

**Towards environmentally safe faecal sludge management in informal settlements:
A context sensitive emptying model for Notun Char Bosoti**

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Declaration

I declare that this thesis represents my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this university or to any other institution for degree, diploma or any other qualification.

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Abstract

“Towards environmentally safe faecal sludge management in informal settlements: a context sensitive emptying model for Notun Char bosoti”

Faecal sludge management (FSM) globally prescribed as de-facto solution for sustaining on-site sanitations of urban settlements. But developing countries are struggling for context specific solutions for emptying operations. Different top down approaches are being applied as emptying solutions and as a result those are facing up constrains to reach many settlements for safe emptying; specially for informal settlements. This study focuses on FSM challenges of informal settlements and determines its purposes to response for those challenges. The purposes of this study were, to explore peoples’ FSM practice among informal settlements, to identify factors behind environmentally unsafe practices and to develop a context sensitive model for environmentally safe emptying and conveyance of faecal sludge. The whole study is focused to develop concepts within environmental sanitation and informed by city wide inclusive sanitation. To progress in case study research approach, this study has selected Notun Char settlement, Khulna city as a case. This study is conducted as qualitative inquiry following social constructivist paradigm and worked in people centric approach for learning from people. Sample containment and population been selected in combined purposeful sampling methods. Containments been selected in maximum variation sampling method, population from shared toilet user been selected from snow ball sampling method for KII and also been selected in random purposeful sampling for FGD. For KII of local emptier been selected in opportunistic sampling, vacutug manager been selected in snow ball sampling and NGO personnel been selected in convenience sampling method. For FGD of CDC members also been selected in opportunistic sampling and manual emptiers been selected in random purposeful sampling method. This study conducted KII, FGD, observation for data collection and used mapping, theme identification and content analysis as data analysis method. Results for FSM practice been presented in built environmental mapping and FS flow diagrams. Influencing factors of unsafe practices been analyzed in NVivo 11 and presented in word cloud using node and clustering data under generated nodes. This thesis identified strengths of FSM practices among settlement people; such as: (1) Periodical desludging (2) Periodical monitoring; (3) Alley based organization; (4) Collective payment mechanism and (5) Adaptive acceptance quality of settlement people. It also identified environmentally unsafe practices of FSM such as; (a) use of hanging toilet, (b) use of bottom unlined pit, (c) pipe connection for FS discharge to water body and drains, (d) emptying duration more than three years, (e) no use of protective gear

while emptying, (f) entering into containment during emptying, (g) no use of safe equipment, (h) not carrying FS to safe location and (i) spillage in settlement premises during emptying. Finally, this study proposes a model for environmentally safe emptying and conveyance which has core relations with containment management and safe discharge location. Core themes for the proposed model are; (a) Equitable impenetrable and emptiable containment, (b) Periodical emptying and conveyance, (c) Adaptive equipment; (d) Adaptive health safety kit and (e) Proximal safe discharge location for all. The proposed model also identified core technological components to make the model sensitive for studied case and it proposed gulper and MAPET as most convenient equipment for manual emptying process and can be produced locally and also identified transfer station with holding tanks as primary solution to mitigate problems associated with unsafe discharge of FS.

Key words: faecal sludge management, informal settlement, environmentally safe, emptying

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List of Abbreviations

WASH: Water, Sanitation and Hygiene

FS: Faecal Sludge

FSM: Faecal Sludge Management

DEWATS: Decentralized Wastewater Treatment Systems and Sanitation

HH: Household

KCC: Khulna City Corporation

CDC: Community Development Committee

NGO: Non-Government Organization

UNDP: United Nations Development Program

WHO: World Health Organization

CBS: Container Based Sanitation

BORDA: Bremen Overseas Research, Germany

BMGF: Bills and Melinda Gates Foundation

TSK: Towards Sustainable Khulna

ADB: Asian Development

SDG: Sustainable Development Goal

KDA: Khulna Development Authority

GIS: Geographic Information System

BBS: Bangladesh Bureau of Statistics

CSS: Christian Service Society

MAPET: Manual Pit emptying technology

KII: Key Informant Interview

FGD: Focus Group Discussion

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1 Chapter one: Introduction

Chapter one: Introduction

1.1 Background

This study is about faecal sludge management for informal settlements and focuses on finding context sensitive emptying model to move the global concept of city-wide inclusive sanitation forward. Cities are habitat for more than half of the planet's people, with 30% of all city dwellers living in slums, that means one in eight people live in slums in our world and the number is continuously swelling (UN-Water, 2018). Sanitation refers to the provision of facilities and services that globally perceived as sanitation service chain; where faecal sludge management (FSM) is an essential part and inevitable challenge aroused with achievements of remarkable growth of On-site Sanitation facilities in developing countries (BMGF, 2016; ISF-UTS & SNV, 2019; WHO, 2018). In the agenda 2030 of Sustainable development goals(SDG), establishes SDG-6 as clean water and sanitation, which advocates to ensure availability and sustainable management of sanitation for all and achieve access to adequate and equitable sanitation by 2030 (6.2) and acknowledges treatment and disposal of excreta as a bigger challenge over basic toilets (UN-Water, 2018). Sanitation service chain which articulates faecal sludge management; has understood as a de-facto frame work for embracing all settlements in city wide faecal sludge management systems and identifies distinctive interdependent phases of system which are containment, emptying, transport, treatment and disposal (Kong & Bartell, 2018; Scott, 2019). City-wide Inclusive sanitation means Safely managed human waste along the entire sanitation service chain, ensuring benefits for all settlements including slum areas, from adequate service delivery outcome, counting adaptive and varied technical solutions responsive to context specific realities (ADB, 2018). Un-Habitat recommends local governments to acknowledge and coordinate small scale informal operators and service delivery in sanitation service provisions for slum areas (UN-HABITAT, 2016).

In Bangladesh open defecation has been reduced in less than 1% of population with MDG sanitation target and current sanitation challenge is FSM. But only 2% urban faecal sludge is managed and treated with sewerage systems and that is not available in all the cities (BBS & UNICEF, 2014). Which takes to increase reliability on on-site sanitation, including pit latrines and septic tanks and only 12-30% of slum populations have access to safely managed sanitation facilities including FSM (JMP, 2015; Oxfam, 2014). Faecal sludge management is understood as second-generation sanitation challenge and emptying is inevitable for sustaining on-site sanitation systems (ISF-UTS & SNV, 2019). To improve FSM services it is prerequisite to have clear understanding of challenges in informal settlements, but lacking reliable data

(Oxfam, 2014). In addition, having inadequate links between sanitation planning and overall urban planning and budgeting, results unequal progress and specially informal settlements being left behind (WHO, 2018). Like many developing countries, Bangladesh is also struggling to find context sensitive solutions for FSM services (Opel & Khairul Bashar, 2013), but different arrays of faecal sludge emptying services depends on on-site infrastructures (P Scott, 2019). Need of suitable technology and service provision for emptying and transportation of faecal sludge is growing globally with experiments and technological innovations. Contextual differences and varied demands causes a single technology or service model inapplicable to everywhere (Opel & Khairul Bashar, 2013). Emptying process completely depends on the type of on-site sanitation facilities, suitability of containment and availability of safe disposal sites, forms of apparatus possessed by service providers and level of expertise and local availability of sludge emptying method are became top criteria for developing countries (Chipeta, Holm, Kamanula, Mtonga, & de los Reyes, 2017). But in the domination of vacutug based mechanical emptying service provision ignores not only existing contextual practices; but also, inclusivity of informal settlements. That ignorance compels households to rely only on manual emptying practices which are not developing with reduced health risk and environmentally safe management of faecal sludge. To include emptying challenges of informal settlements in city wide sanitation plan; a pragmatic, bottom-up, context-sensitive emptying provision is needed (Chipeta et al., 2017; Hawkins, Blackett, & Heymans, 2013).

1.2 The context of the research

While developing countries are struggling for context specific sanitation provisions for slum areas and even then it is not unknown that a single technology or model can't be applied everywhere, but city authorities are adopting only vacutug based models which has specifications for limited contexts and facing up constrains to reach many settlements for safe emptying (Frenoux & Tsitsikalis, 2015; Opel & Khairul Bashar, 2013). While evaluating parameters of environmentally safe emptying is not only limited to the vacutug based emptying services, rather it depends on quality of emptying and discharging process, containment emptying history, human contact with faecal sludge, use of equipment and safety gears, management of sludge spillage, sludge composting periods and safe landfill sites for disposal (Kabir & Salahuddin, 2014). But vacutug based services was primarily intended for slum areas in Bangladesh (Ross, Scott, Mujika, & Smith, 2016). But its service attracted demand from formal residential and commercial settlements and slum areas are not availing this service, they are really not included with that system (Jakariya, Housna, Islam, Ahsan, & Mahmud, 2018).

In Khulna city corporation (KCC) area different types of demand based faecal sludge emptying services are available. Manual emptiers are providing faecal sludge emptying services informally with manual techniques from long ago, but KCC and CDC (community development committees) has adopted only vacutug based mechanized emptying and providing services from 2012 (SNV, 2017). Though manual emptiers has unconstrained access in varied settlement with unsafe emptying methods, yet their informal roles on sanitation are not properly acknowledged. Besides self-management system of people living in informal settlements remain unexplored.

1.3 Problem Statement

Having overcrowding and high-density population, informal settlements are more potential for spreading diseases greater than less crowded areas; but building traditional type of latrine is rarely possible for them. Due to lack of available spaces to build proper sanitation facilities with appropriate on-site containment and ease of sharing slum dwellers mostly prefers pit latrines which results high filling rate of faecal sludge, difficulties of (FS) emptying and fewer number of septic tanks in settlement. Septic tanks are available only with few shared toilets which are provided by city authorities or NGO's with different sanitation projects to achieve sanitation targets of MDG. As faecal sludge management is second generation sanitation challenge aroused with reduction of open defecation but previous researches claimed that there is absence of emptying practices in informal settlements. But in informal settlements where faecal sludge accumulation rate is high due to dense population people; they do have their own management system. People connect their containments to nearest drains or water bodies with pipes to manage that accumulation. They call informal manual emptiers only when they need emergency removal of FS from containment. Manual emptiers has ease of access in terms of physical diversity of settlement and economic affordability of slum people but they discharge FS to nearest storm drains or water bodies. Besides lack of proper equipment's and transport medium they cause spillage in settlement compound. These management practices are not only environmentally unsafe, but also puts people living in the settlement in high risk of health diseases. These discharging practices are directly associated with water and eutrophication of water sources leading downstream which can affect many other localities too. On the other hand, available safe services like vacutug based model does not have access to the informal settlements due to constrains of narrow roads and economic affordability of people. For these reasons there is certain need of recognition of these FSM practices in informal settlements and development of context sensitive emptying model to include informal settlements in an

environmentally safe emptying and conveyance system to achieve city-wide inclusive sanitation.

