and can view the snapshot of the FSM situation accordingly in the dashboard section.

CONTAINMENT

1. Are the permits required for the construction of on-site sanitation systems (OSS) in existing or new buildings? ◉ Yes ○ In-process ○ No

1.1 Which institutional organization issues the permits for construction of OSS?

Khulna Development Authority (KDA)

2. Are the specifications for construction of OSS clearly identified in the national building code or other similar documents? ○ Yes ○ In-process ◉ No

3. What are the types of toilet in the area? Write percentage of selected toilet types.

☑ Dry Toilet	25.00 %
☐ Urine Diversion Dry Toilet (UDDT)	%
☐ Urinal	%
☑ Pour Flush Toilet	45.00 %
☑ Cistern Flush Toilet	30.00 %
☐ Urine Diverting Flush Toilet (UDFT)	%
☐ Others, please specify	%

4. What percentage of containment area is: flood prone and non flood prone
Flood prone area %
Non flood prone area %

5. What is the groundwater table in the containment area?
○ High (pit bottom <1.5m from Groundwater table) ○ Both
◉ Low (pit bottom >1.5m from Groundwater table)

5.2 What percentage of containment area has low groundwater table? 100.00 % area with low GWT

6. What are the soil types in the containment area? Write percentage of selected soil types.

☑ Clayey	75.00 %
☑ Silty	10.00 %
☑ Sand	15.00 %
☐ Gravel	%
☐ Rocky	%
☐ Others, please specify	%

7. Coverage of On Site Sanitation (OSS)

7.1 % of household with :

a) Septic tanks (watertight chamber with inlet and outlet pipe)	73.00 %
b) Single pit latrine (a sinlge pit dug into the ground which is used to contain excreta)	12.00 %
c) Twin pit latrine (double pits dug into the ground which is used to contain excreta)	15.00 %
d) Cesspool (leaching pools/pits which is used to contain sewage/excreta)	%
e) Without any connection i.e. public/community toilet	%

(Note: "Household OSS" includes septic tanks as a lined containment & single pit latrine, twin pit latrine and cesspool as an unlined containment)

7.2 % of commercial establishments with :

a) Septic tanks	%
b) Others	%

(Note: "Commercial OSS" includes septic tanks which is a lined containement)

7.3 % of institutional establishments with :

a) Septic tanks	%
b) Others	%

(Note: "Institutional OSS" includes septic tanks which is a lined containment)

8. Average volume of OSS

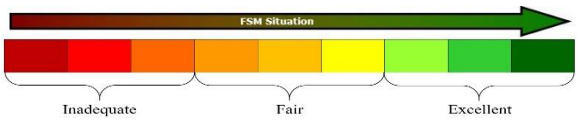
8.1 For Household:	
a) HH septic tanks	65.00 m^3
b) HH single pit latrine	10.00 m^3
c) HH twin pit latrine	16.00 m^3
d) HH cesspool	m^3
8.2 For Commercial establishments:	
a) Commercial Septic tanks	m^3
8.3 For Institutional establishments:	
a) Institutional Septic tanks	m^3

9. Are there subsidies for households to construct proper OSS? ○ Yes ○ In-process ◉ No

10. Are people aware of the proper use and maintenance of septic tanks? ○ Yes ○ In-process ◉ No

11. Are there enough FSM advocacy materials available on septic tanks? ○ Yes ◉ In-process ○ No

11.1 Please select the type of available advocacy materials ☐ Publications ☐ Audio ☐ Video ☑ Multimedia
☐ Others, please specify



Fair

Emptying

FSM Situational Assessment Tool

EMPTYING

1. Is there a mandate in desludging? (*Note:Desludging is a process of removing FS by emptying the containment) ◉ Yes ○ In-process ○ No

