Study on Faecal Sludge Management in Kushtia Municipality and its Future Development and Sustainability

by

Noman Al- Hafiz

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering in the Department of Civil Engineering

Khulna University of Engineering & Technology
Khulna 9203, Bangladesh

December, 2017

Declaration

This is to certify that the thesis work entitled *"Study on Faecal Sludge Management in Kushtia Municipality and its Future Development and Sustainability."* has been carried out by *Noman Al- Hafiz* in the Department of *Civil Engineering*, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above thesis work or any part of this work has not been submitted anywhere for the award of any degree or diploma.

Signature of Supervisor

Noman Al- Hafiz
Signature of Candidate

Approval

This is to certify that the thesis work submitted by *Noman Al-Hafiz* entitled *"Study on Faecal Sludge Management in Kushtia Municipality and its Future Development and Sustainability."* has been approved by the board of examiners for the partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering in the Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna, Bangladesh in November 2017.

BOARD OF EXAMINERS

1. _____ Chairman (Supervisor)
Dr. Muhammed Alamgir
Professor, Department of Civil Engineering
Khulna University of Engineering & Technology
Khulna-9203, Bangladesh

2. _____ Member
Head of the Department
Department of Civil Engineering
Khulna University of Engineering & Technology
Khulna-9203, Bangladesh

3. _____ 26/12/17 Member
Dr. Quazi Hamidul Bari
Professor, Department of Civil Engineering
Khulna University of Engineering & Technology
Khulna-9203, Bangladesh

4. _____ Member
Dr. Khondoker Mahbub Hassan
Professor, Department of Civil Engineering
Khulna University of Engineering & Technology
Khulna-9203, Bangladesh

5. _____ Member (External)
Dr. Md. Ashraf Ali
Professor, Department of Civil Engineering
Bangladesh University of Engineering & Technology
Dhaka, Bangladesh

Acknowledgement

All praises and gratitude is to Almighty Allah, the most merciful. It is well known that for any accomplishment requires the sincere efforts of many people and this thesis is not out of this nature of the rule.

The author wishes to express the deepest gratitude, sincere appreciation and the hearties gratitude and profound indebtedness to his supervisor Dr. Muhammed Alamgir, Professor, Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna for his increscent guidance, spirited encouragement and constructive censure at every stage of this thesis. His interest in these topic valuable advices was the source of author's inspiration.

The author wishes to convey honest gratefulness to Dr. Muhammad Harunur Rashid, Professor and head, Department of Civil Engineering, KUET for his valuable suggestions, support and Co-operation.

The author remembers with indebtedness for the worthy Co-operations and advices of Dr. Quazi Hamidul Bari, Professor, Department of Civil Engineering, KUET to enrich complete the thesis.

The author expresses his heartfelt indebtedness to Dr. Kh. Mahbub Hassan, Professor, Department of Civil Engineering, KUET for his valuable advices to complete the courses and the thesis.

The author wishes to express his gratitude to Anwar Ali, honourable Mayor of Kushtia Municipality and Ranver Ahmed, Town Planner, Kushtia Municipality for their supporting to conduct field work, sample collection and other valuable information. The author is indeed, thankful to Sayed Ahsan Ali, Technical officer, Sarder Shahidul Alam Principal Laboratory Assistant, Environment Engineering Laboratory and Md. Monirul Islam, Technician, Geotechnical Engineering Laboratory of KUET for their sincere assistance in conducting different types of tests essential to complete the thesis.

The author thankfully acknowledges the financial and logistic support provided by SNV Netherlands Development Organization through its KCC FSM Scholarship, unique initiative for provision of resource on faecal sludge.

The author is obliged to his father Md. Hafizur Rahman and mother Nasima Akter for providing moral support and encouragement.

Finally, the author prays to Almighty Allah for prosperous and peaceful life for all of us in future.

Abstract

The treatment and proper disposal of Faecal Sludge (FS) is an expensive and environmentally sensitive problem like Organic Solid Waste (OSW). The research was conducted to study the Faecal Sludge Management (FSM) in Kushtia Municipality and its future development on basis of treatment and end-use options. After data collection, Situational Assessment Tool (SAT) was used to look up the overall FSM in the municipality. Raw FS, waste water and dried FS were collected for detailed laboratory tests. Total FS generation within the municipality area is estimated at 140,798 m^3/yr as per calculation, whereas Technical and Financial Assessment Tool the value is 498,926 m^3/yr considering septic tank volume and 37,595 m^3/yr considering per capita FS generation rate. So, total FS generation is a variable figure depending assumptions, regions, factors etc. Both drying bed dewatering efficiency and coco peat filter treatment efficiency is greatly impressive, where all treated effluent parameters are within the standard limit. Although some organic and inorganic substances are released in the water body but not destructive for aquatic animals like fish and microorganisms. The decomposition of organic compounds consumes much oxygen and leads to the decrease in BOD level. In spite of good laboratory result, reality is little dissimilar because of only 27 % raw FS treatment within 220,000 liters FS collection/ month. So a majority of collected sludge is released or discarded in natural body without any kind of treatment. COD, BOD5, TS, TSS, T.C, F.C, Alkalinity and Phosphate removal from drying beds in percentage is 98.15, 80.96, 97.35, 98.52, 95.07, 98.09, 87.76 and 99.06 respectively. After dewatering the FS, proper co-composting process with OSW a reusable product is achieved where physiochemical, microbial and heavy metals parameters are within Bangladesh compost standards and WHO guideline. Comparing test results different times done in SRDI, BARI it is revealed that, compost is still good quality on basis laboratory analysis. Specially C/N ratio would be maximum 20:1 and it was found in compost as 7.3:1. So the C/N ratio after maturation level satisfied the above suggested limits and is suitable for addition to soil. After getting results from SRDI, it is seen that, presence of heavy metals are within tolerable limit. Lead is 27 ppm and Nickel is 7 ppm in range of standard limit of 30 ppm. Other chemical constituents like Phosphorus, Potassium, Sulphur are also within standard limit which are rich sources of nutrient content in compost. Even though municipality residents are known to the FSM, compost and its impact but ministry permission besides campaigning and marketing is essential for running co-composting business. FSM will be sustainable with more FS treatment and large scale co-composting business. There is no problem in treatment as well as its value chain. Day by day population will be increased where staying the present condition won't fulfill the FSM necessity. So it is highly necessary of more drying beds or another treatment plant in Kushtia to upgrade its FSM performance. Aimed at additional capability need to be created in future achieving its sustainability.

Contents

LIST OF TABLES

LIST OF FIGURES

Nomenclature

FSM	Faecal Sludge Management
FS	Faecal Sludge
OSW	Organic Solid Waste
SWM	Solid Waste Management
WSS	Water Supply and Sanitation
FSTP	Faecal Sludge Treatment Plant
COD	Chemical Oxygen Demand
BOD	Biochemical Oxygen Demand
SVI	Sludge Volume Index
KII	Key Informant Interviews
MDG	Millennium Development Goals
BBS	Bangladesh Bureau of Statistic
SVRS	Sample Vital Registration System
AIT	Asian Institute of Technology
ADB	Asian Development Bank
DoE	Department of Environment
SRDI	Soil Research and Development Institute
BINA	Bangladesh Institute of Nuclear Agriculture
LGED	Local Government Engineering Department
KUET	Khulna University of Engineering & Technology
TS	Total solids
VS	Volatile solids
SAT	Situational Assessment Tool
VSS	Volatile Suspended Solids
MC	Moisture content
BARI	Bangladesh Agricultural Research Institute
BVS	Biodegradable volatile solids
UNCRD	United Nations Center for Regional Development
EC	Electrical Conductivity
FS	Fixed Solids
CFU	Colony Forming Unit

CHAPTER I

Introduction

1.1 General

Increasing living standards in low middle income countries as a result of technology development, communication improvement have headed to increase a rapid solid waste generation. Not only solid waste generation but also sanitation coverage has put a global impact in environmental pollution. As many of the developing countries are moving towards increased sanitation coverage, the issue of safe handling of sludge has emerged as an important and challenging issue of concern. In the city, this challenge is even more acute due to the factors like high population density, rapid and unplanned growth, inadequate and often inaccessible service provisions. In cities where most of the household practice on-site sanitation, the emptying septic of tanks or pits, and transport of Faecal Sludge (FS) to a safe dumping site for treatment becomes an emerging need (Opel et al, 2012). Therefore cities and local governments are working hard for safe and sustainable sanitation management scenario. Present sanitation coverage emphasizes reduce, reuse, recycle, recover where there will be no residue left that will be designated as waste. So called the Faecal Sludge Management (FSM) includes the storage, collection, transport, treatment and safe end-use or disposal of FS.

FS comes from onsite sanitation technologies, which is not transported through a sewer. It is raw or partially digested, a slurry or semisolid, and results from the collection, storage or treatment of combinations of excreta and blackwater, with or without greywater (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014). FS has been used for centuries to fertilize fields and fishponds, and to maintain or replenish the soil. These practices have led to a strong economic link between urban dwellers (food consumers as well as waste producers) and urban farmers (waste recyclers and food producers). Faecal Sludge is a rich source of nutrients such as nitrogen, phosphorus and potassium. In human excreta, most of the organic matter is contained in faeces, while most of the nitrogen (70-80%) and potassium are contained in urine (Enayetullah, 2015). Each day, humans excrete in the order of 30 g of carbon (90 g of organic matter), 10-12 g of nitrogen, 2 g of phosphorus and 3 g of potassium (Strauss et al, 2003).

In the same fashion Municipal Solid Waste (MSW) traditionally used in developing countries such as collection and final disposal. The scenery has changed to management of biodegradable portion together with FS a common form of enduse and resource recovery. Usually the organic wastes which are disposed directly or together with other wastes to landfills create further long term problems by producing secondary pollutants including methane, ammonia, hydrogen sulfide, volatile organic compounds and leachate through anaerobic decomposition (Bari, 1999). Safe co-composting process defined as the biological degradation of highly concentrated biodegradable organic wastes and pre-treated and thickened faecal sludge in the presence of oxygen (aerobically) to carbon dioxide and water, whereby the biologically generated waste heat is sufficient to raise the temperature of the composting mass to the thermophilic range (50 to 65^{o}C) (Alamgir, 2009). The final product of composting is a stable humus-like material known as compost.

Although the Water Supply and Sanitation (WSS) sector has an impressive array of legal instruments, policies, strategies and plans in place (the National Policy for Safe Water Supply and Sanitation became effective in 1998), FSM has long been neglected and it is not yet institutionalized. The effective management of FS depends upon on suitable treatment of FS and its engineering approach to recover an end product. A low cost treatment technology option can definitely encounter the final requirements of any city level sanitation problems. Solid-liquid separation of the FS may be achieved through sedimentation and thickening in ponds or tanks or through filtration and drying in sludge drying beds. The resulting solid and liquid fractions both require further treatment (Koné, D. and Peter, S., 2008).

Bangladesh is experiencing a rapid urbanization process as more and more people from rural areas come and settle in the cities. In Dhaka, septic tanks and pits in the whole city do not require emptying as they are either covered by the sewerage networks or connected to the storm drainage or other drainage systems (Opel et al, 2012). But the outlet of septic tanks in most of the houses in cities of Bangladesh is connected directly to drains and local line-agencies have been unable to regulate pollution effectively despite the detrimental effects on the environment or the public health threat (Ahmed, 2000).

Kushtia, a growing district in Bangladesh has a FSM system operated by Kushtia Municipality. The municipality operating the FSM to address a safe and sustainable sanitation within its area. In order to tackle Solid Waste Management (SWM) as well as FSM problems, the pilot project had been initiated in Kushtia Municipality in November 2012. A baseline survey was conducted by SNV and its partners for the FSM project during September-November, 2014 in Kushtia, which revealed a lot of information about the current situation of toilets and fecal sludge (FS) containment infrastructure. Other issues of this running FSM like FS generation, its treatment technology performance, and reuse options are still yet to be determined by the way of presentation i.e. whether the sludge has been applying untreated or treated and what treatment method has been used for treating the faecal sludge after collection. Therefore, this report will analyze the FSM status in Kushtia Municipality and its sustainability by gathering basic knowledge and relevant issues.

1.2 Objectives of the Research

The main objectives of the research were to study the FS generation in the Kushtia Municipality, Faecal Sludge Treatment Plant (FSTP) treatment efficiency and to prove conformity of the use of FS as raw materials of fertilizer and conditioner. The specific objectives of these research areas are given below:

i. To identify the generation of faecal sludge for treatment and co-composting in Kushtia Municipality.
ii. To determine the treatment efficiency of existing faecal sludge treatment plant and its development to meet the needs in the future.
iii. To assess the quality of compost for its potential use as soil conditioner in agricultural field and improvement of compost quality as per the demand of users level.

1.3 Outline of Methodology

To achieve all the mentioned objectives, the following tasks were done:

I. For total FS generation of a municipality or any local authority the details primary and secondary information need to be collected. For Kushtia Municipality the baseline survey report was studied and relevant information was collected, various literatures were reviewed and FSM Toolbox method was also applied.