1.4 Research Question

The following question is to address research problem of this study:

How can environmentally safe emptying and conveyance model be developed from people's practices of faecal sludge management in informal settlements?

1.5 Research Objectives:

To find answer of the research question, specific objectives of this study are:

1. To explore current practices of faecal sludge management in informal settlements
2. To identify influencing factors behind unsafe practices
3. To develop a model for environmentally safe emptying and conveyance of faecal sludge for informal settlements

1.6 Scope and Limitation of the Research

Scope and limitations of this study are as follows:

1. This study had a scope to identify FS emptying challenges of informal settlements which been identified both from literature and from the case.
2. AS flow of FS is invisible. This study found a scope to identify methodologies how FS flow can be mapped with built environmental mapping. This study combined observation and KII to generate maps and used different tools to make FS visible for this research.
3. This study had a scope to explore FSM practices in informal settlement and identify environmentally unsafe practices. Which can contribute to the theories of environmental health and slum upgradation programmers.
4. This study had a scope to contribute to the concepts of environmentally safe emptying and to develop a model for finding environmentally safe emptying solutions. Which also can contribute to develop emptying equipment sensitive for informal settlements for which developing countries are struggling.
5. As this study focused on environmental health it had a scope observe toilets as many as available in the case. It included single pit latrine, twin pit latrine, toilets with septic tank and hanging toilets into the study.

5. Initially this study was focused on emptying, but emptying is found very well connected with containment management and FS discharge; that's why this study also found scope to address problems of containments and discharge which are influencing environmentally unsafe emptying practices.

6. As the study has time limitation, it took only one informal settlement as a case, which is largest in the Khulna city and it tries to generalize the phenomenon complying all type of FSM practices which are available in different informal settlements.

7. The study has limited its focus on FSM only and it has not discussed about the problems relating black water. Studying black water usually the primary concern of decentralized waste water management (DWWAT), which is another section of Environmental sanitation.

1.7 Outcome of the research

The outcome of this study suggests a systematic research inquiry process to gather contextual knowledges around FSM in informal settlements. This research also provides a process to develop a contextual model for environmentally safe emptying and conveyance, which can be implemented in informal settlement for FSM solutions. The study identifies contextual field of analysis for further research inquiry to develop FSM practices. Which would help equipment designer, planner, service provider and policy makers to enhance the quality and contextuality of faecal sludge emptying provisions and to develop city wide inclusive sanitation.

1.8 Structure of the thesis

This thesis is structured in five chapter. All chapters are presented here in such a way that relevance can be found among the chapters.

Chapter 1: This chapter is the overview of the thesis. Global and national perspectives and crises related to FSM and emptying are been discussed in this chapter. This chapter articulates research background, research context, problem statement, research question, research objectives and scope and significance of the thesis. These connecting sections reflects key areas of this research which been detailed in further chapters.

Chapter 2: Primary concerns of these chapter is to discuss relevant literatures of FSM, informal settlement, environmental sanitation, city wide inclusive sanitation, emptying models and techniques. This chapter tried to connect each topics of discussion within a frame work to develop conceptions for further research work.

Chapter 3: key concern of this chapter is research methodologies which been applied to conduct the research. As this research been conducted in case study approach this research also been conducted in qualitative manner under the social constructivist paradigm. Methods and tools of data collection and methods of data analysis also been discussed in this chapter. Total process of the thesis been presented in analytical framework in this chapter.

Chapter 4: this chapter started with exploration of FSM practices by informal settlement people and identification of environmentally unsafe practices within the settlement. Further it explores influencing factors behind unsafe practices and finally this chapter presents development of a context sensitive model.

Chapter 5: The ending chapter of this study represents the concluding remarks of the whole study. This chapter also consists suggestions for further research and way forward from this empirical study.

2 Chapter Two: Literature review

Chapter Two: Literature review

2.1 Positioning thoughts on environmentally safe FSM for informal settlements

Sustainable development goals (SDG), establishes SDG-6 as clean water and sanitation, which advocates to ensure availability and sustainable management of sanitation for all in agenda 2030 and suggests to achieve access to adequate and equitable sanitation (6.2). which also acknowledges treatment and disposal of excreta as a bigger challenge over basic toilets (UN-Water, 2018). To acknowledge the treatment and disposal of excreta beyond off-site sanitation systems and to include on-site systems into management; sanitation service chain been proposed globally (BMGF, 2016). Sanitation service chain articulates faecal sludge management; which is understood as de-facto frame work to embrace all settlements in city wide faecal sludge management systems and identifies distinctive interdependent phases of the system (Kong & Bartell, 2018; Scott, 2019). But that de-facto chain is not enough to include all settlements which has been prescribed by SDG as achieving adequate and equitable sanitation, which has been reflected in city wide inclusive sanitation. City-wide Inclusive sanitation means Safely managed human waste along the entire sanitation service chain, ensuring benefits for all including informal settlements, from adequate service delivery outcome, counting on adaptive and varied technical solutions responsive to context specific realities (ADB, 2018). But safely managed human waste along entire sanitation service chain always gets effected by context-specific realities of different settlements. Safe management is not merely the management of FS but also has relation with health risk of human emptiers. This section of thesis will explore environmentally safe FSM informed by context specific realities of informal settlements from literatures.

2.2 City wide inclusive Sanitation

Developing countries and their development partners are adopting new approaches to achieve SDGs' sanitation targets with massive investments; but centralized conventional infrastructure benefits only a small percentage of population (UN-Water, 2018). Conventional approaches require priorities from political domain, allocation of fund, co-ordination of institutions and also involves design, planning and management practices to ensure adequate sanitation for all. It generally does not engage incremental approaches for affordable and equitable coverage for urban areas and fails to consider the trade-offs among various investment of sanitation. Only a radical shift practices and mindsets can make differences and conventional sanitation myths should be revealed. Citywide inclusive sanitation acknowledges benefits for all from adequate delivery of sanitation services; where human waste is managed safely along sanitation service

chain with effective resource recovery and reuse. Under this model, a variety of technical solutions can be employed with adaptive, mixed, and incremental approaches (ADB, 2018). On-site and sewerage solutions are combined in either centralized or decentralized systems so they can respond to the urban contextual realities in developing countries. To employ citywide inclusive sanitation, cities need to develop wide-ranging approaches to improve sanitation that incorporate long-term planning, technical innovation, institutional reforms, and financial mobilization. Professionals working in development of urban areas need to coordinate their roles more effectively. To achieve safe management of human waste, sanitation professionals must blend conventional and new solutions in ways that consider the needs and resources of their clients and solutions that link to wider urban development.

2.3 Environmental Sanitation

Environmental sanitation can be understood as a set of activities required to achieve a sanitary physical environment. Based on the Bellagio Principles for Sustainable Sanitation, environmental sanitation was developed by a team of WASH experts in 2000 in response to the shortfalls of conventional sanitation policies and practices in meeting the needs of the developing world. Environmental sanitation is advanced concept from traditional idea of “sanitation” which is limited only in aspects of toilet provision and human excreta of immediate surroundings. It considers all aspects relating human health and quality of life within and beyond settlements and it articulates a holistic approach to achieve sanitary urban environment (Bright-Davies, 2016). Environmentally safe disposal of human waste is primary concern of environmental sanitation in some cases and it also includes safe water supply and disposal of human refuse within particular communities occasionally (Saeed, Al-Muyeed, & Ahmed, 2013). But in the model developed by city sanitation planning; sanitation, excreta & wastewater management is one part of its four-dimensional model. Sanitation, excreta & wastewater management includes both FSM and DEWATS (Bright-Davies, 2016). DEWATS offer alternatives to central sewerage systems with decentralized and flexible solutions and FSM provides professional, on-demand services for the emptying of pit latrines, followed by the safe treatment and disposal of faecal sludge with transfer station or full treatment system collectively.

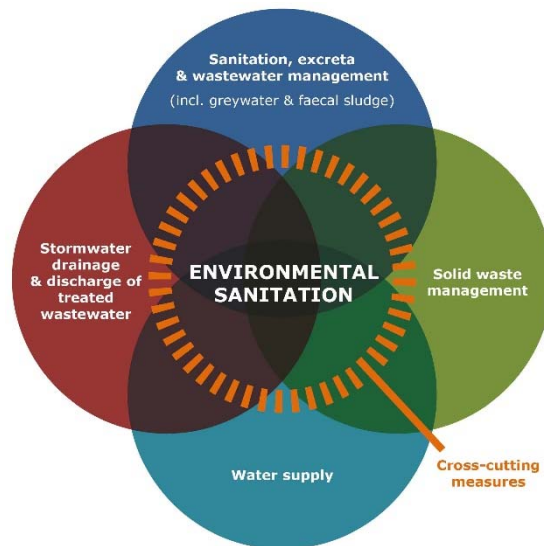


Figure 2.1 : environmental sanitation (source: (BORDA, 2018))

2.4 Faecal sludge management:

Faecal sludge comprises all liquid and semi-liquid contents of pits and tanks accumulating in on-site FS storages, namely non-sewered public and private latrines or toilets, aqua privies and septic tanks (Hemkend-Reis, Henseler, & Güdel, 2008; Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2014). On-site sanitation is a system of sanitation whose storage facilities are contained within the plot occupied by a dwelling and its immediate surrounding. For some systems (e. g. double-pit or vault latrines), faecal matter treatment is conducted on-site and also by extended in-pit consolidation and storage. With other systems (e. g. septic tanks, single-pit or vault installations), the sludge has to be collected and treated off-site (Hemkend-Reis et al., 2008). Faecal sludge (FS) management deals with on-site sanitation systems. FS may be treated in separate treatment works or co-treated with sludges produced in wastewater treatment plants (Hemkend-Reis et al., 2008).