   1.1 Are the households aware of mandatory desluging? ○ Yes ○ In-process ◉ No

2. Frequency of desludging ◉ 3 years ○ 4 years ○ 5 years ○ Other, please specify: _____

3. % of Desludging

   3.1 a) % of household septic tank that can be desludged 38.00 %

   b) % of household single pit latrines that can be desludged 9.00 %

   c) % of household twin pit latrines that can be desludged 10.00 %

   d) % of household cesspool that can be desludged _____ %

   3.2 % of commercial septic tank that can be desludged _____ %

   3.3 % of institutional septic tank that can be desludged _____ %

4. % of Accessibility

   4.1 % of household OSS that are accessible 27.00 %

   4.2 % of commercial OSS that are accessible _____ %

   4.3 % of institutional OSS that are accessible _____ %

5. Are permits and license required for emptying? ○ Yes ○ In-process ◉ No

6. What is the most common method of emptying fecal sludge? ○ Manual ○ Mechanical ◉ Both ○ Other, please specify:

   6.1 (If Manual) Are the safety standards clearly defined in the FSM operators manuals? ◉ Yes ○ No

   6.1.1 What is the current fee for manual emptying? 30.00 Local currency/m^3 for households

   _____ Local currency/m^3 for slums

   6.1.2 Who checks the compliance of these safety standards? None

   6.1.3 Are there penalties for non-compliance? ○ Yes ◉ No

   6.2 (If Mechanical) Are the safety standards clearly defined in the FSM operators manual? ◉ Yes ○ No

   6.2.1 What is the current fee for mechanical emptying? 25.00 Local currency/m^3 for households

   _____ Local currency/m^3 for slums

   6.2.2 What is the % collection efficiency of FSM tariff? _____ %

   6.2.3 Who checks the compliance of these safety standards? None

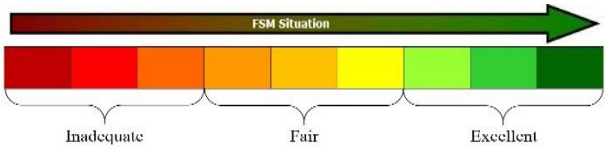
   6.2.4 Are there penalties for non-compliance? ○ Yes ◉ No

7. Is there any awareness program on the desludging process? ◉ Yes ○ In-process ○ No

8. Are there any FSM advocacy materials on desludging? ○ Yes ◉ In-process ○ No

9. Are there any advocacy programs for service providers/workers about the health risks of Fecal Sludge? ○ Yes ◉ In-process ○ No

10. Are there any FSM advocacy materials targeted at FSM workers involved in Fecal Sludge collecting and emptying? ◉ Yes ○ In-process ○ No



Inadequate

E-3. Rail Junction Bosti (Slum Area)

Containment

FSM Situational Assessment Tool

Note: This sheet includes the assessment questions on the first component of FSM service chain i.e. Containment. However, the users can either assess the entire FSM chain by answering all the question or assess any of the FSM service chain component by answering individual sheet of the tool- depending upon their interest and/or the problems in their area; and can view the snapshot of the FSM situation accordingly in the dashboard section.

CONTAINMENT

1. Are the permits required for the construction of on-site sanitation systems (OSS) in existing or new buildings? ◉ Yes ○ In-process ○ No

1.1 Which institutional organization issues the permits for construction of OSS?

Khulna Development Authority (KDA)

2. Are the specifications for construction of OSS clearly identified in the national building code or other similar documents? ○ Yes ○ In-process ◉ No

3. What are the types of toilet in the area? Write percentage of selected toilet types.

☑ Dry Toilet	15.00 %
☐ Urine Diversion Dry Toilet (UDDT)	%
☐ Urinal	%
☑ Pour Flush Toilet	85.00 %
☐ Cistern Flush Toilet	%
☐ Urine Diverting Flush Toilet (UDFT)	%
☐ Others, please specify	%

4. What percentage of containment area is: flood prone and non flood prone
Flood prone area %
Non flood prone area %

5. What is the groundwater table in the containment area? ○ High (pit bottom <1.5m from Groundwater table) ○ Both ◉ Low (pit bottom >1.5m from Groundwater table)

5.2 What percentage of containment area has low groundwater table? 100.00 % area with low GWT

6. What are the soil types in the area? Write percentage of selected soil types.

☑ Clayey	75.00 %
☑ Silty	10.00 %
☑ Sand	15.00 %
☐ Gravel	%
☐ Rocky	%
☐ Others, please specify	%