II. For determining the efficiency of the FSTP, random samples were collected from the Kushtia FSTP. Samples were raw FS, dried FS from drying bed. Moreover two different waste water samples were also collected. The first one from effluent tank (before the cocopeat filter) and the second one from the outlet i.e. after treatment through cocopeat filter. The physiochemical parameters for raw FS and dried FS were tested: Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Temperature, Nitrate-Nitrogen, (Ortho) Phosphate (PO_4), Water content, Total and Volatile Suspended Solids, Total Coliform, E. Coli, Sludge Volume Index (SVI), Electrical Conductivity and Alkalinity. For wastewater tests were like pH, BOD_5, COD, TS, TSS, TVS, VSS, TC, E. Coli, SVI, Fe, NO_3, PO_4, EC, Temperature and Total Alkalinity (as $CaCO_3$). Moreover some recommendations were put forward for future development of the FSTP.

III. For determining the quality of the compost the raw FS was dried and for this a simple drying bed (8 ft × 5 ft) was prepared for dewatering process. Then the dewatered FS and OSW was mixed at a ratio of 1:3 and for this a total 5 kg of samples was taken. Then various tests were conducted like Colour, Odour, pH, Moisture, TVS, Fixed Solids (FS), TS, Total Organic Carbon, Total Kjeldahl Nitrogen (TKN), Phosphorus, Potassium, Lead, Nickel, etc. Same tests were also done for the readymade compost that was collected from Kushtia FSTP. After for improvement of the compost quality as per the demand of users' level a simple Key Informant Interviews (KII) was done from different focal persons.

1.4 Organization of the Thesis

The thesis consists of 5 chapters arranged in the following order:

Chapter 1 as discussed here provides the introduction of the overall thesis works.

Chapter 2 presents a literature review that was performed to summarize the characteristics of FS, dried FS, waste water quality, standards, composting process and resource recovery quality. Moreover the relevant tests methods were also reviewed. Process of KII and FSM Toolbox method were also took under this action.

Chapter 3 provides an overall description of the methodology that were used in the laboratory to study and characterize the raw FS, dried FS, waste water characteristics, compost quality. Moreover the application of FSM Toolbox and KII performance have revealed here to find out required results and information.

Chapter 4 entails results and relevant discussion of the study that comprises characterization of the FS, the treatment efficiency of the existing FSTP, quality of the compost, output of the KII and FSM Toolbox, etc. that were done in chapter 3.

Chapter 5 presents the conclusion from this research study along with recommendations for future research on the field of Faecal Sludge Management.

CHAPTER II

Literature Review

2.1 General

This chapter discusses the outcome of studies of various research and works done previously in the fields of FSM. Particular attention was given to identify any mentionable work related to faecal sludge generation, treatment and compost made from both FS and MSW.

Throughout this chapter country sanitation context, faecal sludge and its practices have been discussed. With the help of previous studies previously performed, an idea of the per capita FS generation is presented. The treatment technology, its development to meet the future demand are discussed. A general idea on various methods of composting and co-composting in practice and as suggested by various authors is presented to provide a better understanding of the processes involved. Finally, an effort is made to assess the possibilities of resource recovery from the co-composting system, improvement of the quality of the compost.

2.2 Bangladesh Sanitation Situation

Sanitation is still one of the biggest challenges for Bangladesh although it has made some good progress in increasing sanitation coverage over the past 25 years. A recent gap analysis report says, "with sewerage system (only in parts of Dhaka city) and septic tanks (largely used in urban centers) discharging into open water bodies, the urban scenario falls far behind hygienic sanitation coverage in true sense. Growing slum population in the major cities and other secondary towns are still struggling to get within the purview of sanitation services primarily due to the issues of land tenure-ship. With the increase in sanitation coverage in urban areas using septic tanks and pit latrines, it is expected that faecal sludge volume will increase considerably within a few years. If collection and disposal systems are not in place, serious environmental degradation and associated health risk will increase" (Rahman, 2009).

According to Millennium Development Goals (MDG) 2015, Bangladesh has a remarkable achievement by rapid drop of open defecation from 33% in 1990 to 6% in 2009, which ultimately reached to 1% in 2015 as reported in the country report on Sanitation (MGD: Bangaldesh Progress Report, 2016). It has been also revealed that, In Bangladesh, waterborne sewerage systems cover only 20% of the city of Dhaka's population (about 2% of the country's population) (GoB, 2011). The vast majority (about 94% of the country's population) are served by on-site sanitation (OSS) systems such as septic tanks, improved pit latrines and unimproved pit latrines.

Again according to Bangladesh Bureau of Statistics (BBS), 2017 publication, percentage of improved sanitation facilities is 75% whereas open defecation is 2.7% and others toilet users is 22.3% as per reported by Bangladesh Sample Vital Registration System (SVRS, 2016). In most cases there is hardly any effective or safe collection, transportation, treatment or disposal of sludge. Much of it ends up in water bodies or polluting nearby land.

On the other hand, the Bangladesh Joint Monitoring Programme (JMP) Report 2015 of UNICEF claims that, an open defecation is now down to 3% of the population, a claim that is not fully supported by many Civil Society Organisations (CSOs) (Dasgupta et al., 2016).

2.3 Faecal Sludge

Sludges of variable consistency collected from so called on-site sanitation systems; viz. latrines, non-sewered public toilets, septic tanks, and aqua privies (Montanegro & Strauss, 2002).

In urban areas of Sub-Saharan Africa, 80% of existing sanitation access is met by onsite technologies, and the sludge that accumulates in these systems is referred to as "faecal sludge" (Koné, 2010).

Globally a huge number of people rely for their sanitation on non -sewered systems which generate a mix of solid and liquid wastes generally termed 'faecal sludge'. For the purpose of this report, faecal sludge will be defined as human excreta that is disposed of in facilities located on a housing plot (on-site sanitation facilities) and in fields, forests, bodies of water or other open spaces (open defecation) (EAWAG/SANDEC, 2008). EAWAG/SANDEC (2008) also uses the following technical definition: "Faecal sludge is the general term for undigested or partially digested slurry or solids resulting from storage or treatment of black water or excreta".

2.3.1 Characteristics of Faecal Sludge (FS)

The first step in designing faecal sludge (FS) treatment technologies that will meet defined treatment objectives is to quantify and characterize the FS to be treated. The typical FS characteristics are difficult to determine due the variety of onsite sanitation technologies in use, such as pit latrines, public ablution blocks, septic tanks, aqua privies, and dry toilets. In many cities, a mixture of these technologies often exist side-by-side, and there is generally a prevalence of different technologies in different geographical regions (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014). There is currently a lack of detailed information on the characteristics of FS. However, research is actively being conducted in this field. Storage duration, ambient temperature, intrusion of groundwater into vaults or pits of on-site sanitation installations; installations sizing, and tank emptying technology and pattern are important factors influencing the sludge quality (Strauss et al, 2003). The following table shows the FS characteristics from various observations.

Table 2.1: Reported characteristics of faecal sludge from onsite sanitation facilities and wastewater sludge

Parameter	FS source		WWTP sludge	References
	Public toilet	Septic tank		
pH	1.5-12.6			(USEPA, 1994)
	6.55-9.34			(Kengne et al., 2011)
Total Solids, TS (mg/L)	52,500	12,000-35,000	–	(Koné & Strauss, 2004)
	30,000	22,000	–	(NWSC, 2008)

	–	34,106	–	(USEPA, 1994)
	≥3.5%	<3%	<1%	(Heinss, Larmie, & Strauss, 1998)
Total Volatile Solids, TVS (as % of TS)	68	50-73	-	(Koné & Strauss, 2004)
	65	45	-	(NWSC, 2008)
COD (mg/L)	49,000	1,200-7,800	-	(Koné & Strauss, 2004)
	30,000	10,000	7-608	(NWSC, 2008)
	20,000-50,000	<10,000	500-2,500	(Heinss, Larmie, & Strauss, 1998)
BOD (mg/L)	7,600	840-2,600	-	(Koné & Strauss, 2004)
	-	-	20-229	(NWSC, 2008)
Total Nitrogen, TN (mg/L)	-	190-300	-	(Koné & Strauss, 2004)
			32-250	(NWSC, 2008)
Total Kjeldahl Nitrogen, TKN (mg/L)	3,400	1,000	-	(Katukiza et al., 2012)
NH4 -N (mg/L)	3,300	150-1,200	-	(Koné & Strauss, 2004)
	2,000	400	2-168	(NWSC, 2008)
	2,000-5,000	<1,000	30-70	(Heinss, Larmie, & Strauss, 1998)
Nitrates, NO_3^- (mg N/L)	-	0.2-21	-	Koottatep et al., (2005)
Total Phosphorus, TP (mg P/L)	450	150	9-63	(NWSC, 2008)
Faecal coliforms (cfu/100 mL)	$1x10^5$	$1x10^5$	$6.3x10^4$-$6.6x10^5$	(NWSC, 2008)
Helminth eggs (Numbers/L)	2,500	4,000-5,700	-	(Heinss, Larmie, & Strauss, 1994)
	20,000-60,000	4,000	300-2,000	(Heinss, Larmie, & Strauss, 1998)
		600-6,000		(Ingallinella et al., 2002)
		16,000		(Yen-Phi et al., 2010)

Table 2.2 shows typical FS characteristics and typical characteristics of municipal wastewater as may be encountered in tropical countries. Storage duration, ambient temperature, intrusion of groundwater into vaults or pits of on-site sanitation installations; installations sizing, and tank emptying technology and pattern are important factors influencing the sludge quality.

Table 2.2: Faecal sludges from on-site sanitation systems in tropical countries: characteristics, classification and comparison with tropical sewage after (Strauss et al., 1997)* and (Mara, 1978)**

Item	Type "A" (high-strength) *	Type "B" (low-strength) *	Sewage ** (for comparison purposes)
Example	Public toilet or bucket latrine sludge	Septage	Tropical sewage
Characterisation	Highly concentrated, mostly fresh FS; stored for days or weeks only	Highly concentrated, mostly fresh FS; stored for days or weeks only	
COD mg/l	20, - 50,000	< 15,000	500 - 2,500
COD/BOD	5: 1.... 10 : 1		2 : 1
NH4 -N mg/l	2, - 5,000	< 1,000	30 - 70
TS mg/l	≥3.5 %	< 3 %	< 0.1 %
SS mg/l	≥30,000	≅7,000	200 - 700
Helm. eggs no./l	20, - 60,000	≅4,000	300 - 2,000

2.3.2 FS Specific Quantities and Generation

Deriving accurate estimates for the volume of FS produced is essential for the proper sizing of infrastructure required for collection and transport networks, discharge sites, treatment plants, and end-use or disposal options. However, no proven methods exist for quantifying the production of FS in urban areas, and the data collection required in order to accurately quantify FS volumes would be too labour intensive, especially in areas where there is no existing information (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014). The following Table 2.3 shows faecal sludge production rates.

Table 2.3: Reported faecal production rates (with urine)

Location	Wet weight (g/person/day)	References
high income countries	100-200	(Lentner et al., 1981) (Feachem et al., 1983) (Feachem et al., 1983) (Jönsson et al., 2005) (Jönsson et al., 2005) (Vinnerås, et al., 2006)
low income countries, rural	350	(Feachem et al., 1983)
low income countries ,urban	250	(Feachem et al., 1983)
China	315	(Gao, et al., 2002)
Kenya	520	(Feachem et al., 1983)

Thailand	Thailand	(Schouw et al., 2002)

Again in case of South Asia, in calculating theoretical market size, it is assumed that, pit and Septic Tank (ST) are being filled in @ 0.3 liter per person per day and 0.7 liter per person per day, respectively (AIT, 2015). In Bangladesh, about 80 metric tonnes of sludge is generated every day and 24 metric tonnes of sludge generated every day in the urban areas of the country of which only 960 tonnes that means only 4 per cent of urban sludge is being treated at Pagla treatment plant (Jahan, H. & Al-Muyeed, 2015).

2.4 Faecal Sludge Management

Faecal Sludge Management (FSM) is one of the technical solutions available to provide a safely managed sanitation service. It involves the manual or mechanical emptying of FS from onsite sanitation systems to treatment facilities using road based transportation equipment (O'Riordan, 2009).

FS management deals with on-site sanitation systems, while wastewater management is concerned with sewered sanitation. FS may be treated in separate treatment works or co-treated with sludges produced in wastewater treatment plants (Strauss et al., 2002).