2.5 Sanitation service chain: a de-facto framework for FSM

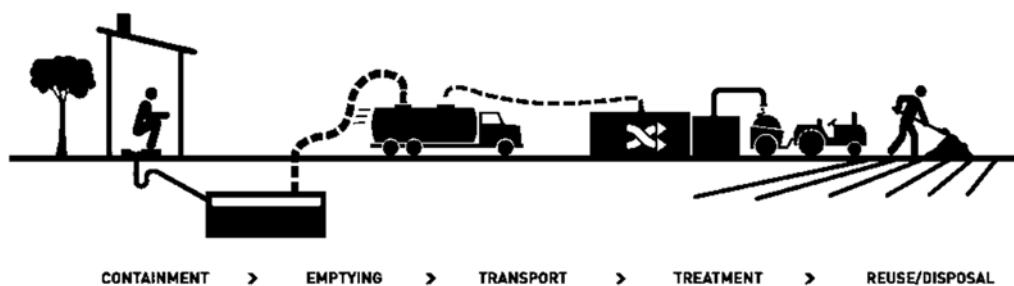


Figure 2.2 : Sanitation Service Chain (BMGF, 2016)

The functioning and process flow of an on-site sanitation is characterized by access to toilets, emptying, transport, treatment and disposal or reuse as highlighted in the figure, and this is

referred to as the 'sanitation service (delivery) chain. The chain has been widely used de-facto framework for analyzing the physical flow of FS through the sanitation systems (Rao, Otoo, Drechsel, & Hanjra, 2017; Scott, 2019). The different parts of the chain are briefly described below:






1. Containment: sanitation technologies which deals with open defecation practice and lack of facilities are understood as containment, which can safely contain and store human excreta. Conventionally containments are available as septic tanks and pits which can be connected with user interface termed as toilet.
2. Emptying and transport: Gradual accumulation of human excreta causes fill-up of septic tanks and pits over time. These gradual accumulations depend on number of user and large number user affects the fill rate of FS. Once containments are full, collected sludge needs to be emptied and transported to a safe discharge location for treatment.
3. Treatment: The FS collected from on-site facilities needs treatment to bring solid and liquid fractions of FS in a condition that does not harm to the environment and public health.
4. Disposal: treated sludge can be disposed to environment ensuring isolation of FS from human and environmental contact. Safe disposal of FS can be made but it does not provide value for resource recovery.
5. Reuse: FS resources like energy, water and nutrients and these all have intrinsic value. Reuse of FS can bring monetary recovery of faecal sludge management cost and cost of treatment plant (Rao et al., 2017).

2.6 Conventional models Emptying Faecal sludge from on-site Sanitation Facilities:

Emptying is second key concern area for environmentally safe FSM. As with many technologies and practices, emptying depends greatly on the locations of toilets. This section will explain how sanitation facility type, filling rates, spatial dimension of toilet premises, emptying duration and conveyance opportunity makes impact on development of conventional emptying models. In emptying operations, spillage of excreta can affect the health of not only emptiers, but also the nearby community as the pathogens contained within the excreta can be transmitted by flies. It is important to take care of all stages whilst emptying to keep equipment and the surrounding area clean (Boot, 2007). In many countries and cities, both mechanized and manual pit emptying services are being offered. Mechanized services are rendered by

municipal authorities or by small to medium-sized enterprises (Hemkend-Reis et al., 2008)but informal manual emptiers also provides the service with their manual powered equipment's.

Table 2.1: Advantages and limitations of emptying technologies,
source: (Thye, Templeton, & Ali, 2011), Practical Action 2017

	Manual emptying	Vacuum tanker	Vacutug	MAPET	Gulper
process	Dig out FS using hand tools	A vacuum pump carried on motorized tanker	A self-propelled mechanized vacuum pump	A manual hand powered pump and small tank mounted on pushcarts	Manual hand pump
advantage	<ul style="list-style-type: none"> • can access most locations • Affordable and easy-to-use • available equipment 	<ul style="list-style-type: none"> • Safe in terms of less contact with FS • Emptying takes few times 	<ul style="list-style-type: none"> • can access most locations • Safe in terms of less contact with FS • More mobile than vacuum tanker • Faster emptying than manual methods 	<ul style="list-style-type: none"> • can access most of the locations • Cheaper than motorized equipment's • Can be made locally 	<ul style="list-style-type: none"> • Can access most locations • Cheap • Can be made locally • Easy to carry with hand for having light weight
limitation	<ul style="list-style-type: none"> • No means of disposing sludge off site • Sometime destroys squatting slab • Risk of health • risk of spillage • protection gear is necessary • Slow emptying • Associated social stigma 	<ul style="list-style-type: none"> • narrow roads hampers accessibility • operation and equipment are expensive • requires high maintenance • Difficult to empty dense sludge and solid material 	<ul style="list-style-type: none"> • Cannot access very dense areas • Expensive, but cheaper than conventional vacuum tanker • Slow speed • Limited storage capacity 	<ul style="list-style-type: none"> • Difficult to transport FS over long distances • Specialized repair required (welding) 	<ul style="list-style-type: none"> • No means of disposing the sludge off site • Cannot empty entire pit (if pit is deep) • Slow emptying times
image & source	 SNV Khulna	 SNV Khulna	 Author	 practical action	 practical action

2.7 Specialized FSM models applied in different informal settlements

In this section some specialized models specially for informal settlements are reviewed to identify key concern areas of those models. Initially it is found that these models are too much context specific and cannot be introduced directly on another context.

2.7.1 Peepoo model

The Peepoo model provides bio-degradable bag for single use toilet to collect faeces and urines at defecation and designed in two part. Outer 15 x 40cm bag with an inner hand cover for folding over the hand during use. The bag is opened and either held by hand or put into a small bucket or bottle, e.g. a cut 1.5 L PET bottle. The user can squat over the bag to defecate and



Figure 2.3 : Peepoo value chain, source: (peepoole, 2010)

after use the bag can be sealed with a simple knot. The bag can remain odorless for over 24 h, allowing user for initial storage. The outer packaging material of the Peepoo Personal Pack is made from OPP and PE, providing a shelf life of 2 years (Vinnerås, Hedenkvist, Nordin, & Wilhelmson, 2009). Peepoo is a complete in-shelter sanitation solution. It has three products i.e. Peepoo Personal Pack as key product; Peepoo Kiti and Peepoo Yizi as supporting products. The Peepoo Personal Pack provides toilets for one person for one month - it has 28 Peepoo and one sludge collection bag. The Peepoo Kiti is a specially designed with PP seat/holder for sitting or squatting. The Peepoo Yizi is a privacy tent for use in home (Khan, Avicenna Consulting, Peepoole, & UN-HABITAT, 2012). Peepoo model tried to address different issues of informal settlement like unavailable space for conventional toilet, land tenure, lack of water supplies, security issues in shared toilet, accessibility constrains for FSM services and lack of dignified toilets. Adopting cultural practices of flying toilet, it maintains total

environmentally safe management of faecal sludge with ensuring daily collection and activating various options for conveyance.

2.7.2 Container based sanitation (CBS) model

CBS consists of an end to end service to collect waste hygienically from dry toilets built with sealable, removable containers and that are then transport to treatment site. It is an alternative sanitation option for urban areas where conventional on-site sanitation is infeasible. It is concerned about limited space of informal settlements, on rapid growth, ground water level and unsafe emptying practices, absence of water access and investment constrains for sanitation infrastructure (Bank, 2019). The main target group for CBS services are the urban poor, who typically live in dense settlements, in rented spaces or without formal land title. The prominent



Figure 2.4 : CBS value chain, source: Wikipedia

appeal of CBS is its portable nature; which makes it acceptable to context. It requires little space and limited or no in-house construction increases its acceptance. In some cases, potential customers who live in single-room dwellings may have insufficient space to install a CBS household toilet, thereby rendering single-household CBS responses unfeasible. In such conditions, shared CBS have emerged with contracting agreements with authorities (Bank, 2019)

Table 2.2: Identifying area of concern and variables of specialized models,

source: author

concern	spatial	socio-cultural	technological	environmental	Economic	
model						
Peepoo	land	security	availability	water crisis	affordable	variables
	Tenure	dignity	multiplicity	self-treated	cost refund	
	Access	self-sanitization	applicability	ease disposal	reuse	
	in-house	practice regular	adaptive	safety	no investment	
CBS	land	practice	multiplicity	water crisis	scalable	variables
	Tenure	preference	Adaptive	disposal option	self-sustaining	
	space	regular	portability	health risk	low investment	
	Access		maintenance	safety	reuse	
	topography					
	in-house					

2.8 Environmentally Safe Emptying and conveyance

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 (Kabir & Salahuddin, 2014). The F-diagram on faecal-oral disease transmission although several of its elements can be clearly identified in the figure 2.4, identified by WHO. The purpose of the figure was to highlight the role of safe sanitation system to develop sanitation wall against transmission of FS at each step chain. The diagram captures that transmission routes are not only faecal-oral but have complex ways where different risks and risky events correlate (WHO, 2018).



Figure 2.5 : The health impact of unsafe sanitation, source: (WHO, 2018)

Another FS flow diagram identifies that which activities causes hazardous events at each step of sanitation service chain and related to unsafe practice of FSM (figure 2.5).