7. Coverage of On Site Sanitation (OSS)

7.1 % of household with :

a) Septic tanks (watertight chamber with inlet and outlet pipe)	24.00 %
b) Single pit latrine (a sinlge pit dug into the ground which is used to contain excreta)	56.00 %
c) Twin pit latrine (double pits dug into the ground which is used to contain excreta)	20.00 %
d) Cesspool (leaching pools/pits which is used to contain sewage/excreta)	%
e) Without any connection i.e. public/community toilet	%

(Note: "Household OSS" includes septic tanks as a lined containment & single pit latrine, twin pit latrine and cesspool as an unlined containment)

7.2 % of commercial establishments with :

a) Septic tanks	%
b) Others	%

(Note: "Commercial OSS" includes septic tanks which is a lined containement)

7.3 % of institutional establishments with :

a) Septic tanks	%
b) Others	%

(Note: "Institutional OSS" includes septic tanks which is a lined containment)

8. Average volume of OSS

8.1 For Household:

a) HH septic tanks	100.00 m^3
b) HH single pit latrine	10.00 m^3
c) HH twin pit latrine	16.00 m^3
d) HH cesspool	m^3

8.2 For Commercial establishments:

a) Commercial Septic tanks	m^3

8.3 For Institutional establishments:

a) Institutional Septic tanks	m^3

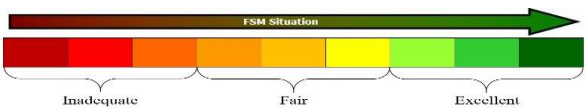
9. Are there subsidies for households to construct proper OSS? ○ Yes ○ In-process ◉ No

10. Are people aware of the proper use and maintenance of septic tanks? ○ Yes ○ In-process ◉ No

11. Are there enough FSM advocacy materials available on septic tanks? ○ Yes ◉ In-process ○ No

11.1 Please select the type of available advocacy materials ☐ Publications ☐ Audio ☐ Video ☑ Multimedia

☐ Others, please specify



Inadequate

Emptying

FSM Situational Assessment Tool

EMPTYING

1. Is there a mandate in desludging? (*Note:Desludging is a process of removing FS by emptying the containment) ◉ Yes ○ In-process ○ No

   1.1 Are the households aware of mandatory desluging? ○ Yes ○ In-process ◉ No

2. Frequency of desludging ◉ 3 years ○ 4 years ○ 5 years ○ Other, please specify: _____

3. % of Desludging

   3.1 a) % of household septic tank that can be desludged 2.00 %

   b) % of household single pit latrines that can be desludged 35.00 %

   c) % of household twin pit latrines that can be desludged 7.00 %

   d) % of household cesspool that can be desludged _____ %

   3.2 % of commercial septic tank that can be desludged _____ %

   3.3 % of institutional septic tank that can be desludged _____ %

4. % of Accessibility

   4.1 % of household OSS that are accessible 3.00 %

   4.2 % of commercial OSS that are accessible _____ %

   4.3 % of institutional OSS that are accessible _____ %

5. Are permits and license required for emptying? ○ Yes ○ In-process ◉ No

6. What is the most common method of emptying fecal sludge? ◉ Manual ○ Mechanical ○ Both ○ Other, please specify:

   6.1 (If Manual) Are the safety standards clearly defined in the FSM operators manuals? ◉ Yes ○ No

   6.1.1 What is the current fee for manual emptying? 25.00 Local currency/m^3 for households

   _____ Local currency/m^3 for slums

   6.1.2 Who checks the compliance of these safety standards? None

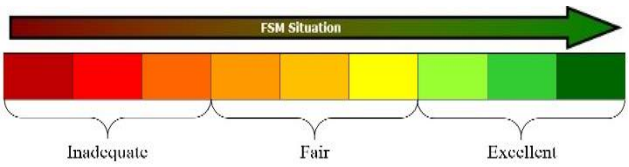
   6.1.3 Are there penalties for non-compliance? ○ Yes ◉ No

7. Is there any awareness program on the desludging process? ◉ Yes ○ In-process ○ No

8. Are there any FSM advocacy materials on desludging? ○ Yes ◉ In-process ○ No

9. Are there any advocacy programs for service providers/workers about the health risks of Fecal Sludge? ○ Yes ◉ In-process ○ No

10. Are there any FSM advocacy materials targeted at FSM workers involved in Fecal Sludge collecting and emptying? ◉ Yes ○ In-process ○ No



Inadequate