According to EAWAG/SANDEC (2008), faecal sludge management comprises the following aspects:

- Legislation, policy and strategy to set objectives and criteria
- Implementation
  - Collection
  - Treatment
  - Re-use and disposal
  - Responsibilities, communication and coordination; financial arrangements, timeframe

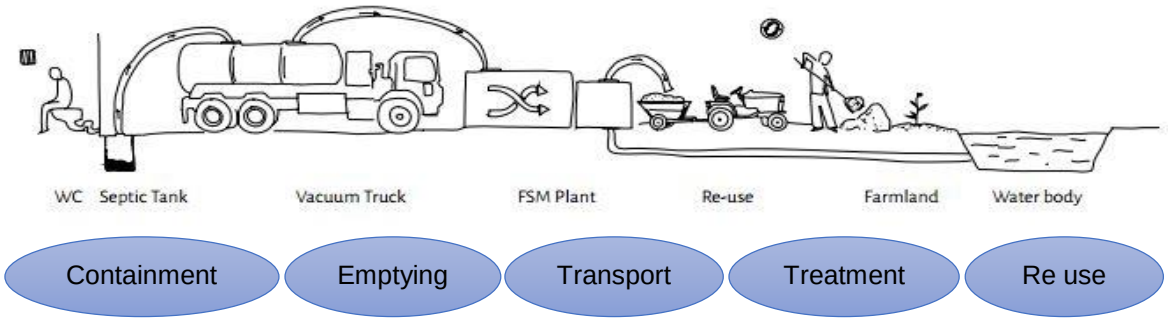


Figure 2.1: Faecal Sludge Management Service Chain, Source: (Dasgupta et al., 2016)

2.5 Faecal Sludge Treatment

There are a number of technologies available for the treatment of FS. Faecal sludge should be treated to render the treatment products (bio-solids and effluent liquids) suitable for discharge into the environment (including landfilling), or to produce biosolids, which may be safely used in agriculture. If the final goal is to make a dry product that can be reused in

agriculture, then particular care has to be paid to dewatering and pathogen reduction. If the goal is to incinerate the sludge for energy production, then dryness is very important while pathogens do not play a role (outside of worker protection) (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014). (Klingel et. al., 2002) identified a list of faecal sludge treatment processes that are considered potentially suitable for developing countries. These are:

- Solids-liquid separation;
- Settling/thickening tanks or ponds (non mechanised, batch-operated);
- Unplanted drying beds;
- Constructed wetlands; Pond treatment of faecal sludge supernatants or percolates;
- Combined composting with organic solid waste; and
- Anaerobic digestion with biogas utilization.

New treatment technologies still being experimented on or in pilot stage include:

- Pyrolysis – the thermal decomposition of human solid waste in an oxygen-free environment to produce biochar;
- Electrolysis – using electrical currents to break down the chemicals in human liquid-waste;
- Pasteurization – a heat treating process which thermally sterilizes human waste;
- Plasma gasification – using microwave technology to gasify human waste; and
- On-site membrane technology to purify liquid waste through filtration.

Options of treatment are based on the quality of final products, solid and liquid. For low-cost treatment processes, the treatment options are usually referred to Figure 2.2

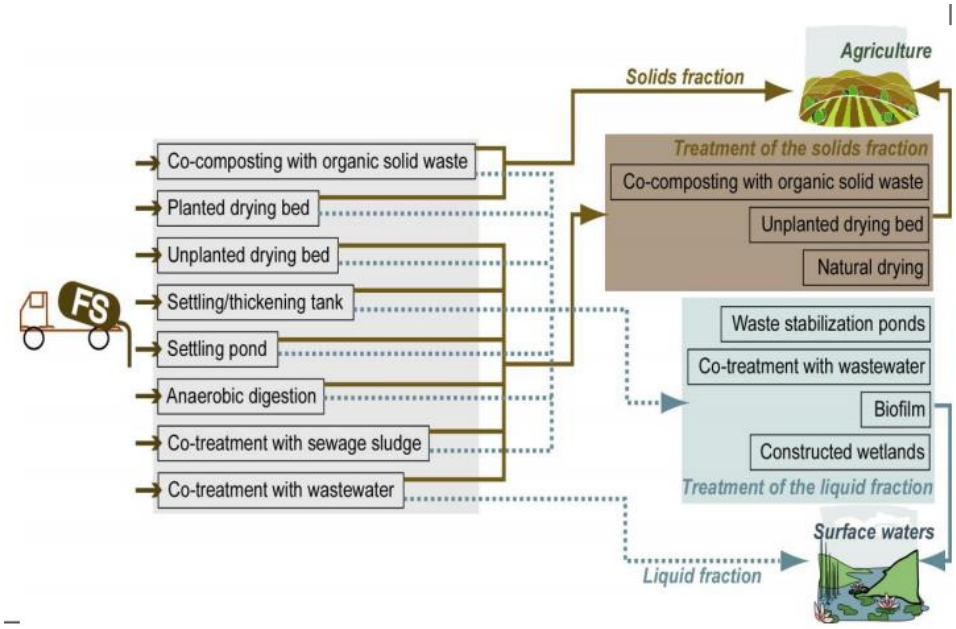


Figure 2.2: FS treatment options, Source: (Ingallinella et al., 2002)

2.5.1 Drying bed

The drying bed consists of a gravel-sand filter and a drainage system. A drying bed separates solids from liquids by the physical filtration process to drainage and evaporation. The separated solid is deposited in the bed. Drying beds are often used with and without sand/gravel media. Sludge obtained from drying beds is not free of pathogens especially

helminthes eggs. However, it can be used either as a soil conditioner or fertilizer in agriculture under proper design and operation. This system can also be used as second stage of dewatering from anaerobic digestion tank (ASIAN INSTITUTE OF TECHNOLOGY (AIT), 2015).

Figure 2.3: Sludge Drying Bed in Kushtia FSTP, Bangladesh (picture taken on May 16, 2017)

2.5.2 Constructed wetland

Constructed wetlands (CWs) are a natural, low-cost, eco-technological biological wastewater treatment technology, which are designed to replicate the processes found in natural wetland ecosystems. The shape of constructed wetlands may vary based on design. However, it is a shallow basin filled with some sort of filter material known as media, sand or gravel. A constructed wetland typically comprises following components: a basin, media, vegetation, liner and inlet/outlet arrangement system. During treatment, the wastewater/ fecal sludge are fed into the basin filled with media and planted with vegetation. The wastewater/fecal sludge flow over or through the substrate depending upon the type of constructed wetlands. The mechanisms of treatment are subjected to physical, chemical, as well as microbial interactions, where it will be treated. At the early stages of operation, attention is required mainly on the growth of planted vegetation on constructed wetland. The contamination level and organic load will be much higher in fecal sludge and needs to be acclimatized slowly. Therefore, a proper and complete process needs to be carefully followed during the startup of constructed wetlands for faecal sludge treatment (ASIAN INSTITUTE OF TECHNOLOGY (AIT), 2015).

Figure 2.4: Typical Constructed Wetland in Shakipur FSTP, Tangail, Bangladesh. (Picture taken on 15 November, 2016)

2.6 Enduse of Treatment Products

Historically, the most common resource recovery from sludge has been as a soil conditioner and organic fertilizer, as excreta contain essential plant nutrients and organic matter that increases the water retaining capacity of soils. Each treatment technology results in end products which need to be further treated, disposed of, or harnessed for some type of resource recovery. End products, for example dried or partially dried sludge, compost, leachate, and biogas, each have an intrinsic value, which can turn treatment from merely a method for environmental and public health protection to resource recovery and value creation. Table 2.4 represents the potential resource recovery options from faecal sludge.

Table 2.4: Summary of potential resource recovery options from faecal sludge

Produced Product	Treatment or Processing Technology
Soil conditioner	Untreated FS Sludge from drying beds Compost Pelletizing process Digestate from anaerobic digestion Residual from Black Soldier fly
Reclaimed water	Untreated liquid FS Treatment plant effluent
Protein	Black Soldier fly process
Fodder and plants	Planted drying beds
Fish and plants	Stabilisation ponds or effluent for aquaculture
Building materials	Incorporation of dried sludge
Biofuels	Biogas from anaerobic digestion Incineration/co-combustion of dried sludge Pyrolysis of FS Biodiesel from FS

(Source: Strande, L., Ronteltap, M. and Brdjanovic, D., 2014)

2.6.1 Co-composting of Faecal Sludge

Composting is a biological process that involves microorganisms that decompose organic matter under controlled predominantly aerobic conditions (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014). Again, Composting refers to the process by which biodegradable waste is bio-logically decomposed under controlled conditions by microorganisms (mainly bacteria and fungi) under aerobic and thermophilic conditions. The resulting compost is a stabilized organic product produced by the above mentioned biological decomposition process in such a manner that the product may be handled, stored and applied to land according to a set of directions for use. Important to note is that the process of "composting" differs from the process of "natural decomposition" by the human activity of "control" (Strauss et al, 2003).

Co-composting is the controlled aerobic degradation of organics, using more than one feedstock (faecal sludge and organic solid waste) (Tilley et. al., 2014). Faecal sludge has a high moisture and nitrogen content, while biodegradable solid waste is high in organic carbon and has good bulking properties (i.e., it allows air to flow and circulate) (Eawag and

ENPHO, 2014). In co-composting, two or more raw materials are composted together –for instance, faecal sludge and organic solid waste whereby the biologically generated waste heat is sufficient to raise the temperature of the composting mass to the thermophilic range (50 to 65^{o}C). The final product of composting is a stable humus-like material known as compost (Hafiz & Almagir, 2017).

Figure 2.5: Compost piles in Demo Compost Plant, Source: (Alamgir, 2009)

2.6.2 Organic Solid Waste Management with Faecal Sludge

The urban area of Bangladesh generates approximately 18,015 tons of waste per day, which adds up to over 6.58 million tons annually. It is projected that this amount will grow up to 49,000 tons/day and close to 19.16 million tons per year by 2025 (Ahsan, 2005). In Bangladesh, city authority is responsible for overall management of MSW in urban areas as per the Municipality Act. The ultimate goal of waste management is the absence of waste, i.e. to get rid of it, to use it as a resource, or not to have it in the first place (Alamgir & Ahsan, 2007a).

Public authorities in developing countries spend 20-50% of their annual budget on solid waste management, but services covered less than 50% of the population in the cities (Nzeadibe & Ajaero, 2010 and Kadafa et. al., 2013). However, in the developing countries, even though about 60% of the municipal solid waste stream compositions are compostable material composting is not formally integrated in urban solid waste management (Harir. et. al., 2015). So biological treatment is a very economical natural treatment process for organic solid wastes in a country like Bangaldesh. So reducing the burden of both FS and MSW, co-composting is the best solution not only to solve the country's sanitation issues but also to lessen poor management of solid waste. Municipal solid waste after sorting into several piles of organic waste to which dried fecal sludge is added in a process known as co-composting. Different raw material including saw dust, Eppawala Rock Phosphate (ERP), rice husk and fecal sludge are then added in varying proportions to develop value- added organic fertilizer (Raj, 2015).

Figure 2.6: Co-composting in a Compost Plant, Source: Kurunegala Municipal Council (KMC) compost plant, Srilanka.

2.7 Effluent Standards of Waste Water in Bangladesh

In most newly industrialized countries, effluent discharge legislation and standards have been constituted. The standards usually apply to both wastewater and faecal sludge treatment. To have a clean, hygiene and environment-friendly city, the generated wastewater must be managed in an appropriate way, which is absent in most of the cities of developing countries. A major challenge faced by the developing countries like Bangladesh is that human waste as well as human faeces, urine, gray water and other types of domestic wastewater collection, treatment and safely disposal to natural streams. In developing countries, almost half of the urban populations have inadequate waste disposal facilities (Saha & Alamgir, 2015).

Department of Environment (DoE), Bangladesh has set a standard limitations of effluent disposal regarding sewage discharge mentioned in schedule 9 which has been taken as a standard for effluents from any FSTP in Bangladesh. Any effluent after treatment of a FSTP unit should satisfy the following limits mentioned in Table 2.5

Table 2.5: Standards for Sewage and Waste Water Discharge (Disposal in Inland Water Bodies)

Parameter	Unit	Standard Limit
BOD	milligram/l	40
Nitrate	,,	250
Phosphate	,,	35
Suspended Solids (SS)	,,	100
Temperature	Degree Centigrade	30
Coliform	number per 100 ml	1000

Notes:

- This limit shall be applicable to discharges into surface and inland waters bodies.
- Sewage shall be chlorinated before final discharge.
- Inland Surface Water means drains/ponds/tanks/water bodies/ ditches, canals, rivers, springs and estuaries.