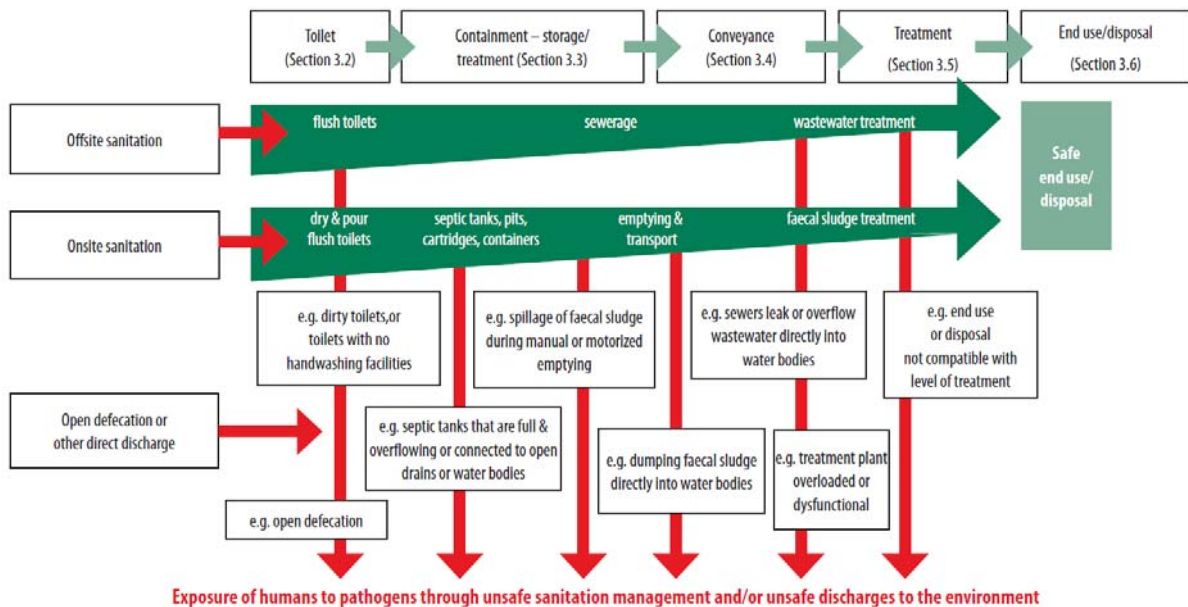


Figure 2.6 : FS flow diagram showing examples of hazardous events at each step of chain, source: (WHO, 2018)

Table 2.5: Identifying required activities for environmentally safe emptying and conveyance, source: author

Author	Practices for environmentally safe emptying and conveyance
(Kabir & Salahuddin, 2014)	<ul style="list-style-type: none"> • FS is not discharged directly to environment, open drains or open ground • Pits or tanks older than three years have been emptied within the last three years • No one entered the containment at any time during emptying • Emptiers wore protective gear during toilet emptying • Emptiers used safe emptying devices • Available pipe connection to sewer with no leakage or available digestion systems • Compost or FS is only disposed after minimum six months' storage • User of containment aware about emptying
(WHO, 2018)	<ul style="list-style-type: none"> • No open defecation practice in settlement premises • Application of a system that separates FS from human contact at all steps • Containments are impenetrable by water and flies • No direct exposure of emptiers with FS • FS not discharged on house hold surfaces or toilet premises • Un-treated FS not discharged to the water body or drains • FS never over flowed from containment • Sufficient pathogen removal process from FS in treatment facilities • No discharge practice of untreated sludge to the environment

	<ul style="list-style-type: none">• Protection of sanitation workers been ensured with compatible equipment• Community people and emptier are not exposed in direct inhalation of pathogen• Emptiers not entered into the containment during emptying• FS being accumulated for two years• Emptier wore protective gears such as gloves, masks, hats, full overalls and enclosed waterproof footwear• Emptied FS buried safely to the ground but not in crop field
(Akhilesh Gautam, K. Naga Sreenivas, Sunil Kumar Giri, Shiva Prasad Narala, Anwasha De & Prasanna Laxmi, 2017)	<ul style="list-style-type: none">• Practicing emptying cycle period of three year for single HH and more accelerated cycle for common facilities• Using proper safety gear like uniform, tools and well-maintained vehicles• Using personal safety equipment like safety helmet, goggles, reusable nose mask, rubber hand gloves, suite, gum boot and safety torch• Cleaning toilet premises after emptying operations• Not discharging FS to the field, forest, river and open drains

2.9 Recognizing FSM challenges in informal settlements

According to Un-habitat informal settlements are residential areas where inhabitants does not have tenure for land or dwellings (UN-Habitat, 2015). The settlements usually are cut off from, city infrastructures and basic services. Current planning and building regulations may not comply with informal housing and often situated in hazardous lands. Slums are most deprived form of informal settlements characterized by poverty. With addition of tenure insecurity dwellers lack formal supply of basic services and constantly exposed to disease, violence and evictions (UN-Habitat, 2015). But the practice of informality in informal settlements are the management of poverty. If poverty is a problem then informality is that how poverty is managed in informal settlements. As kim devoy mentioned informal urbanism as a complex adaptive assemblage which means; in informal settlements there exists a complex adaptive system of growth, conservation, release and re-organization and the system is intermeshed with the chain of whole urbanism (Dovey, 2012). People of informal settlements manages their situations with their own informal practices without basic services of the city. As in Un-habitat issue paper, it was prescribed to recognize challenges of informal settlements first and to adopt people centered approach to work with (UN-Habitat, 2016). This section is focused on recognizing FSM challenges of informal settlements identified in previous researches.

Having overcrowding and high-density population, informal settlements are more potential for spreading diseases greater than less crowded areas; but building traditional type of latrine is

impossible (Isunju, Schwartz, Schouten, Johnson, & van Dijk, 2011). Due to lack of available spaces to build proper sanitation facilities with appropriate on-site containment and ease of sharing slum dwellers mostly prefers pit latrines which results high filling rate of faecal sludge, difficulties of (FS) emptying and fewer number of septic tanks (Simiyu, 2017). Narrow street and passages, continual division of plot, physical diversity, topography, type and storage capacity of containment, location of containment and location of disposal site affects accessibility, mobility and affordability of availing vacutug based mechanical services which were primarily intended for slum areas for safe emptying (Isunju et al., 2011; Opel & Khairul Bashar, 2013; Ross, Scott, Mujika, & Smith, 2016; Thye, Templeton, & Ali, 2011). On the other hand, manual service providers has ease of access in terms of physical diversity and economic affordability; but due to lack of skills, capacity of equipment, constrains related to FS transportation, availability of disposal site and shortage of on-site facilities causes health risk due to spillage of FS in slum compound, discharging FS into nearest storm drains, water bodies and dug trenches which leads to the nearest ponds (Opel & Khairul Bashar, 2013; Ross et al., 2016; Simiyu, 2015; Thye et al., 2011) which are very far away from safe emptying and similar practices also happens when slum people empties their containments themselves. Further from slum peoples practices of connecting toilet directly with open drains and connecting containment with nearest storm drains with pipe or drains to escape from emptying costs not only adds more pollution to the slum environments (Ross et al., 2016) but also causes eutrophication of water sources leading downstream which can affect many other localities (Isunju et al., 2011). Tariff structures and payment mechanisms of existing services largely affects affordability of slum people (Ross et al., 2016). Availing an emptying service is primarily depends on cost of money. When slum population primarily focuses on survival of living; it seems to them an extra cost in contrast to their economic ability, which affects their willingness to pay for servicing of on-site sanitation facilities (Isunju et al., 2011). Legal status of slum compound, land tenure system and dynamics of tenant-tenant and tenant-landlord relationship causes transient nature of population who reflects very little willingness to pay for servicing on-site containments (Isunju et al., 2011; Ross et al., 2016; Simiyu, 2017). There are a lot of socio-cultural issues that influences faecal sludge emptying practices in slum areas. Lack of awareness of faecal sludge emptying, knowledge of availability of services, and social stigma of living in slum creates distances among dwellers from getting safe emptying services (Ross et al., 2016; SNV, 2017; Thye et al., 2011). A complex decision-making process of slum people and extent and boundary of shared responsibilities always hampers maintenance of toilets, containments and proper operation of emptying process in containment sites (Isunju et

al., 2011; Simiyu, 2015). These maintenance and operations are also getting affected by conflicts among tenant-tenant and tenant landlord relationship and variations of preferences selecting service options. Limited social network of transient population also develops poor linkage with well managed disposal sites and difficulties relating well managed disposal causes failure of safe emptying (Isunju et al., 2011). Ease of availing service, Visibility and smell of FS in emptying period, emptying duration, flexibility and timeliness of services and preferred time decided from slum neighborhood also affects preferences of availing services and quality of faecal sludge emptying (SNV, 2017). These instances indicate, there is a need to make manual emptiers process safe and safer service providers need to address containment and disposal site bound complexities from slum areas to increase demand and quality of emptying.

2.10 Aspects and Factors of FSM in informal settlements

Author	Socio-cultural	Spatial	Economic	technological
(Ross et al., 2016)	willingness to pay	tenancy	availability	service provision
	awareness	extent of sharing	tariff	transportation
	knowledge	space allocation	ability to pay	Fill rate of FS
	Ease of availing	containment location	payment mechanism	containment type
	responsiveness	accessibility		safety
	Lack of skills	disposal site		spillage of sludge
		equipment capacity		
		human contact		
(SNV, 2017)	visibility and smell	accessibility	Tariff structure	clean removal of FS
	ease of availing	containment location	affordability	
	timeliness			safety
	willingness to pay			equipment capacity
	decision making			type of containment
	social stigma			
(Isunju, Schwartz, Schouten, Johnson, & van Dijk, 2011)	shared responsibility	tenure	income focus	physical diversity
	social cohesion	transiency	ability to pay	
	responsibility edge	plot size		
	preference	space allocation		
	political process			
	extent of sharing			
(Simiyu, 2015)	internal conflicts	accessibility	affordability	type of containment
	cooperation	land tenure		high fill rate
	sharing restrictions	containment location		facilities shortages
	willingness			
	network			
	Knowledge	space allocation		Ease of sharing

(Simiyu, 2017)	population density	accessibility		containment preferences
	boundary of sharing	relocation of containment		exposure of FS
(Thye et al., 2011)	time of emptying	accessibility	affordability	quality of sludge
	social stigma	mobility		storage capacity
	emptying duration	discharge distance		safety
(Opel & Khairul Bashar, 2013)	process and paperwork's	topography	affordability	efficiency
	linking containment with drain	accessibility		mobility
(Blackett, Hawkins, & Peal, 2014)	density	accessibility	no reuse	containment storage
	user number/pit	unsafe dumping		containment quality
	high sludge accumulation rate			treatment facility
	refusal of collection			
	solid material in pit			

2.11 Importance of learning from informal settlements

It is very strange that peoples of informal settlements faces higher frequency of FS accumulation but some how they manages the fill-up of FS to keep running their toilets. As people practices informality to cope with poverty they may also cope with constrains of FSM with their own way. To improve environment of informal settlements and to look forward for healthy settlement it is necessary to learn from current FSM practices by people. Previous initiatives for safe FSM like vaccutug are not being accepted by people as they percived those are not for them. What they do and what they accept is important to learn to do something for them. This thesis tried to adopt a people centric approach to learn from them and initially focusses to know what are current practices of FSM in informal settlements. It also tried to conjoint the concept of FSM and the concept of environmentally safe which are directly concerned about settlement health under the bigger umbrella of environmental sanitation. As informal settlements are not the isolated reality in a city rather it is connected with the whole; this thesis tried to develop a context sensitive model for environmentally safe emptying and conveyence and also focuse to connect it with the running systems of the city. Which have been reviewd in literature as city wide inclusive sanitation.