(Source: ECR, 1997)

2.8 Compost Standards in Bangladesh

The properly treated end product is a stabilized organic product that may be safely handled, stored and applied to land according to a specified guidelines. The government approved the following specification of Organic Fertilizer by the power vested in section-7 under the Fertilizer (Management) Act, 2006 according to the recommendation of the national Fertilizer standardization Committee

Table 2.6: Compost Standards in Bangladesh

Parameter	Content
Physical	
Colour	Dark grey to Black
Physical condition	Non-granular form
Odor	Absence of foul odor
Moisture	Maximum 15%
Chemical	
P^H	5.0-8.5
Organic Carbon	10-25%
Total Nitrogen (N)	0.5-4.0%
C: N	Maximum 20:1
Phosphorus (P)	0.5-1.5%
Potassium (K)	1.0-3.0%
Sulfur (S)	0.1-0.5%
Zinc (Zn)	Maximum 0.1%
Copper (Cu)	Maximum 0.05%
Arsenic (As)	Maximum 20 ppm
Chromium (Cr)	Maximum 50 ppm
Cadmium (Cd)	Maximum 5 ppm
Lead (Pb)	Maximum 30 ppm
Mercury (Hg)	Maximum 0.1 ppm
Nickel (Ni)	Maximum 30 ppm
Inert Material	Maximum 1%

Source: Fertilizer (Management) Act 2006 and Compost Standards of Ministry of Agriculture, Government of Bangladesh for use in the agricultural purposes

2.8.1 Legal and Regulatory Framework for Fertilizer

The following Acts, Rules, Ordinances and guidelines provided the legal and regulatory framework for production, storage, marketing, sales and use of Fertilizers:

- Fertilizer (Control) Ordinance, 1999
- Fertilizer (Management)Act,2006
- Fertilizer (Management) Guidelines, 2007
- Fertilizer (Management) Guidelines, 2007 Amendment
- Fertilizer (Management) (Amendment) Ordinance, 2008
- Fertilizer (Management) (Amendment) Act, 2009
- Fertilizer Dealer Appointment and
- Fertilizer Distribution Integrated Policy 2009

Amendment/Supplement/Clarification of Fertilizer Dealer Appointment and Fertilizer Distribution Integrated Policy (From 2009-2011)

2.8.2 Terms and Conditions Pertaining Registration of Organic Fertilizer

1. Any organic Fertilizer must be manufactured from organic sources and shall not be allowed to manufacture from inorganic sources like plastic materials, toxic waste or hospital waste etc. The name and sources of raw materials used in the organic Fertilizer shall be clearly mentioned in application form submitted for standardization (or, setting standard)
2. Under the Fertilizer (Management) Act 2006, two members from BARI/BINA/SRDI nominated by the chair of Technical Sub-Committee along with representative(s) from DAE shall inspect physically and collect random sample on-spot during physical inspection of the production facility and procedure of the organic Fertilizer hereby applied for standardization on behalf of Fertilizer Technical Sub-Committee and shall arrange laboratory test to at least three nominated laboratory in due course of standardization process
3. To determine the amount of Organic Carbon Tyurin's Method (1931/1936) shall be used as unified method by the laboratories of five (5) Government nominated Institutions (BARI/BINA/SRDI/BSTI/Dhaka University)
4. All details about the production process (e.g. aerobic/anaerobic/semi-aerobic technologies etc.) shall be clearly mentioned in the application form for Specification/Registration
5. Organic Fertilizer production after receiving registration shall come under verification through examining the random samples by the specified laboratories collected from open market by DAE representative(s). Legal action shall be solicited under country's existing laws in case any form of discrimination of the set specification.
6. Import/marketing/distribution /use of any organic Fertilizer produced in abroad is prohibited in Bangladesh
7. To verify the effectiveness of the organic Fertilizers economic analysis shall be undertaken following the methods of Integrated Plant Nutrient System (IPNS).

Source: (Mondol, 2017)

2.9 Nutrient Content Obtained by Co-composting Human Waste

Nutrient contents of composts, which have been produced from co-composting human waste (faecal or sewage treatment plant sludge) are shown in Table 2.7. However, the data show that nutrient, notably N, contents do not range particularly high which were collated from many references and for composts produced from many different raw materials, including human waste. The reason for composts produced from human waste not exhibiting higher nutrient contents than other compost (as judged from the limited data available) might be due to nitrogen (ammonia) losses during pre-composting storage and treatment (e.g. by dewatering on sludge drying beds) of the human waste. In theory, such compost should exhibit higher nutrients than compost, which is produced from such material as organic municipal refuse, woodchips, sawdust, i.e. material with N contents lower than in human waste (Cofie, 2003).

Table 2.7: Nutrient Levels in Compost Using Human Waste as one Raw Material

Constituent	% of dry weight	Reference
Nitrogen (as N)	1.3 – 1.6	(Shuval et al., 1981)
	1.3	(Obeng & Wright, 1987)[1]
	0.35 – 0.63	(Kim, 1981)[2]
	0.45	(Byrde, 2001)[3]
Phosphorus (as P_2O_5)	0.6 – 0.7	(Shuval et al., 1981)
	0.9	(Obeng and Wright, 1987)[1]
		(Kim, 1981)[2]
Potassium (K_2O)	---	(Shuval et al., 1981)
	1.0	(Obeng and Wright, 1987)[1]
Organic matter (% TVS)	12 - 30	(Kim, 1981)[2]
Carbon (C)	46 – 50	(Shuval et al., 1981)
	13	(Byrde, 2001)[3]

- [1]Chosen as "typical values" by the authors in their chapter on the economic feasibility of co-composting
- [2]Raw material composed of varying ratios of FS (TS = 4 %), household waste and straw
- [3]Raw material composed of municipal solid waste and FS

2.10 Key Factors of the Composting Process

The key factors affecting the biological decomposition processes and/or the resulting compost quality are listed below. They comprise:

- Carbon to nitrogen ratio
- Moisture content
- Oxygen supply,
- aeration Particle size
- pH
- Temperature
- Turning frequency
- Microorganisms and invertebrates
- Control of pathogens
- Degree of decomposition
- Nitrogen conservation

Detailed description of the significance of the specific factors is explained more in detail in (Strauss et. al., 2000).

2.11 Sustainability of FSM Regarding Treatment and Resource Recovery

Sustainability requires organizations to adhere to ideologies of sustainable development. A movement for more sustainable business model has many challenges. Moreover, putting a value on sustainability initiatives can pose a systematic and universal challenge especially where the benefits are difficult to quantify. Therefore, relationship between sustainability and value creation will be a key issue to be tackled over the long term. The ability to express benefits in financial terms is one of the key drivers needed to instill sustainability into company business models. Despite intense activities and great achievements in terms of reaching the Millennium Development Goal (MDG) on safe drinking water and basic sanitation, there are still 2.5 billion people in the world that lack access to improved

sanitation which is a hindrance in the way of sustainable sanitation solution. Around 1 billion people are still practicing open defecation (http://www.susana.org, 2017).

Overall, depending on local circumstances, Faecal Sludge and FSM can be much less expensive than centralized sewer-based solutions (Dodane et. al., 2012). Treatment of FS and its further use as soil conditioner need a large scale marketplace. Sustainable environmental sanitation may be achieved or enhanced only by applying appropriate financial incentives and sanctions (Wright , 1997).

In a society where the use of FS is strictly taboo, other solutions such as co-treatment with other waste streams, use in building materials, or as a fuel might be more appropriate and accepted technologies (Diener, et al., 2014). So for sustainable solution, a market demand is essentail from any pilot scale commercial sector. The market demand for end products can also help to ensure that the treatment plants are operated properly, as operators are trying to fulfil customer satisfaction (Robbins, et. al., 2012).

On the other hand, managing FS at the city level in an effieint and sustainable way requires the involvement and support of all the concerned stakeholders i.e. the "key stakeholders'. With stakeholde is meant any grouup, organization, that can influence or by the project (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014). At the end, achieving socio-cultural acceptance on the FSM sustainable solution system is one of the most common reasons for past projects failures. So influence and interest is the most criteria for achieving FSM sustainablility (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014).

2.12 Assessment of the FSM Situation

In any running FSM project or at the beginning of any FSM initiative, current situation of a city where sewerage system is not present is very vital. This type of assessment gives a snapshot of the project. It describes the existing service chain, starting with the type of latrines, the formal and informal sludge emptying sector, the organization of the system and links between the stakeholders. It also identifies the enabling environment, government support, the legal and regulatory framework, institutional arrangements, skills and capacity, financial arrangements and socio-cultural acceptance (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014).

2.12.1 FSM Situational Assessment Toolkit

FSM Situational Assessment Toolkit (SAT) is a systematic process to assess the present situation of FSM in any designed location and help users to take part in FSM oriented options and programs. It also helps to identify the problems and possible solutions with the aim of better FSM situation in the future (FSM Toolbox, 2015). SAT Tool is excel based tool, provide questions to assess and identify FSM city existing situation for entire FSM service chain and report graphical summaries for city FSM status and challenges and problems – Dashboard 1 & 2 (Hafiz, Islam, & Almagir, 2017).

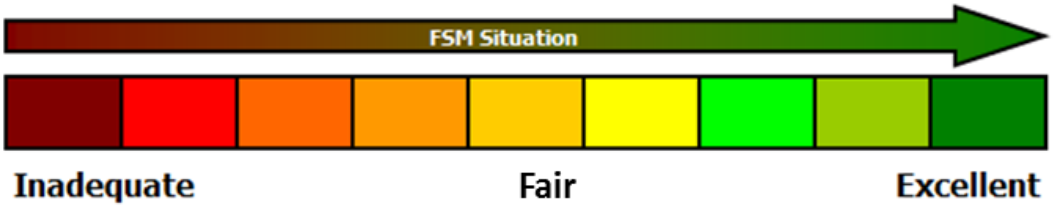


Figure 2.7: FSM situation dashboard, Source: (FSM Toolbox, 2015)

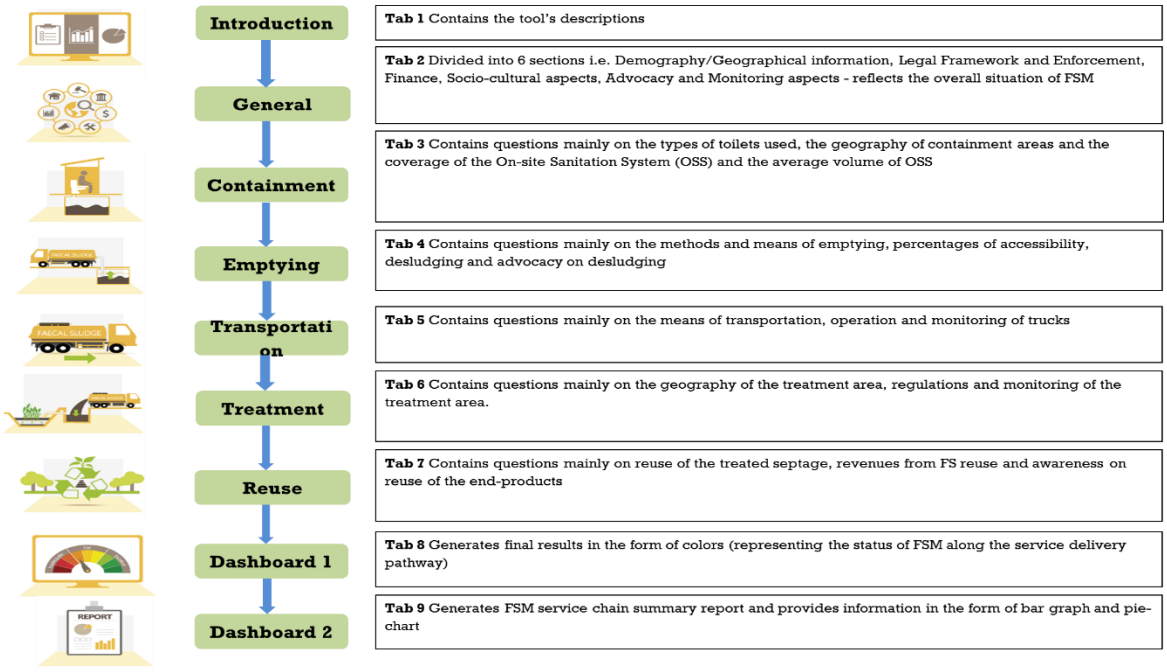


Figure 2.8: Steps involved in the situational assessment tool, Source: (Hafiz, Islam, & Almagir, 2017)

2.13 Qualitative Interview Approach (Key Informant Interviews)

Key informant interviews are qualitative in-depth interviews with people who know what is going on in the community. The purpose of key informant interviews is to collect information from a wide range of people—including community leaders, professionals, or residents—who have first-hand knowledge about the community. These community experts, with their particular knowledge and understanding, can provide insight on the nature of problems and give recommendations for solutions (UCLA, 2016). The term "key informant" refers to a person who can provide detailed information and opinions on a particular subject based on his/her knowledge of this particular issue.

2.13.1 When are KIIs needed?

- Key informant interviews are tools that will help one to develop an in-depth understanding of qualitative issues and obtain suggestions and recommendations from key informants. They may thus provide a basis to explore new ideas that have not been discussed before.
- Often, KIIs are used to gather qualitative information that will be used to "triangulate"1 the findings of other types of evaluation methods (e.g., quantitative surveys).
- While there are other qualitative evaluation tools (e.g., focus group discussions), KIIs are best used if some type of information can only be obtained in a context of full confidentiality.
- Also, this is the method best recommended for complex issues of a more general nature or for issues that may concern the whole community and for which individual farmers may not have answers (Asia Pacific Division, 2011).

CHAPTER III

Materials and Methods

3.1 General

This chapter discusses the overall procedures involved in this research starting from the collection and preparation of Faecal Sludge (FS) sample, the co-composting system and the procedures used for determination of the compost parameters. Moreover it also discusses the overall methods applied to determine the efficiency of the treatment plant.

This chapter deals in details, the process of collection of FS, and Organic Solid Waste (OSW). Then a short discussion on how the sample was stored for co-composting process. Then presented the methodology involved in determination of physicochemical parameters and other parameters of the raw sample and the matured compost. It also gives a short discussion on how waste water sample and treated effluent was collected, its tests, and performance regarding the FSTP in Kushtia Municipality. The procedures are accompanied with necessary figures and formulae whenever deemed appropriate

3.2 Site Selection

The choice of study area was made through meso (city) choice level where, Kushtia Municipality (KM) was selected mainly because it's a large number of population (3,75,149 nos) in north-west part in Bangladesh. Faecal Sludge Management (FSM) still is practiced in this municipality after a project initiated in 2012. The municipality collects both faecal sludge and solid waste, making co-composting an appropriate technique for resource recovery in Kushtia (Waste Concern, 2015). In order to get proper knowledge about full FSM service, its authority body performing the FSM with local people and staff, Kushtia municipality is a best choice for conducting the research work. Moreover, this research was funded by SNV Netherlands Development Organization where sanitation and FSM were main issue. Considering all circumnstances, Kushtia is a suitable selection for conducting this research work.

3.3 Preliminary Data Collection

For quantitative and qualitative data, various sources were taken into consideration. This procedure started with visiting the Kushtia FSTP and Kushtia Municipality. General data about Kushtia Municipality, its FSM situation and management related information were collected from authority. Moreover some journals, articles, videos, photos, reports, were taken into consideration for data collection. At first, document data were collected and arranged, which included different reports of government and non-government organizations, published literatures from websites, books. Then, semi-structured key informant interviews were conducted with the purpose of enhancing or supplementing existing literatures; and in some cases, information were gathered though observation technique. However, the data were collected from three different sources – documents, interviews and observations

3.3.1 Document Data

As one of the research objectives is to identify the generation of faecal sludge for treatment and co-composting in Kushtia Municipality, therefore data were collected from reports, journals and from existing online literatures. Those data were acquired by different individuals at an earlier time point.

3.3.2 Interview Data

For this research, informants from different GO and NGO were interviewed. The Interview was taken with respect to 5/6 questions depending on the good use of limited time. No assistant was taken with this kind of interview and recordings were taken when it was available. Due to informants' personal issue and privacy, no images and photos were taken. Detailed question sample has given in Annex-1.

3.3.3 Observation Data

According to research targets, some observations were also needed. It is a classic form of data collection in field research in the context of a natural scene. Data from some observations were taken for conducting the research work. Several visits of the Kushtia Municipality and Kushtia FSTP helped to gather some information and gathering data as per requirement.

3.4 Data compilation and analysis

Collecting and gathering all required information and data, analysis was done by FSM Toolbox for addressing the whole FSM situation in Kushtia Municipality. Analysis was done using an excel based method named Situational Assessment Tool (SAT). Detailed analysis result has been shown in the following chapter 4. Annex-2 is the summary of compiled data that were collected from various sources mentioned for clarification.

3.5 Sample Collection

The laboratory procedure started with the collection of raw faecal sludge sample that was composted with organic solid waste. As a distance from Kushtia Municipality to Khulna is nearly 154 km. so collection of sample is the most importmant part of the research. Not only the collection of the sample but also carrying the sample is also an important issue. Mainly three types of sample were collected like is first one is raw faecal sludge , second one is compost and dried sludge made in Kushita FSTP and the third one is the waste water before and after treatment.

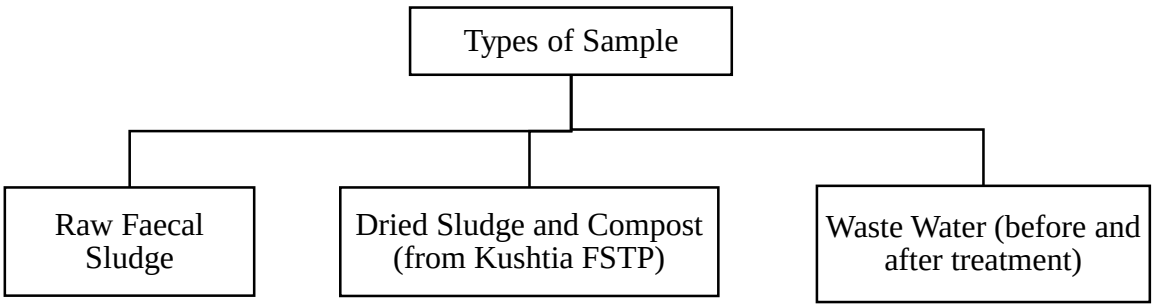


Figure 3.1: Sample Collection classification

3.5.1 Raw FS collection

Sample collection consists with the conveyance from Khulna to Kushtia that was very first morning. Every location where sample will be collected was visited by researcher located within Kushtia Municipality. A total 6 Liters of sample was collected from Kushtia Municipality in 3 containers, each of 2 liters. First sample was collected from a household pit latrine, second one was collected from a septic tank and the third sample was collected from a dumping site (jugia, kadomtola) where the Faecal Sludge Treatment Plant is located. Then the sample containers were put in a 24 Liter sized cool box with ice before being transported to the environment laboratory at Kuet campus. This was to prevent any change of faecal sludge quality which could occur between the time of collection and analysis in the laboratory. This was done mainly for a 4/5 hours travel distance and that will ensure the accurate characteristics. Moreover all containers were airtight so that bad smell or any chance of accident could occur. Some parameters which were determined immediately upon arrival in the laboratory included Faecal Coliform, DO and BOD_5.

Figure 3.2: Sample Collection from Kushtia Minicipality.

A list of location/ source has given in the following table from samples were collected.

Table 3.1: Location and detail information of the sample source

Serial No	Location	Address	Sample type
Sample - 1	23°54’37.02” N 89°7’43.63” E	Munshi Kamal Wahid, c/o: Munshi Wahidur Rahman. 29 Khodadad Khana Road, Thanapara, Kushtia	Septic tank Faecal Sludge
Sample - 2	23°55’2.81” N 89°9’32.9” E	Md. Afzal Hossain, father: Late Ansar Ali Mondol. 523, A.K. Mukharjee Road, Baradi, Kushtia, 01723-598264	Pit Faecal Sludge
Sample - 3	23°54’42.93” N 89°6’42.06” E	Kushtia Faecal Sludge Treatment Plant, Baradi Bhagar, Jugia, Kadomtola	Faecal Sludge during dumping

(Sample collection date: 29 August, 2016)

3.5.1.1 Preparation of drying bed and composting heap

Collected faecal sludge from Kushtia Municipality need to be dewatered, which is the first step of treatment process. For this purpose KUET waste management plant was selected as

a suitable place for conducting the initial co-composting steps. That's why, a simple drying bed (8 ft × 5 ft) was prepared for dewatering the faecal sludge, where least depth of the bed at edge was 6 inch and at middle it was kept 8 inch. A compost heap was made with wooden frame and wire mesh at side wall, sized 6 ft long, 4 ft wide and 2 feet height. The purpose of the heap was to make a compost box to recycle the faecal sludge and organic solid waste at a combined process. It was made in such a way that, many small scale composting process can be done by a number of researchers.

Figure 3.3: Prepared compost heap and drying bed (inside KUET waste management plant)

3.5.2 Dried FS collection

Separation of the FS solids from the liquids is the process-of-choice in FS treatment unless FS is co-treated in an existing or planned wastewater treatment plant, and if the FS loads are small compared to the flow of wastewater (EAWAG/SANDEC, 2008). The dried FS was removed from the drying beds once it became separable (about 14 days) and stored prior to co-composting. On the other hand, parallel the dried sludge was also collected from Kushtia FSTP for laboratory test. Dried FS can be used in the manufacturing of cement and bricks, and in the production of clay-based products. Here the dried FS is taken only for production of compost.

After 14 days, from drying bed collected dried FS was weighted as 3.5 K.G. On the other side, from Kushtia FSTP, the amount of collected dried FS was about 1.0 K.G that was taken for various physiochemical parameters.

Figure 3.4: Dried Faecal Sludge Collection from readymade drying bed and from Kushtia FSTP

3.5.3 Compost collection

Likewise dried FS, also compost was also collected from Kushtia FSTP. But the process of collection early started with the collection of Organic Solid Waste (OSW) that was mixed with the dried FS for making compost. The main criterion for collection was considered to

be the bio-degradability of the materials collected, as that is the primary feature for running a composting system. Care was taken to pick up leftovers from raw vegetables, fruits, leaves and such other bio-degradable organic materials that are suitable for composting. All types of inorganic wastes were thoroughly avoided. Special care was taken not to incorporate some of very commonly available wastes like paper as they, though are organic in nature and constituent, are not bio-degradable and hence, are clearly objectionable for the composting process. The wastes were collected using sanitary hand gloves to avoid contamination and maintain sanitary conditions and collected in plastic/polythene bag.

As the whole co-composting process have conducted in KUET waste management plant, that's why the organic solid waste was collected from waste management plant. Amount of waste collected is about 3.5 K.G for maintain ratio of 1:3. Moreover amount of compost collected from Kushtia FSTP for various tests weighting about 1.0 K.G.

Figure 3.5: Collected compost for laboratory tests (left: from KUET waste management plant, right: from Kushtia FSTP)

3.5.4 Influent and Effluent waste water collection

Proper FS treatment, either in combination with wastewater or separately, has yet been practiced only in a few countries (EAWAG/SANDEC, 2008). Like other middle income countries, Bangladesh is also practicing the FSM in some major cities to treat both the solid FS and liquid wastewater/ percolate (Dasgupta et. al., 2016).

Kushtia FSTP has a coco pit filter through which waste water is treated and released to nearby pond. When the drying bed becomes filled up, it is kept there for few days so that sludge gets dried and the percolate is transferred into the connected percolate tank. The percolate is pumped into the coco peat filtration unit for further treatment. The filtered water coming out from the coco peat has high nutrient, and can be safely released into agricultural land for irrigation purpose. That's why the two types of water was collected, influent and effluent waste water before and after the treatment process by coco pit filter.

A total of 1 liter sample was collected in 4 bottles, from two different points mentioned in the following picture. Then the sample bottles were put in a cool box with ice cubes before being transported to the environment laboratory at KUET campus. This was to prevent any change of wastewater quality which could occur between the time of collection and analysis in the laboratory. Some parameters which were determined immediately upon arrival in the laboratory included Faecal Coliform, DO and BOD_5.

Figure 3.6: Collection of waste water from Kushtia FSTP

3.6 Laboratory Tests of Collected and Prepared Samples

Laboratory tests of various samples is the most important part of the research work. It involves from collection to sampling for various parameters as per standard methods. Different types of tests (physiochemical, microbial, heavy metals) have been performed for different samples that were collected. The whole experiment was carried out in the Environmental Laboratory in KUET campus, except heavy metals tests. Heavy metals and some nutrient content parameters were experimented at Soil Research and Development Institute (SRDI) in Doulotpur, Khulna. The following Table represents the laboratory tests of various samples

Table 3.2: Laboratory tests performed for different kind of samples

Raw Faecal Sludge	**Dried Sludge**	**Compost**	**Waste water**
pH	pH	pH	pH
Biochemical Oxygen Demand (BOD_5)	Colour	Colour	Biochemical Oxygen Demand (BOD_5)
Chemical Oxygen Demand (COD)	Odour	Odour	Chemical Oxygen Demand (COD)
Temperature	Temperature	Temperature	Temperature
Nitrate-Nitrogen	Nitrate-Nitrogen	Nitrate-Nitrogen	Nitrate
(Ortho) Phosphate	(Ortho) Phosphate	(Ortho) Phosphate	(Ortho) Phosphate
Sludge Volume Index (SVI)	Moisture (%)	Moisture (%)	Sludge Volume Index
Alkalinity	Total Volatile Solids (TVS)	Total Volatile Solids (TVS)	Total Alkalinity
Total Solids (TS)	Total Solids (TS)	Total Solids (TS)	Total Solids (TS)
Total Suspended Solids (TSS)	Total Kjeldahl Nitrogen	Total Kjeldahl Nitrogen	Total Suspended Solids (TSS)
Total Volatile Suspended Solids (VSS)	Fixed Solids (FS)	Fixed Solids (FS)	Total Volatile Solids (TVS)
Fixed Solids (FS)	Electrical Conductivity (EC)	Electrical Conductivity (EC)	Iron

Total Dissolved Solids (TDS)	Total Organic Nitrogen	Total Organic Nitrogen	Electrical Conductivity (EC)
Electrical Conductivity (EC)	Total Organic Carbon (TOC)	Total Organic Carbon (TOC)	Total Coliform (T.C) and E. Coli
Total Organic Carbon (TOC)	C: N	C: N	
Total Coliform (T.C) and Faecal Coliform (F.C)	Total Coliform (T.C) and Faecal Coliform (F.C)	Total Coliform (T.C) and Faecal Coliform (F.C)	
	Phosphorus	Phosphorus	
	Potassium	Potassium	
	Lead	Lead	
	Nickel	Nickel	
	Sulphur	Sulphur	
	Chromium	Chromium	
		Helminth eggs	

(Tests were performed on basis of sample collection, laboratory equipment availability, time except university and government vacation)

3.6.1 Physiochemical parameters

Laboratory tests were performed by practicing standard lab procedures. Minimizing errors more than once test were experimented for each parameters. For raw FS, dried FS, compost and for waste water some physiochemical parameters were tested in KUET Environmental Engg. Laboratory. The following table represents the list of physiochemical parameters with their standards manual.