Figure 2.7 : Theoretical Framework; (source: author)

3 Chapter Three: Methodology

Chapter Three: Methodology

3.1 Introduction

Learning from literature review suggests that, to understand peoples' practice of FSM in their settlement; needed an in-depth exploration of information from settlement people. Only visible portions of spatial situation of toilet premises and settlement compound can be observed. But flow of faecal sludge to the environment is not visible. These flows cannot be identified from visual exploration only. Because conditions of containments remain underneath the ground which can be understood only from respondents' information who observed the construction or know how it is constructed. This information became the primary source to map a clear picture of what is out there and what happens with it. Even what happens during emptying, where different population were involved in the different activities with different roles. To bring proper information about the phenomenon the research was needed a precise methodology. This chapter describes which methods been applied to fulfill each steps of this research work sequentially.

3.2 Selecting of qualitative method for research inquiry

Qualitative research inquiry covers an array of interpretive methods which narrates, interprets, renders and comes to terms with meaning of naturally occurring phenomena in the social world and qualitative researchers are interested to understand the meaning constructed by people which make sense of their world and experienced in their world (Merriam & Tisdell, 2015). To understand the FSM context of informal settlements this research needed to understand the voices, people tells about their own management system. To construct meaning from naturally occurring phenomena from FSM activities and to identify where to look at for the improvement of the practice. Selecting qualitative research method, this study has followed four main characteristics of qualitative research which are focusing on systematic process of inquiry with phase by phase exploration, understanding the phenomena from a neutral position, developing meaning which naturally being constructed and being the primary instrument as researcher for collection of data and analysis. This research also focuses on inductive process which been suggested by previous qualitative researchers and it generated products in a descriptive manner (Creswell, 2007; Merriam & Tisdell, 2015). Following the common concepts of qualitative method this thesis explored for information from three different populations. Firstly, settlement people who are main concern of this study, secondly manual emptiers who plays key role in the emptying operations and thirdly population who has involvement with sanitation of

informal settlements. But this thesis was not conducted with direct participation as it requires time; and it followed data collection method to collect information from participants.

3.3 Positioning the study in Social constructivism

After choosing qualitative research; researchers make choice with which they shape their research by bringing to the paradigms of inquiry (Creswell, 2007). Research paradigms are basic set of beliefs which guides action of the research. In his book, Creswell (2007) focused on four different paradigms such as postpositivist, constructivist, participatory and pragmatists. But this research chooses social constructivist paradigm for research inquiries. Because in this paradigm people understand the world in which they live and work. This thesis searches for information from informal settlement people and looked for the complexities of views. Views about a single event of FSM from different population been accommodated in this research to construct the phenomenon. Not starting with a theory this research inductively develop a pattern of meaning from FSM practices of people and identifies which practices are environmentally unsafe and further explore why those practices occurs. The questions used for inquiry are made broader and general so that respondents can construct the meaning of FSM situations. For these reasons more open-ended questions been used for this research. This research is focused on specific context of informal settlement and FSM which became the exact reason to choose the social constructivist paradigm. This research also explored; how different researchers belonged in social constructivist paradigm while studying informal settlements. As in gentleman's city Ananya Roy (2004) where she was interested for developing the relations among different moments of her study (Ananya, 2004), which indicates her paradigm was social constructivism as a researcher. Also, kim devoy (2012) applied inductive approach from social constructivist paradigm to conjoint two theory such as complex adaptive system and assemblage to construct the theory of informal urbanism as complex adaptive assemblage (Dovey, 2012). This study tried to follow learnings from researchers who worked for informal settlements to positioning the research in social constructivist paradigm.

3.4 Case study approach for in-depth research

Case study is an approach for research in which a single or multiple case of a phenomenon can be studied in-depth. Case study approach is not only restricted in social science researches, but rather been used in many practical contexts (Given, 2008). This study relies on case study approach to extract in-depth information about FSM from settlement people, manual emptiers and population related with sanitation. Recent theoretical approaches gave strong emphasis on ideas and timings. Case study approach became a favorite tool for accommodating the ideas

within time limitations. Besides, as theories of social constructivism stresses the importance of the perceptions of individuals and discourses in social processes and case studies can be heavily supportive for investing on tracing of ideas with in-depth interviews and discourse analysis (Given, 2008). Qualitative researchers suggest to select cases as path-dependent entities, which been followed in this research. Further this study also followed thick description of FSM practices among the people and tried to trace the processes they followed; and it applied people centered approach rather variable centered which dominates in positivist researches.

3.5 Selection of case study area

Social constructivists occasionally selects theoretically “crucial cases” but “least likely” and “most likely” cases also taken up as devices for case selection from theoretical orientation (Given, 2008). Constructivist researchers shares their opinion for selecting of crucial cases but chooses where generalization possible. This study focuses on least likely case for selection of the settlement which consists common toilet samples of informal settlements such as pit toilets and environmentally crucial samples are also available such as hanging toilets. More over toilets with septic tanks are also available in a large number to conduct the study. Every settlement has different realities, sanitation facility condition, physical-spatial condition, availability of resource and socio-economic differences. Case study area has been selected in Khulna, because in Khulna there are different types of faecal sludge emptying provisions are available. KCC and CDC provides vacutug based services from 2012 and manual emptiers providing services from long ago (SNV, 2017). Notun Bazar Char Bosoti has been selected as the least likely case for the study. Least likely case selection aims at which been labeled as “Sinatra inference” (Given, 2008). There is a paradigmatic example studied by Robert Michels (in 1962) on oligarchies in organizations - “*If a theory can make it here, it can make it everywhere*” (Given, 2008). Notun Bazar Char settlement is located near Rupsha Ferighat. As this thesis tries to identify environmental issues for healthy settlement and FS is directly related with water contamination; the location of Notun Bazar Char settlement also potential to identify the relation of FSM and water bodies because the settlement has nearby river named Rupsha. There are also available water bodies like ponds within Notun Bazar Char settlement. From floating population census, it is identified that the settlement is the largest one in Khulna consisting 854 households. The settlement is well connected with city wide roads and roads at settlement level having all types of toilets like hanging toilet, single pit toilet, twin pit toilet,

toilet with septic tank which are privately owned or shared. As this study initially tries to find the flow of FS from containment to environment, it studied all type of toilets as case.



Figure 3.1 : Location of Notun Bazar Char settlement; (source: TSK (left),

3.6 Selection of sample containment and population

This research is primarily focused on purposeful sampling. Purposeful sampling is general concept for sampling in qualitative research (Creswell, 2007). It helps to understand research problem and central phenomenon purposefully. It is important to make decision about what is to be sampled, who to be sampled, what will be the form of sampling, how many people or site location need to be sampled (Creswell, 2007). In this study it required sampling of toilet types according containment types and population from user groups, manual emptiers and other stake holders. In this section the sampling methods and sample size been discussed.

3.6.1 Sampling of toilet and Containment

From secondary data it was informed that, in Notun Char settlement there are three different type of toilets are available. First one is very common sample for informal settlements which is pit toilets, second one is hanging toilet which does not have containment and third type of toilet is shared toilets with septic tank. As this thesis is focused on environmentally safe emptying and conveyance of faecal sludge, it was required to sample all different types of toilets for further generalization of the study. For these purposes this research used maximum variation sampling method for containment selection. The purpose of maximum variation sampling is to document diverse variations and identifies important common patterns

(Creswell, 2007). Although in case study research more than 4-5 cases are not suggested but to reach the maximum variation total 17 containment been selected during this study. Besides individual user and two type of group user also been found during pilot survey. For the final selection alley-based organization of user groups also influenced the sampling of containment. Selection of sample containment influenced further activities of data collection.

Table 3.1: Selection of toilet samples

User	containment type	organization	number of selected toilets
Single HH	single pit	N/A	3
Single HH	no containment	N/A	2
Shared HH	Single pit	single alley	3
Shared HH	Single pit	double alley	1
Shared HH	Twin pit	single alley	1
Shared HH	Septic tank	single alley	5
Shared HH	Septic tank	double alley	2
total number of toilet sample			17

3.6.2 Sampling of population

Purposive sampling also been applied for the selection of population. Respondent and focus group selection from settlement been made based on typology of toilets and users of those toilets identified in previous section. In the settlement there are two types of single HH single pit users one who connects their containment with pond and another who connected their containment with drains. Theses respondents been selected during the selection of toilet. But in the case of shared toilets snow ball sampling method been applied to select respondent from user groups. Snowball sampling identifies cases of interest from people who know and which cases have rich information (Creswell, 2007). For focus group discussion among shared toilet users random purposeful sampling method been applied. Random purposeful sampling adds credibility when potential sample is too large (Creswell, 2007). In the case of shared toilets, the user number largely varied with number of households. The variation found from three household to maximum fifty-six house hold for single toilet premise. That's why random purposeful sampling became most credible tool for sampling population for focus group discussion. After sampling population from settlement population this study sampled population of manual emptier. During the study it was an opportunity to find a manual emptier

within the settlement. He was been identified from interview of sample population of users. Opportunistic sampling of population can be conducted in qualitative research which can lead for new information and can bring unexpected information (Creswell, 2007). Manual emptier from the settlement has participated in several emptying operation within the settlement and helped to gather information about the containment management of the whole settlement. Besides population from manual emptiers of Harizan community been sampled for focus group discussion to bring information about their emptying work in informal settlements. Population from Harizan community been sampled in random purposeful sampling method. Population from CDC member been selected from in opportunistic sampling method. One CDC member been found during survey among selected user group population. But she was interviewed individually further and she also helped to find other CDC members as respondent of FGD for the study. Population from NGOs also been interviewed as key informant. Which NGOs worked for sanitation projects for informal settlements within KCC area and has involvement with city wide FSM been selected to search for respondent. Nobolok and SNV, Khulna been selected to search for respondent and respondent been selected as convenience for selection. Convenience sampling can be applied as it saves time but reduces credibility (Creswell, 2007). As in this research there was time limitation, there was no other way for sampling. A respondent structural engineer who works for sanitation projects of UNDP also been interviewed as key informant. He also been selected in convenience method. As this study applied different sampling methods for selecting respondents from different types of population, this study can declare the overall sampling method as combine or mixed method, which needs further triangulation to meet the multiple interest and needs during the study as suggested by Creswell (2007). Combination of methods also gives flexibility to the researcher and increase credibility of collected information. In table 3.2 applied sampling methods for different data collection method are presented and in table 3.3 basic information of respondents are presented.