Table 3.3: List of Physiochemical Parameters

Serial No.	Name of the Test	Standard Methods (SM) of Analysis***
01	pH	SM 4500-H* B
02	Biochemical Oxygen Demand (BOD_5)	SM 5210 B
03	Chemical Oxygen Demand (COD)	SM 5220 C
04	Total Solids (TS)	SM 2540 B
05	Total Suspended Solids (TSS)	SM 2540 D
06	Total Volatile Solids (TVS)	SM 2540 E
07	Fixed Solids (FS)	SM 2540 E
08	Sludge Volume Index	SM 2710 D
09	Iron (Fe)	SM 3500-Fe B
10	Nitrate (NO_3)	SM 4500 NO_3 E
11	Phosphate (PO_4)	SM 4500-P E
12	Electrical Conductivity (EC),	SM 2510 B
13	Temperature	SM 2550 B
14	Total Alkalinity (as $CaCO_3$)	SM 2320 B
15	Colour	physically**
16	Odour	physically**
17	Total Kjeldahl Nitrogen	
18	Phosphorus	Spectrophotometric moylbdo-vanadate method

19	Potassium	Flame photometric method
20	Sulphur	Turbidimetric method

(***All tests were performed from source of Standard Methods for the Examination of Water and Wastewater, 20th edition, Clesceri, 1999)

(**Colour and odour test have been performed on basis of practical judgment)

3.6.2 Microbial parameters

Fecal coliform bacteria are found in the feces of humans and other warm-blooded animals. These bacteria can enter rivers directly or from agricultural and storm runoff carrying wastes from birds and mammals, and from human sewage discharged into the water (Flint River GREEN, 2011). Helminth eggs are expected to be the most resistant pathogens in FS. Although die-off of helminth eggs in the sludge layer of ponds has been documented (Nelson et. al., 2004). If pathogens are present in both wastewater and compost it can cause serious harm to compost users as well as river water. That's why in FS it is important to consider the pathogen activation. So, some microbial parameters were also tested to justify the possible presence of fecal contamination. The following table represents the list of microbial parameters that were tested for raw FS, dried FS, compost and waste water.

Table 3.4: List of Microbial parameters

Serial No.	Name of the Test	Standard Methods (SM) of Analysis***
01	Total Coliform	SM 9222 B
02	E. Coli (Faecal Coliform)	SM 9222 D
03	Helminth eggs	$ZnSO_4$ Method

(***All tests were performed from source of Standard Methods for the Examination of Water and Wastewater, 20th edition)

3.6.3 Heavy metal parameters

Heavy metals are not removed during the treatment process, and it is therefore important to avoid contamination of the FS in the first place. Heavy metals are not usually a concern when dealing with domestic FS as these compounds typically come from industrial sources. When using FS as a soil conditioner, the fate of and exposure to pathogens and heavy metals needs to be taken into consideration. Organic Solid Waste (OSW) sometimes is mixed with industrial wastes in the dumping site which impacts on the heavy metals concentration. That's why, to ensure the heavy metal concentration in dried sludge, compost (both collected from Kushtia FSTP and the readymade) samples were tested. Due to unavailability of equipment and laboratory facility, heavy metals test was conducted by SRDI, Doultopur in Khulna.

Table 3.5: List of Heavy Metals Parameters

Serial No.	Name of the Test	Standard Methods (SM) of Analysis
01	Lead	Atomic Absorption Spectrophotometric method
02	Nickel	Atomic Absorption Spectrophotometric method
03	Chromium	Atomic Absorption Spectrophotometric method

(Heavy metals were tested by SRDI, Doulotpur at Khulna)

3.7 Co-composting Process, It's Monitoring and Controlling

Co-composting means composting of two or more raw materials together like fecal sludge and solid waste. Other organic materials, which can be used or subjected to co composting, comprise animal manure, saw dust, wood chips, bark, slaughterhouse waste, sludge or solid residues from food and beverage industries (Strauss et al, 2003).

After collection of vegetable waste/ OSW, dried FS, the composting units were setup where aerobic decomposition of the organic waste would take place. The whole co-composting process was carried out at the KUET waste management plant. A total 40 days of co-composting period was considered by mixing the dried FS and OSW at a ratio of 1:3. Moreover a turning frequency of every 5 days was considered due to similarity of Kushtia FSTP. A few vital considerations were taken into account while setting up the system and consequently required steps were taken along the process

- It is absolutely necessary to allow sufficient air to flow through the system as the decomposition must be an aerobic one. Insufficient air flow would lead to an anaerobic environment, which may be appropriate in some other cases, but is not desired here.
- Exposure to light and air, though is important, too much heat and temperature rise might lower the quality of compost by developing pathogens and other harmful microorganisms. Keeping that factor in mind, the compost heaps were placed at a shade protecting area from excessive exposure to sunlight.

Monitoring Aspects

In order to maintain an efficient operation and develop a safe attractive product, co-composting process have been regularly monitored.

1. **Temperature Control**

This microbiological activity results in a temperature increase to 65-70^0 C within 1 to 2 days. Temperatures above 70^0 C need to be avoided as they are too high for most soil micro-organisms and the process comes to a halt. Although composting will occur at temperatures below 65^0 C, a temperature of around 65^0 C favors rapid composting and ensures the destruction of weed seeds, insect larvae, and potential plant or human pathogens. The ways been used to measure temperature are:

- A thermometer was used to measure the daily temperature of the compost.
- Into the compost the thermometer was pushed to record the daily temperature.
- Daily ambient temperature was also recorded.

2. **Moisture Control**

To measure the moisture a handful of compost was taken by researcher for squeezing it hard. If only a few drops of water appear the moisture content is in the optimal range. If no drops emerge the moisture content is below 40%, indicating that the nutrient provision is hampered. Consequently, the composting process slows down. Sometimes, the temperature of the waste pile decreased though the process is not finished, because the water content is too low. Adding water raises the temperature of the composting pile and the decomposition process continues. Again some unusual cases also hampered the moisture content like sometimes rain, sometimes hot weather, unexpected humidity etc.

3.8 Interview of key personnel

Key Informant Interviews (KII) was done to get in-depth information from different key personnel regarding compost, its future, its marketing, improvement etc. KII mainly done by two common techniques such as Telephone Interviews and Face-to-Face Interviews. In this report face-to-face interviews was taken into consideration.

Key personnel was chosen based on FSM related knowledge, compost related knowledge people (individual) to gather information about my questions. Typically a list of people is needed for any KII/ FGD. Due to get a proper qualitative analysis result few number of persons were selected for KII. The following table shows detailed information about the key personnel. Due to get a fixed information about a particular subject, a particular background or sector of people was the main target. That's why, Key informant diversity is not so important in this research. Moreover, mainly government related people have been chosen to get better idea about compost in national level, its perception and view from them which represent the focus point of the compost, its future.

Table 3.6: List of key personals chosen for KII

Serial No.	Informant Name	Informant Address
01	Dr. Nazmul Ahsan	Professor, Fisheries and Marine Resources Technology Discipline, Khulna University. Mobile: 01712248038
02	Ranver Ahmed	Town Planner, Kushtia Municipality, Mobile: 01731217239, E-mail: ranver.jugia@gmail.com
03	Md. Selim Hossain	Director and Senior Agriculturist, BCS (Agriculture), Department of Agricultural Extension, Kushtia Sadar, Kushtia. Mobile: 01716001009. E-mail: selimsau07@gmail.com
04	Md. Masud Hossian Palash	Officer, Department of Agricultural Extension, Kushtia Sadar, Kushtia. Mobile: 01726598433
05	Vhabananda Basak	Senior Scientific Officer, Soil Research and Development Institute (SRDI), Kushtia. Mobile: 01712911367, E-mail: bhabananda@srdi.gov.bd.com
06	Shimul mondal	Scientific Officer, On-Farm Research Division, Regional Agricultural Research Station, BARI, Jessore. Mobile: 01717785539
07	Md. Jahurul Islam	Conservancy Inspector (In-charge), Kushtia Municipality. Mobile: 01725078741
08	Md. Ashifur Rahman	Production Manager, Environmental Resource Advancement (ERAS). Mobile: 01775615128
09	Md. Nazrul Islam	Marketing Officer, Environmental Resource Advancement (ERAS). Mobile: 01779155623
10	Jalal Mia	Payara tola, Ram Chandra Ray Chowdhury Rd, Kushtia. Mobile: 01942577813

CHAPTER IV

Results and Discussions

4.1 General

This chapter discusses the overall results obtained from survey, visit to Kushtia Municipality, Kushtia FSTP. It also represents the current FSM condition through description and by FSM Toolbox. Result of the total current FS generation in Kushtia Municipality, tests results of the FS characteristics, dried FS, compost, efficiency of treatment have been discussed here. In addition, it has been tried to explain whether the change in the values of the parameters or concentration of the constituents be beneficial or harmful in context of application to agricultural soil. Moreover an effort is made to decide on the quality of the compost based on the parameters and constituent concentration as determined by the test procedures.

Finally, an idea of sustainability of faecal sludge management system based on economically viable, socially acceptable, technically and institutionally appropriateness and protection the environment and the natural resources will be shortly discussed so that in future some strong steps can be taken to improve the FSM in Kushtia Municipality.

4.2 FSM in Kushtia Municipality

Although the Water Supply and Sanitation (WSS) sector has an impressive array of legal instruments, policies, strategies and plans in place (the National Policy for Safe Water Supply and Sanitation became effective in 1998), faecal sludge management has long been neglected and it is not yet institutionalised (Kabir & Salahuddin, 2015).

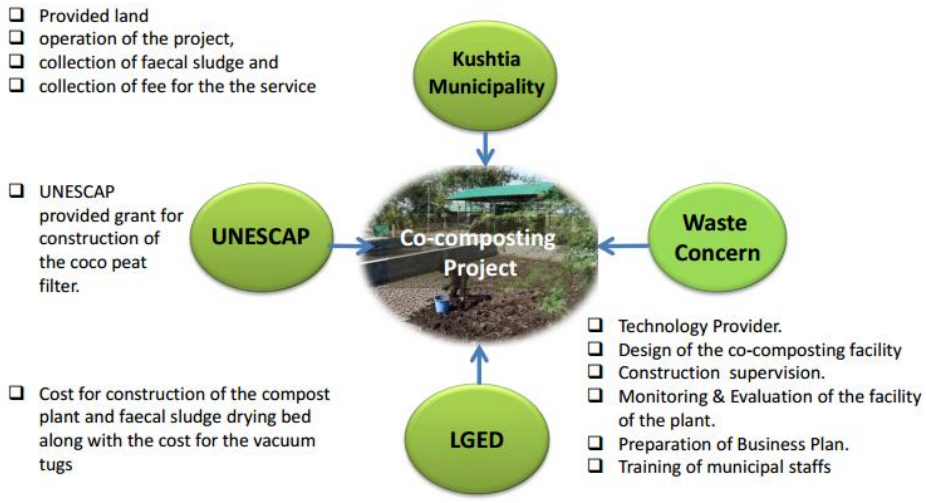


Figure 4.1: FSM project partners in Kushita Municipality

Kushtia Municipality with the support from the Institute for Global Environmental Strategies (IGES) and UNCRD and in partnership with the Department of Environment, Ministry of Environment & Forest, has introduced 3R (reduce, reuse and recycling of Waste) initiatives

in Kushtia Pourashava through a number of interventions (i.e., source separation of waste, awareness and training programs, decentralized co-composting etc.) in 2008. The municipality has established a Co-compost Plant at Baradi, about 3.5 km from city center. Figure 4.1 showed the FSM project Prtners in Kushtia Municipality. Kushtia Municipality and Waste Concern jointly organized a workshop on "Community Based Co-composting Initiative in Kushtia Pourashava, Bangladesh" on February 10, 2008 at the Municipality Auditorium. The event was supported by the Institute for Global Environmental Strategies (IGES) and United Nations Centre for Regional Development (UNCRD) (Ali & Ahmed, 2015).

4.2.1 Description of the Study area

Kushtia is a small city, was a part of Jessore District in the Company era. Kushtia Thana was transferred from north-western part of Dakdaha in front of Talbaria, opposite to the bank of Chaltedoh (present Gorai River) to north-eastern part of the village Majampur to save the city from the cruel nature of river Padma. Kushtia is bounded on the north by Rajshahi, Natore and Pabna districts, on the east by Pabna and Rajbari Districts, on the south by Jhenaidah, Chuadanga and Meherpur Districts and on the west by Chuadanga and Meherpur Districts and India. It lies between 23°42´ and 24°12´ north latitude and between 88°42´ and 89°22´ east longitudes. The total area of the district is 1621.15 sq.km (625.93 sq. miles).