Table 3.2: Combined method population sampling

data collection	sample population	sample selection method	respondents/groups
KII	Single HH toilet user	pre-selection with toilets	4 (respondent)
KII	shared toilet user	snow ball	13 (respondent)
FGD	shared toilet user	random purposeful	6 (group)
KII	local emptier	opportunistic	1 (respondent)
KII	Vacutug manager	snow ball	1 (respondent)
FGD	Harizan emptiers	random purposeful	1 (group)
KII	NGO/ UNDP	convenience	3 (respondent)
FGD	CDC	opportunistic	3 (respondent)

Table 3.3: respondent details of different data collection method

Method and population	male	Female	age range
KII with single HH toilet user	2	3	26-55
KII with shared toilet users	1	11	22-65
KII with local emptier	1		45
FGD at Kashem alley		3	35-60
FGD at khan saheb alley	1	3	26-68
FGD at sufi saheb alley		5	25-55
FGD at Hemayet Mollah alley	2	4	20-65
FGD at Hanif Sheikh alley		4	24-34
FGD at ranga mia alley		4	22-36
FGD with CDC members		3	28-37
FGD with Harizan emptiers	8		19-45
KII with vacutug manager	1		26
KII with NGO/UNDP personnel	3		39-54

3.7 Data collection methods

Different new forms of data been emerged in qualitative researches, but Creswell grouped those forms in four basic types. Those basic types are information, observations that ranges from participant to non-participant, interviews that ranges from close ended to open ended, documents ranges from public to private and audio-visual materials such as photographs, videos and audio recordings (Creswell, 2007). Data which are conveyed by words are been labeled as qualitative data. But data does not wait out there to be collected as garbage bag in pathways; they have to be noticed by researchers to treat as data for the purpose of the study (Merriam & Tisdell, 2015). Data must be considered as specific information determined by the researcher's theoretical orientation, problem statement, research objectives and selected samples (Merriam & Tisdell, 2015). During this study different types of data collection method been applied and this section will describe what are the methods and why those been applied.

3.7.1 Key informant interview

In qualitative research the most common form of data collection is interview. Research interview is a process in which researcher engages with participant in conversation focusing on questions which are related with the study (Merriam & Tisdell, 2015). In this study, key informant interview been conducted with different respondents sampled for the study. Primarily key informant interview been conducted with respondents from toilet users. Semi-structured interview with both close and open-ended questioner been asked to the respondents to understand the whole scenario of toilet premises, the condition of containments and what they do when pit or tank is full with FS. These interviews been recorded in mobile as audio files and transcribed in Bengali language in laptop first and further transcriptions been translated into English, which areas of interviews were seemed important to generate maps, FS flow diagrams, spatial mapping and to identify themes. These interviews also helped during observation of containments, settlement drains and to identify primary discharging location of FS. Most of the interviews of settlement people been conducted in the location of toilet premises. Questions related with toilet infrastructure, respondents indicated with their body language about where it is, how it is constructed and about how they manage the situations related to FSM. Interview with local manual emptier been conducted with open-ended and unstructured questioner in a designated place where he suggested. Interviews with NGO personnel been conducted in their own office with open ended semi-structured questioners.

3.7.2 Observation

As like interviews observations are also primary source of data collection for qualitative research (Merriam & Tisdell, 2015). Observations are different in two ways from interview. Firstly, observations take place in the setting where phenomenon naturally occurs secondly, observational data represent a firsthand encounter with the phenomenon. But the phenomenon related to FSM and emptying are not observed firsthand during the study, but while interviewing respondent indicated with their body language what they do for FSM practices and what emptiers did for emptying. Respondents indication been observed which helped to generate further built environmental mapping of their toilet premises. During observation, alleys, toilet premises and household living areas been observed and photograph, video recordings been taken which been used to produce further built environmental mapping and FS flow diagrams. Measurements of streets, toilet infrastructures and spatial dimensions also been taken with digital measuring device and recorded as field notes on settlement map printed from GIS mapping generated by KDA planners.

3.7.3 Focus group discussion

Main advantage of FGD is the interaction among respondents can bring the best information about the phenomenon (Creswell, 2007). It is best way to gather information within limited time. FGD makes respondent comfortable to provide information about the phenomenon. In this study focus group discussion been conducted with population from shared toilet users, manual emptiers from horizon community and CDC members. Focus group discussion with shared toilet user been conducted in their alley and sampling method was random purposeful. In focus group discussion random respondents are found mainly female who know the most of the information about their toilet, containment and FSM practices and answered most frequently. Containments which are being used by two alleys, both alleys are covered with separate focus group discussion. Total five FGD been conducted among shared toilet users of the settlement. FGD with CDC members been conducted in an alley of the settlement where they suggested for interview location. FGD with manual emptiers from Harizan community been conducted in Harizan settlement. To identify the Harizan emptier group primarily a meeting was arranged with their leader and he asked a group of emptier to share their views for focus group discussion. All FGD been completed with open-ended questioner and recorded in audio format and further it was transcribed using laptop and translated further.

3.7.4 Data Analysis and validation

In qualitative data collection and analysis are simultaneous process and timing and integration of analysis with other tasks distinguishes the design of qualitative research from positivist traditional researches (Merriam & Tisdell, 2015). For this research, the data analysis been started during the collection of data. Primarily overall mapping procedure been started with the primary key informant interviews. To develop a reliable evidence of mapping selected site visits been repeated through the whole process. All built environmental mapping been produced with AutoCAD 2017, based on fieldnotes, photographs and video files and information gathered from interviews. After confirming all the mapping theme identification method been applied and three type of subjects been analyzed together. First one is information from key informant interviews, second produced mappings and third is pre-defined environmental issues from literature. Theme identification is a mysterious but fundamental task for qualitative research and theme identification includes both observational and calculative techniques which range from identifying key words from textual data and line by line scrutiny (Ryan & Bernard, 2003). Theme identification involves analysis in several tasks such as discovering themes and sub-themes, examining themes according to relevancy with the study, hierarchy building and linking with theoretical model (Ryan & Bernard, 2003). For this study, theme identification was necessary to relate collected information with theoretical understandings from literatures. In this study identified themes been examined with information triangulation process and discovered influential factors behind the themes. Influential factors been identified from content analysis which is primarily supported by word frequency of homogenous information source and further those are triangulated with other data sources. Word frequency been counted in NVivo 11. During the counting of word frequency, FGD data and KII data from settlement people both are counted to generate word cloud.

Assuring the validity and reliability of data is an essential component of data collection. Validity is considered as accuracy of findings and it is a distinct strength of a qualitative research. For this study, data triangulation method been applied for the validation of data. In triangulation process researchers uses different sources and methods to verify evidences (Creswell, 2007). Typically, this process involves verifying evidence from different sources to enlighten research themes. In this study information gathered from settlement people been triangulated with the data gathered from local manual emptier and local CDC members. Information gathered from KII been triangulated with FGD information and secondary data sources. In the case of double alley cases, FGD with one alley been triangulated with another

alley. Overall information about FSM and emptying been triangulated from the KII with local emptier and FGD with emptiers. Information about containment given by settlement population been triangulated with information from KII with NGO and UNDP personnel and also enlightened with secondary data sources. Clarifying researchers biases from the study is important so that reader can understand the position of researcher and it also can impact the inquiry (Creswell, 2007). In this clarification this study tried to attach comments about experiences and orientations during the presentation of data as it is suggested by previous researchers.

The overall process which been discussed in previous sections of methodology chapter been summarized in analytical framework diagram. The diagram shows each prominent step of the whole research process and relations of the steps with theoretical understandings and objectives.

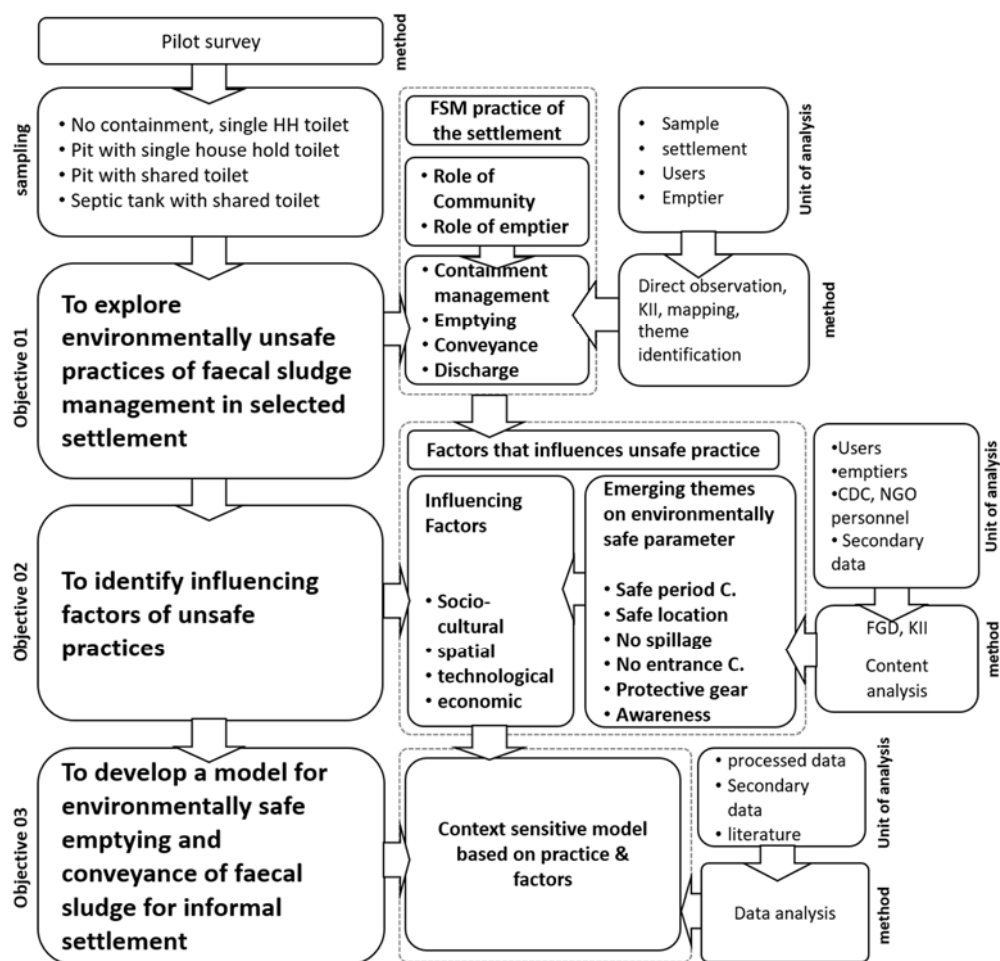


Figure 3.1: Analytical Framework; (source: author)

4 Chapter Four: Analysis and findings

Chapter Four: Analysis and findings

4.1 Outline of the chapter

This chapter is designated for presenting data analysis and findings from data sources. This chapter is mainly comprised of four major section, such as the context, FSM practice in the settlement, key concerns and the way out. This section been designed to attain research objectives sequentially.

4.2 The context

Notun Bazar Char Bosoti is located near Rupsha Ferighat area along Rupsha river. The settlement is bounded by government quarters at west, formal commercial buildings at north, formal residential buildings and industry at south and shops at east which been take as 99-year lease by settlement people. According to slum census 2015 report, there are 854 house hold living in the settlement. Total number of population is 3480, in which male population is 1725 and female 1750 in number (BBS, 2015). Main source income of these population is small business, rikshaw or van pulling, day labor, construction works and anonymous services. Mainly two type of religion found in population of the settlement. Most prominent population are Muslims and Christians.

The settlement is sited on government khas land and khristan community land. The portions Christian community land is owned by CSS Khulna, but Muslim population lives in the settlement with local political support (respondent 14). In previous history the settlement site was an agricultural land almost 70 years ago (respondent 13). It changed into the settlement for human habitat very slowly. People migrated there for better income and started living. The entire settlement is over 12.6 bigha land which recorded for Christian community (respondent 13). They filled the marshy land to make it livable. Now the settlement is not under growth rather it is passing through the conservation period of informality. During last period of BNP government, people been threatened about eviction from but during the current government their tenure became stabled. (respondent 14).

Different types of rooms are found in the settlement. Some are made of bamboo structure and many brick structured rooms are also found in the settlement. People does not pay rent for living in the settlement. But they pay taxes to KCC according to their size of the room and pay electricity bill to the bank. A sample HH pays 198-taka tax per year for 26'x13' size room, which they bought for 9000/- taka (respondent 3). There is system of buying and selling of rooms in the settlement. During surveys, a room was found for sell in the settlement. The

settlement has a prominent characteristic of alley-based organization. Every alley has own name given by the people living in those alleys. Each organization controls the decisions of their own alley. Social organizations have their own negotiations about what to do with their territory. Some organization controls general accessibility with gates at the front of their alleys. They built gates to separate their territory from the whole settlement; although they used the opportunity of dead end of the alley. Khristan goli, Sat vai goli, Kashem goli, school goli and masjid goli are most prominent alleys for public accessibility. The settlement is well connected with main city with 23' wide road. But internal alleys of the settlement found ranging from 1'-6" to 12'-0" (from the measurements taken from field survey). Concrete pavements are found in the alleys and many alleys consists drains with it. There are two water bodies (pond) found within the settlement compound. Although there are tub wells with each alley but people usually collect drinking water from dip tubewell near ferighat. KCC provided drinking water source also available in the settlement but those are no longer running because of organizational problems between alleys. There is a garbage management system of their own running by the CDC. Garbage collector collects garbage from each alley one day in a row. People pays 20 taka per month for that collection (respondent 6, 40).



Figure 4.1: types of studied containment (source: author)

In secondary data source from SNV (figure - 4.2), only two types of containment are shown. From SNV data it is known that 60% of households uses septic tanks, 38% uses pits for containing faecal sludge and 2% nothing at all in the settlement (SNV, 2019). But from pilot surveys it was identified that three types of containments are being used. Identified types are: single pit, twin pit and septic tank (figure 4.1). Each containment is associated with pour flush toilet system. No practice of containment also found in the settlement. For detail observation each type of containments is selected for the study. Selection criteria also depended with user basis, which been discussed in sample selection section of methodology chapter. Total number

of selected containments are 17 for this study. Individual households using single pit latrine, house hold cluster using single pit latrine, household cluster using septic tank, household cluster using twin pit latrine and individual household having no containment (figure 4.3) are surveyed during the study. Individual households built their toilets with their own but shared toilets been provided by different stakeholders. CDC usually provides both type of pit toilets some shared toilets been provided by KCC and some shared toilets been provided by NGO. People can place application to get toilet from CDC if they have membership card; after getting the toilet they pay the cost quarterly. An organization can apply to the NGO for installation of shared toilet with septic tank and they can get only if they can fulfil the requirements asked from NGO (source: settlement respondents, NGO personnel, secondary data).

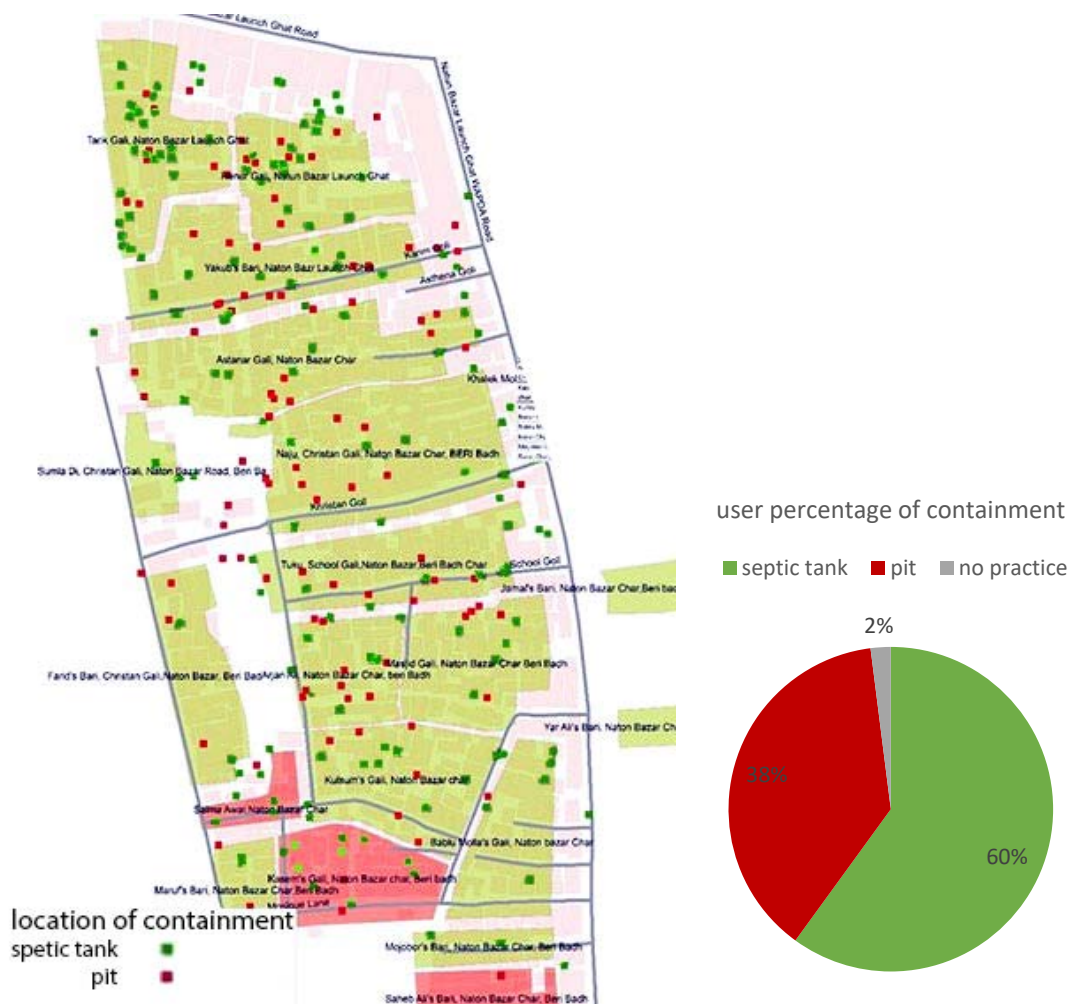


Figure 4.1: location of containment in Notun Char settlement (source: SNV 2019)



Figure 4.3: location of sample containment in Notun Char settlement (source: author)



Pond in Notun Char settlement



Linkage of City drain with Rupsha river

Figure 4.4: water bodies where FS is being discharged directly or through drains, source: author

4.3 The FSM practices

To understand the current FS discharge practice to every type of containments and non-containments are observed in detail and documented in maps. This section is primarily attributed by key informant interviews. Peoples voices been presented as verbatim quotation to enhance the validity of the discussion. interviews Maps are presented keeping focus on the flow of faecal sludge to the environment that's why non containments cases are also discussed in this phase of the study.

4.3.1 FSM practices of single households using hanging toilets

“We built the toilet self-funded, we constructed pan slab only, there is no ring under the toilet and dirt goes to water when the water level raises in the pond, not only us do that; peoples living near pond, all do the same; I mean who does not have ring (chari) toilet or does not use shared (gono) toilet ” - a female respondent (2) from Kashem goli

During pilot survey no containment practice have been found in some single household toilets living near the pond (figure-4.5). They constructed hanging toilet over pond (figure-4.5) water. From detail survey it is observed that, despite these houses are fronted with roads which has drain also but they did not build toilet with the streets. They built it over the pond as it is drawn in the figure-4.8. They use concrete squatting pan over wood and bamboo frame and use CI sheet or bamboo fence to enclose the toilet. Sludges emitted from these toilets sometimes become accumulated high under the pan when pond become dry. They pour buckets of water

brought from nearest tubewell to get rid of from high sludge accumulation which can block their squatting pan.