Basic Information		
Name of the Municipality	:	Kushtia Municipality
Name of Mayor	:	Anwar Ali
Municipal Area	:	42.79 sq.km
No. of Ward	:	21
No. of Mouza included	:	19
Total no. of Municipal Staff	:	166
Population	:	3,75,149
No. of Household	:	83,926
No. of Holding	:	33,936

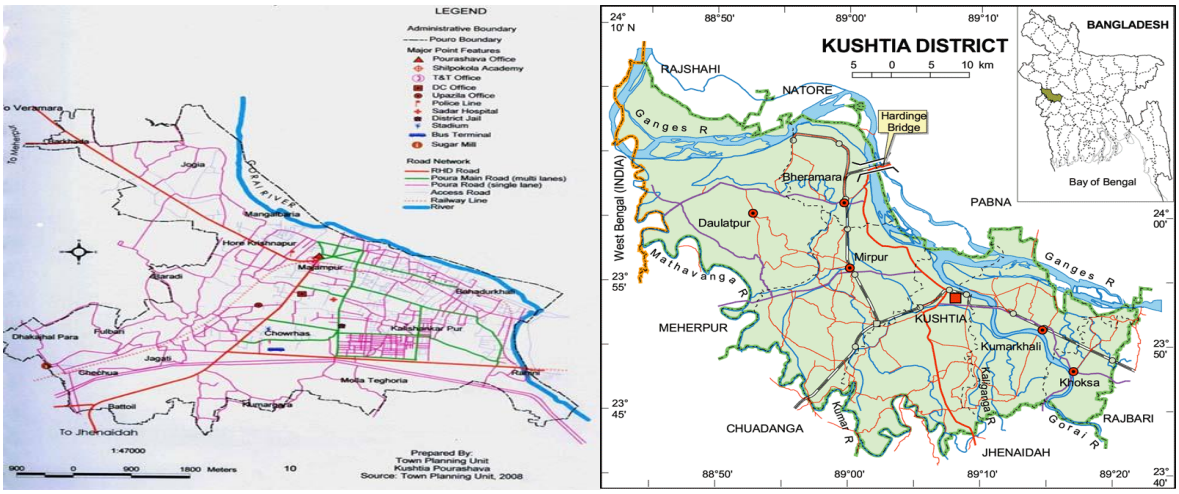


Figure 4.2: Location of Kushtia Municipality

4.2.2 Current FSM scene in Kushtia Municipality

The pilot invention of Kushtia Fecal Sludge Management project was to develop a sustainable faecal sludge management system having full cost recovery and which can be replicated in secondary towns. In order to tackle solid waste management as well as faecal sludge management problems, a pilot project has been initiated in Kushtia Municipality, a secondary town in Bangladesh. Kushtia Municipality is running the FSM successfully by their manpower, local resources, and sanitation knowledge except some hindrances.

4.2.2.1 Containment Tank Location

Majority of households in Kushtia Municipality has septic tank (about 50.1%) and pit latrines (47%) with exceptions of commercial, institutional and other establishments. While most of the holdings have their containment system under the house (70%), a strong majority (75%) have proper access ports. Those without proper access ports, however are generally (57%) unwilling to install them, indicating that encouraging installation of proper access ports would be in important component of behavior change and promotions campaigns (SNV, 2015).

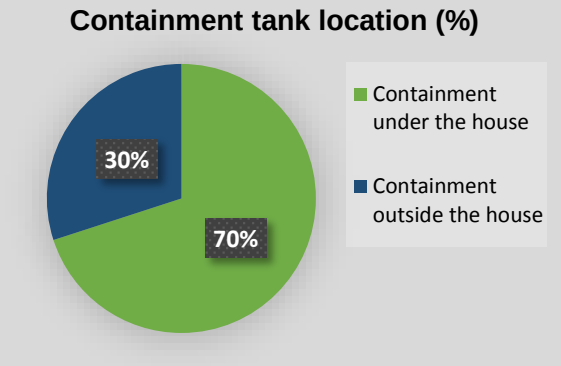


Figure 4.3: Containment Tank Location in ward 5

From survey and FSM baseline study, it has revealed that, pour flash toilet is 90.00% and cistern flush toilet is only 10%. It can be said that, open defecation is comparatively low in Kushita because of low percentage of open defecation (1%).

4.2.2.2 Containment Tank Accessibility

Road access is very necessary for vacutug during desludging operation. Most of the roads are 8 to 10 feet wide in the residential areas (municipality conservancy department) is a big advantage in case of emptying operation. Some homes (12%) are accessible by the larger truck mounted Vacutugs, the vast majority are not, with some (20%) only accessible by 3 wheeler motorcycle tankers, and an additional 20% located on narrow streets inaccessible to anything but hand carts (Figure 4.4). This is an indication that there is an opportunity to engage the informal service providers (sweepers) in a legitimate activity of manually desludging containment systems using approved devices, such as screw augers and the gulper, and operate hand carts for primary conveyance (household to the parking area of the collection or transport truck).

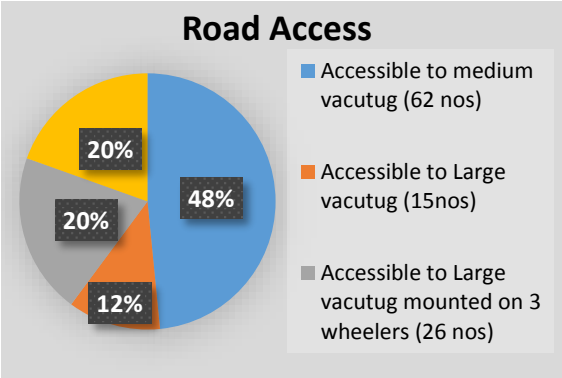


Figure 4.4: Containment Tank Accessibility (Source: SNV, 2015)

4.2.2.3 Status of Vacutug Operation in Kushtia Municipality

Kushtia Municipality gets the first Vacutug having the capacity of 500 Liter from the UN-HABITAT which starts its operation from June 2004. The second Vacutug of 2000 Liter Capacity has been provided by Secondary Town's Integrated Flood Protection Project (STIFPP) which starts its operation from June 2010. The third one has got the capacity of 4000 Liter. Finally in 2014, fourth vacutug whose capacity was 1000 Liter was taken by Kushtia Municipality. The numbers of emptied Septic-Tank & Pit Latrine by the Vacutugs are given below:

Table 4.1: Vacutug operation in Kushtia Municipality

Yearly emptied Septic Tank/ Pit Latrine			
Serial No.	Year	No. of Emptied Septic Tank	No. of Emptied Pit Latrine
1	2004 (June-December)	120	46
2	2005	207	154
3	2006	199	171
4	2007	217	198
5	2008	210	191
6	2009	295	219
7	2010	351	294
8	2011	348	334
9	2012	313	347
10	2013	348	351
11	2014	358	298
12	2015	349	312
	Total	*3315*	*2915*

(Source: Kushtia Municipality Conservancy Department)

4.2.2.4 Treatment of Faecal Sludge

Faecal sludge collected by vacutugs from municipality area is taken to Faecal Sludge Treatment Plant (FTP) for its proper treatment. Faecal sludge which is dumped to the drying beds are used for dewatering. After dewatering process, the percolate is transferred into the connected percolate tank. The percolate is pumped into the cocoa peat filtration unit for

further treatment. The filtered water coming out from the cocoa peat filter has high nutrient, can be safely released into agricultural land for irrigation purpose.

Figure 4.5: Existing Treatment Facilities of Kushtia FSTP (Drying Bed, Cocoa Pit Filter)

4.2.2.5 Co-composting of the Faecal Sludge

Faecal Sludge is a rich source of nutrients such as nitrogen, phosphorus and potassium. In human excreta, most of the organic matter is contained in faeces, while most of the nitrogen (70-80%) and potassium are contained in urine. Before using faecal sludge as a fertilizer, it must be made safe. Composting is the controlled aerobic degradation of the organics using more than one material (faecal sludge and organic municipal solid waste). Faecal sludge has a high moisture and nitrogen content while bio-degradable solid waste is high in organic carbon and has good bulking properties (i.e. it allows air to flow and air to circulate).

By combining the two, the benefits of each can be used to optimize the process and the output product. Composting is a natural process allowing good hygienisation of sludge in a relatively short time. This is due to high temperature of 50 to 70ºC, which is reached during thermophilic degradation process. Composting of pre-treated and thickened faecal sludge with solid waste might be a good solution, even for large sludge volumes.

Figure 4.6: Co-composting of Faecal Sludge and Organic Solid Waste

4.2.3 Scenario of FSM chain by *SAT Toolbox Dashboard*

FSM Situational Assessment Tool (SAT) has been developed to analyze the FSM practices in a city level area where sewered connected sanitation is not available. After connecting all available information from various sources, all data were input in Situational Assessment Tool (SAT) for analyzing the current situation.

Kushtia FSM scenario is fair to excellent where different colors indicate the specific condition of the respective situation. From scorecard it is clear that, the general condition is

fair (0.45-0.55). FSM chain is under excellent category where Containment is within range of 0.68-0.78, Emptying is within range of 0.79-0.89, Transportation is within range of 0.79-0.89, Treatment is within range of 0.68-0.78 and finally Reuse is within range of 0.79-0.89. The score of excellent indicates that, FSM situation is under low risk category and also suggest that the service delivery is largely on place. Figure 4.7 shows the detailed FSM scorecard and evaluates the overall FSM performance.

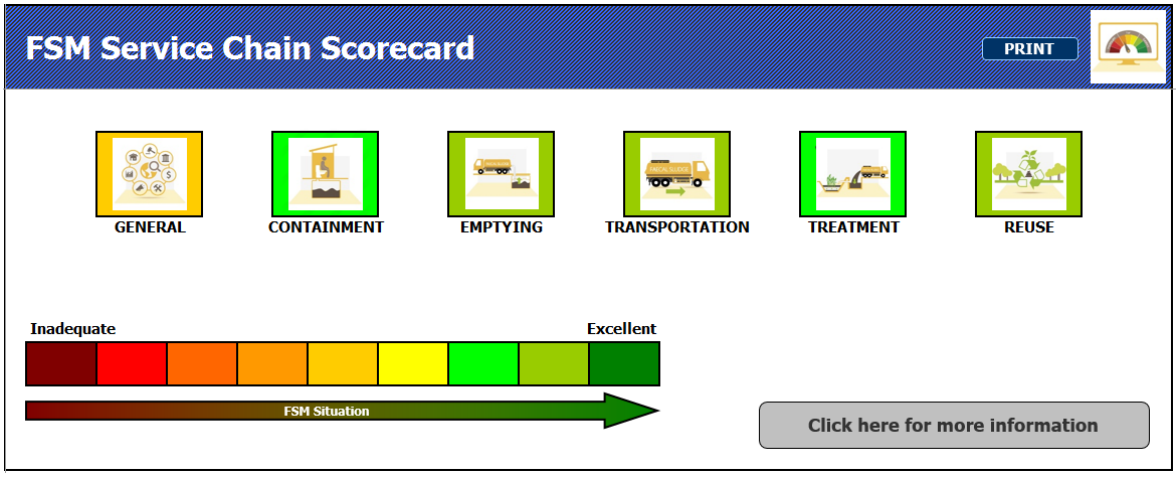


Figure 4.7: FSM Service Chain Scorecard (Overall Situation of the FSM in Kushtia Municipality, Bangladesh)

Detailed score and full FSM service chain report can be found in Annex 2 and Annex 3. Moreover answers of all questions mentioned in every FSM chain (containment, emptying, transportation, treatment and reuse) are given in Annex 4 to Annex 9.

4.3 Total FS generation in Kushtia Municipality

Accurate estimation of FS for Kushtia Municipality is very important for any future development of the FSM service. That's why after literature review, the details estimation has done. In the following Table 4.2 FS generation has shown with baseline data and other data sources.

During calculation some assumptions have been considered which are given below

Assumptions

- Average emptying of ST/Pit within (0~3) years => 1.5 years and Over 3 years => 5 years (AIT, 2015) based on inception report.
- In calculating theoretical market size, it is assumed that pit and ST are being filled in @ 0.3 liter per person per day and 0.7 liter per person per day, respectively (Source: Ministry of Rural Development, and USEPA)

Table 4.2: Faecal Sludge Generation in Kushtia Municipality

Serial No	Baseline Data	Unit	Kushtia Municipality	Data Source
1	Population	Nos.	3,75,149	Kushtia Municipality office and website
2	Number of Households (HH) (4.47 Persons/HH)	Nos.	83,926	Kushtia Municipality office and website
3	No. of Holding	Nos.	33,936	Kushtia Municipality office and website
4	HH with on-site sanitation (OSS)	%	99%	FSM Survey , 2014
5	Number of HH with OSS	Nos.	83087	Estimated values
6	HH with OSS having shared toilets	%	19	FSM Survey, 2014
7	HH with OSS having shared toilets	Nos.	15786	Estimated values
8	Adjusted HH with OSS in total (5.75 HH/share toilet)	Nos.	65244	Estimated values
9	HH with OSS septic tank (ST) toilets	%	54%	FSM Survey, 2014
10	HH with OSS pit toilets	%	46%	FSM Survey, 2014
11	HH with OSS toilets (ST) in total	Nos.	35232	Estimated values
12	HH with OSS toilets (Pit) in total	Nos.	30012	Estimated values
13	Typical Volume (ST)	m^3	15.33	FSM Survey, 2014
14	Typical Volume (Pit)	m^3	2.58	FSM Survey, 2014
15	Average number of users of ST/Pit	Nos.	12 (adapted)	FSM Bangladesh, 2012
16	ST/Pit emptying frequency (within 3 yrs)	%	6%	FSM Survey, 2014
17	ST/Pit emptying frequency (over 3 yrs)	%	94%	FSM Survey, 2014
18	Total number of ST emptied (annually)	Nos.	8033	Estimated values
19	Total number of Pit emptied (annually)	Nos.	6843	Estimated values
20	Fecal Sludge Volume (Field Survey)	m^3/yr	140798	Estimated values
21	Fecal Sludge Volume (Theoretical)	m^3/yr	147457	Estimated values

From the table it is seen that, the amount of FS from field survey is 140798 m^3/ year whereas theoretically it is 147457 m^3/ year. The variation is that, in calculating actual volume, septic tank and pit latrine volume has been considered, but in calculating theoretical volume number of person using the latrine has been considered. That's why theoretical volume is greater than actual volume.