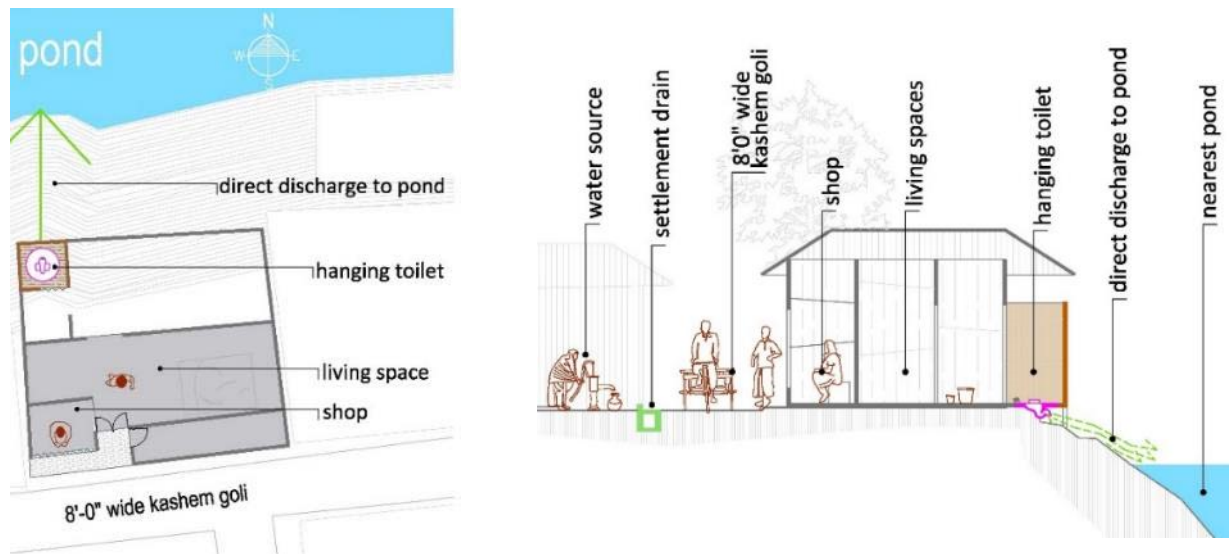


Figure 4.5: periodic FS discharge from hanging toilet of individual HH(R-1), Kashem goli

4.3.2 FSM practice of single households using single pit toilets

“my pit does not require emptying the pit has a connection with the pond ... 16-18 household of this street connected their pit with this pond, we don't have drain with this street.....every one built toilet to road side because it is less costly to connect it with the pond”

- a male respondent (3) from school goli

Individual households using single pit toilets are common scenario in Notun Bazar char settlement (figure-4.8). During the pilot surveys it was found that many of the toilets are built with their own cost and there are very few practices of emptying. Two types of single toilet been found, one that pit is under the pan slab (figure-4.8) and another is not (figure-4.7). They usually connect their pits using pipe with settlement drains and household living near the pond has connected their pit with pond using pipes (figure-4.8) (respondent-2,3). The pipes are placed under the concrete paved street. From survey findings; maximum containments never emptied before and that's why these pits are really not containing the sludge and discharges periodically to nearby drains or water body (figure-4.4) (respondent-3). Only one containment from selected sample found which was emptied four-five years ago because the pipe was blocked with hard sludge (figure-4.7). In that time, they uncovered the drain slab and tried to clear the pipe blockage with their own; using wooden sticks but failed to clear it (respondent - 5). From the observation, there was no service hole with the pit which can be used for emptying



single pit connected with Pond near



single pit connected to covered (operable) drain

Figure 4.6: alley in front of individual HH pit toilets

operation. From in-depth interview it was informed that these pits are constructed with locally made concrete rings with local masons. These pits are not lined with brick sole or concrete casting at the bottom. They used six to eight rings (respondent-3), which adds eight to ten fit depth and the bottom layer of the pit is connected with upper shallow aquifer in ground level.

“four to five years ago we cleaned pit by calling sweeper, they brought drum, bucket and spade.... but they did not discharge the sludge to the pond.... they carried it to the river and discharged near sluice gate”

– a female respondent (5) from Kashem goli

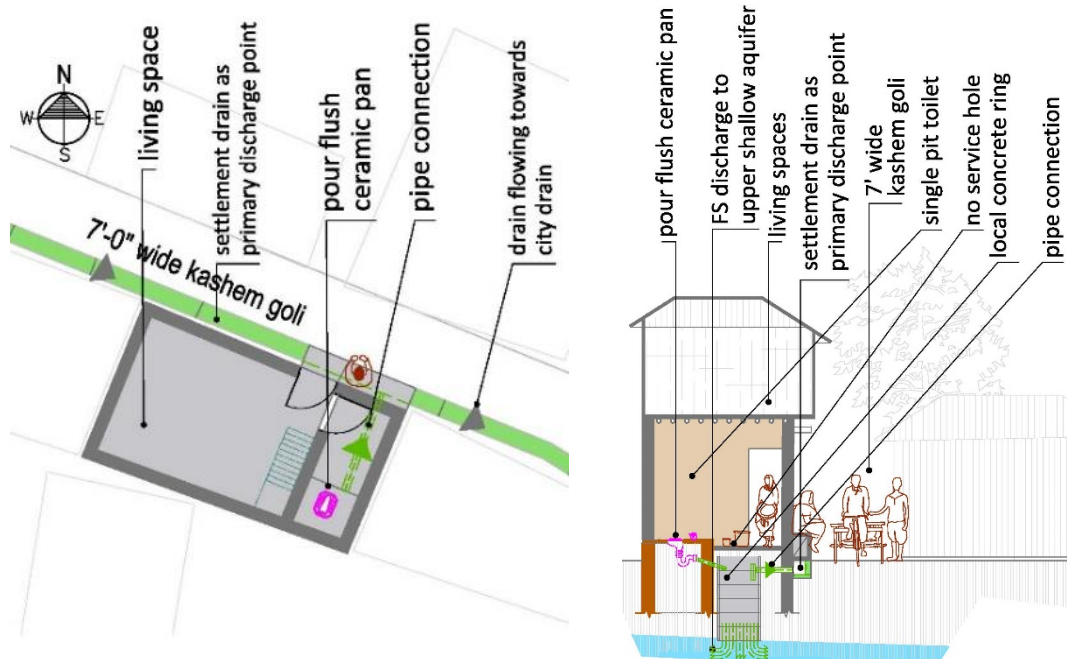


Figure 4.7: periodic FS discharge from of single HH single pit toilet (R-5), Kashem goli

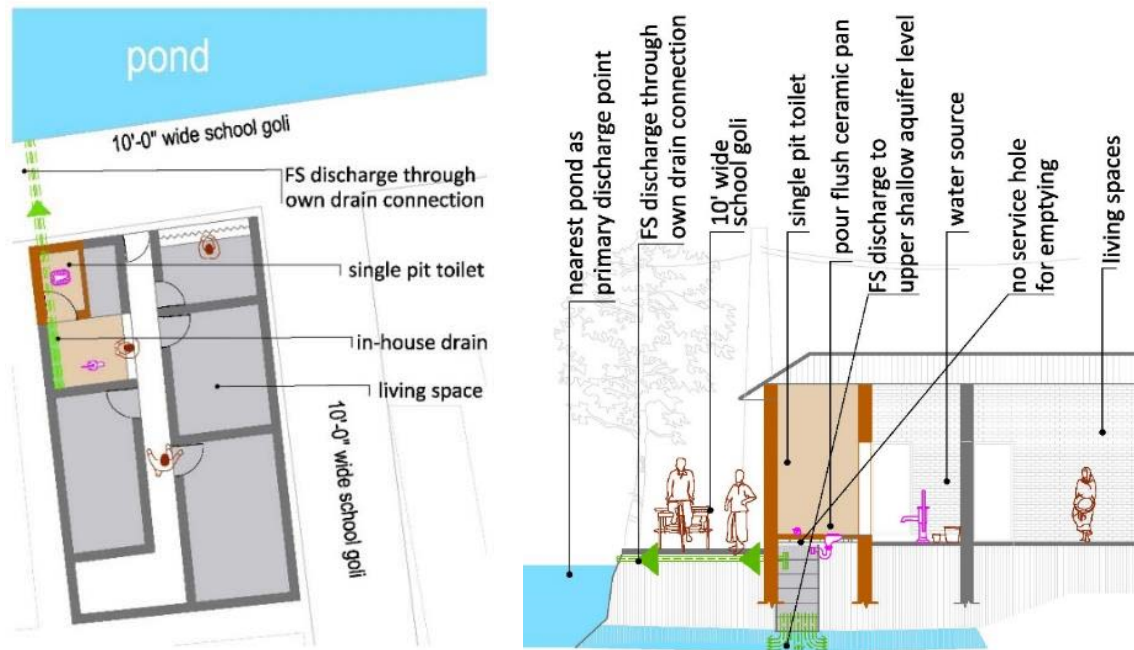


Figure 4.8: periodic FS discharge from single HH single pit toilet (R-3), school goli

People who emptied their pit they faced a high cost (respondent-5), because they had no service hole with their pit. Pit rings are not very large to place the hole over it. It is observed that toilet holders are using pour flush ceramic pan over the pit and it takes a lot space to connect with the pit. For the constrains of space within house they cannot split the position of pit from the pan. As a result, while they face the need of emptying to clear the blockage, they had to break the slab for emptying and it added extra cost for emptying. The selected containment which was emptied before was not under pan slab but had not emptying hole (figure- 4.7). That caused them extra money to break the slab over the pit and to repair it. As they have un-emptiable containment, they are concerned about FS accumulation and they expressed their willingness about making adaptive infrastructural changes with their containment to make it emptiable if they get support (respondent-3).

4.3.3 FSM practice of organizations using single pit shared toilets

“we are 50 people of 7 families using the single toilet, and it gets blocked very frequently...suppose 3-4 months consecutively...Peoples from NGO came to us for toilet but we could not avail for lack of spaces in this narrow alley.... each room of this alley has toilets and are connected with this narrow drain....”

- a female respondent (9) from ranga mia goli