Sample Calculation for Kushtia Municipality:

Total number of ST emptied (annually) = 35,232 x (0.06/1.5) + 35,232 x (0.94/5) = 8033
Total number of Pit emptied (annually) = 30,012 x (0.06/1.5) + 30,012 x (0.94/5) = 6843
Fecal Sludge Volume (Actual Field Survey) = 8033 x 15.33 m^3 + 6843 x 2.58 m^3= 140798 m^3
Fecal Sludge (Theoretical) = (35,232 x 12 x 0.7/1000 x 365) m^3 + (30,012 x 12 x 0.3/1000 x 365) m^3= 147457 m^3

Again from literature review it has been clear that, generation of FS in low income countries like Bangladesh is 250 g/person/day (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014). From this point of view, with help of FSM Toolbox, especially FSM Technical and Financial Assessment Tool this production rate has been applied and an approximate estimation of FS generation has been arisen. The following Table 4.3 represents the FS volume (estimated) where some data were taken from Kushtia Municipality office and conservancy department officials.

Table 4.3: FS Volume Estimation by Technical and Financial Assessment Tool-1

FS volume from households		
Total population in the coverage area	375,149	population
Average number of persons per household	5	persons per household
Estimated number of households	83,366	households
Percentage of homes with lined containment (septic tanks, cesspool, twin pit latrines, etc.)	97%	% with lined containment
Percentage of lined containment that are desludgable	81%	% of lined containment that are desludgeable
Number of working days per year	260	working days per year
Average volume of residential lined containment (septic tanks, cesspool, twin pit latrines, etc.)	30	cubic meters
Frequency of desludging (3 to 5 years)	4	years
Number of days per week that the FSM program will operate	4	days per week
Estimated FS volume per day from households	1,889	cubic meters per day
FS volume from commercial establishments		
Number of commercial establishments in the coverage area	1,400	commercial establishments
Percentage of commercial septic tanks that are accessible	90%	% of septic tanks that are accessible
Average volume of commercial septic tanks	20	cubic meters
Estimated FS volume per day from commercial establishments	24	cubic meters per day
FS volume from institutions		
Number of institutional establishments in the coverage area	304	institutional establishments
Percentage of institutional septic tanks that are accessible	90%	% of septic tanks that are accessible

Average volume of institutional septic tanks	20	cubic meters
Estimated FS volume per day from institutions	5	cubic meters per day
Total FS volume per day	1,919	cubic meters per day
Total FS volume per month	41,577	cubic meters
Total FS volume per year	498,926	cubic meters

(Estimation is based on Septic Tank volume)

When generation rate was considered the daily FS volume generation changed with a value of 103 cubic meters per day which is shown in Table 4.4.

Table 4.4: FS Volume Estimation by Technical and Financial Assessment Tool-2

Estimated annual FS generation rate per capita	0.09	m^3/capita/year
Estimated annual FS generation rate per household	0.41	m^3/household/year
Estimated annual FS generation rate in coverage area	34,232	m^3/year
Estimated FS volume per day from households	103	cubic meters per day

(Estimation is based on per capita FS generation rate)

Where,

250 gm/ capita/ day= (250/1000) x 0.001 x 365= 0.09125 m^3/capita/year

From Table 4.3 and 4.4 it is clear that, the FS volume generation is 1019 cubic meters per day and 103 cubic meters per day based on two different estimation. There is no any developed or standard rule and method by which exact FS volume can be measured or estimated. FSM Situational and Technical Assessment Tool is only an overview of the preliminary FSM situation in a community, city or municipality. Again from Table 4.2 is seen that, FS volume is 140798 m^3/yr which is less than 3.5 times to 498,926 m^3/yr (Table 4.3). All values are calculated in a different way with different estimation technique. That's why various results have been arisen from Table 4.2 to Table 4.4.

4.4 Characteristics of Raw FS

Due to collection of any sample, it is prior to test the characteristics of samples. Same process was also applied to after collection of raw FS from different locations. Parameters that should be considered for the characterization of FS include solids concentration, chemical oxygen demand (COD), biochemical oxygen demand (BOD), nutrients, pathogens, Total solids (TS) with other solids, Electrical conductivity (EC) etc. These parameters are the same as those considered for domestic wastewater analysis, however, it was needed to be highlighted that the characteristics of domestic wastewater and FS are very different. The following Table 4.5 represents the characteristics of the collected samples from different location within Kushtia Municipality.

Table 4.5: Characteristics of Collected FS from Kushtia Municipality

Serial No.	Characteristics	sample from pit latrine	sample from septic tank	sample from dumping site
1	pH	7.31	7.41	7.46
2	COD (mg/L)	12800	19200	9600
3	DO(mg/L)	0.30	0.23	0.23
4	BOD_5(mg/L)	701	676	656
5	Sludge Volume Index (ml/gm)	1.791	1.469	1.699
6	Phosphate (mg/L)	791	509	512
7	Alkalinity (mg/L)	6250	7750	4500
8	TDS (mg/L)	2900	3222	2800
9	TS (mg/L)	39200	44056	46950
10	TSS (mg/L)	36300	40833.33	44150
11	Total Volatile Suspended Solids (%)	69.39	60.99	60.88
12	Fixed Solids (%)	30.61	39.01	39.12
13	Total Organic Carbon (%)	40.24	35.37	35.31
14	Temperature	24.6	26.6	27.8
15	Total Coliform (cfu/100ml)	96000	84000	100000
16	Faecal Coliform (cfu/100ml)	76000	56000	72000
17	Electrical Conductivity (mS/cm)	5.64	4.78	4.91
18	Moisture (%)	93.73	94.06	93.14
19	Nitrate nitrogen (mg/L)	0.6	1.2	0.7

(Sample source in detail description has given in Chapter 3)

From Table 4.5 it is clear that, the result of each sample is similar to Table 2.1. In this table it can be said that raw FS from pit latrine and from dumping is Type "B" (low-strength) sludge on basis of COD value. But FS from septic tank is Type "A" (high-strength) (Montanegro & Strauss, 2002). But it is very difficult to characterize the overall sludge type. BOD_5 is also within satisfactory limit and ratio of COD and BOD_5 is 14.63 for FS collected from dumping site. This ratio represents that FS either high-strength or low-strength (Montanegro & Strauss, 2002). High strength means highly concentrated, mostly fresh FS; stored for days or weeks only where as low-strength means FS of low concentration; usually stored for several years; more stabilized than Type "A". For any FSTP design the characteristics of FS is very important to find out the treatment capacity, sludge loading rate, etc.

Again on the basis of Suspended Solids (SS) this three samples are high-strength because of their higher concentration ($\geq$ 30000). There will be always variability in determining the FS concentration and characteristics. Time, performance of pit latrine or septic tank, temperature, location of ground water table, salinity, tank location, emptying process, no of users, rainfall etc. always influence the overall characteristics of raw FS. Moreover from the characteristics, it can be known the concentration of nutrient content in the FS which has an influence in end-use option. The following Figures represents some tests performed in the KUET Environmental Engineering laboratory.

Figure 4.8: COD test of collected samples

Figure 4.9: Solids determination and SVI test

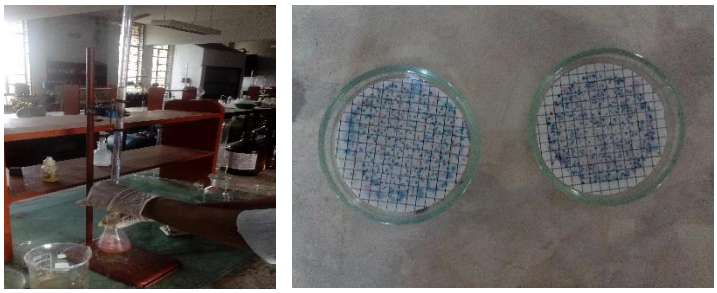


Figure 4.10: Total Coliform and E.Coli test

4.5 Quality of Dried FS

Faecal Sludge collected from drying bed is a rich source of nutrient. Kushtia Municipality is operating the FSTP where raw FS is dried for almost 14 to 15 days depending on the loading. After collection of the dried FS from Kushtia FSTP sample were given to SRDI for some tests and other available tests were conducted in KUET Environmental Engineering laboratory. No exact references were found by which the quality would be justified. Since it is one kind of bio solids and using in agricultural sector, so Bangladesh compost standards and SRDI standards were followed. Table 4.6 represents the overall quality of bio solids (dried FS) collected from Kushtia FSTP. Basic parameters with standards are given in Table 4.6.

Table 4.6: Basic parameters of the dried FS (Bio Solids) with standard limits

Serial no	Characteristics	Result
1	Colour	Dark Gray
2	Odour	Absence of foul odour
3	pH	7.4
4	Moisture (%)	22
5	Total Volatile Solids (%)	42.35
6	Fixed Solids (%)	57.65
7	Total Solids (mg/kg.)	16433
8	Total Organic Carbon (%)	24.56
9	Total Organic Nitrogen (%)	1.99
10	C: N	12.4:1
11	Nitrate nitrogen (mg/kg.)	0.9
12	Electrical Conductivity (mS/cm)	3.62
13	Phosphorus (%)	1.9
14	Potassium (%)	0.8
15	Lead (ppm)	3.2
16	Nickel (ppm)	2.9
17	Sulphur (%)	< 0.1
18	Chromium (ppm)	6.8
19	Total Coliform (cfu/100 ml)	3700
20	Faecal Coliform (cfu/100 ml)	1500

(Parameters from 1 to 12 and from 19-20 were tested in KUET Environmental Engg. Laboratory and parameters from 13 to 18 were tested in SRDI Laboratory at Doulotpur, Khulna.)

From Table 4.6 it is seen that moisture content is at optimum level of 22 %. C: N ratio is also within satisfactory level. Although phosphorus is greater than allowable limit, any serious effect won't arise due to high nutrient uptake value. Heavy metals like lead, nickel, chromium are within satisfactory level. Heavy metals are usually found in commercial and industrial wastewater and may have to be source-controlled if the wastewater is to be reused. Here all kinds of septic tanks FS's is dumped, so heavy metal is a vital element in bio solids. Total Coliform and E. coli are very high in numbers like 3700 and 1500 respectively. The microbial activity of pathogenic organisms is needed further treatment for safe handling of the bio solids. From this table performance of drying bed can be justified. Pathogen content is the main parameter in case of treating raw FS after dumping in drying beds. The drying bed constituted an impermeable barrier for pathogens and bacteria. It can be concluded that the bacterial eggs were therefore concentrated in the bio solids and thus need to be hygienised prior to reuse in agriculture. The subsequent co-composting should allow inactivation of the pathogens.

Again, it is seen that, Total Solids (TS) concentration is 16433 mg/Kg. where, TS is used to assess the reuse potential of wastewater and to determine the most suitable type of treatment operation and process. TVS are those solids that can volatize and be burned off when the TS are ignited (500 +/- 50 °C). Fixed solids (FS) comprise the residue remaining after a sample has been ignited. From the above Table Total Volatile Solids (TVS) is 42.35% and Fixed

Solids is 57.65 % respectively. From Annex-10 test results of dried FS will be cleared where all information has been given for detail understanding.

Figure 4.11: Dried FS from Kushtia FSTP

From Figure 4.11 it is seen that, the dried FS is dark grey in its colour and coarser than compost.

4.6 Results of the influent and effluent waste water of the FSTP

Kushtia Municipality is running the FSTP through solid-liquid separation technique. In simply, human excreta is filtered by two system. One is natural drying bed, other is filter media where liquid is treated by coco pit filter. Two types of samples were collected for realizing the practical condition of the waste water quality. Onsite sanitation technologies can be a sustainable solution to meet sanitation goals in a Faecal Sludge Management (FSM) service chain, as long as the faecal sludge (FS) from these systems is collected, transported, treated, and then used for resource recovery or safely disposed of. Proper disposing in the environment laboratory analysis of the influent waste water is a prime need. That's why after lab test, quality of the influent (from percolate to coco pit filter) and effluent (after filtering by coco pit filter to natural body) were analyzed to evaluate whether co-treatment is feasible or not without causing any interruption. The following Table 4.7 has given below which shows the result of the water quality parameters for both influent and effluent waste water.

Table 4.7: Results of water quality parameters

Serial No	Water Quality Parameters	Units	Sample 1 (Influent/ before cocopit filter)	Sample 2 (Effluent/ after cocopit filter)	Limits for Disposal in Water Bodies (ECR'97, Bangladesh)
1	pH	--	7.95	7.11	--
2	Biochemical Oxygen Demand (BOD_5)	mg/l	129	32	40
3	Chemical Oxygen Demand (COD)	mg/l	256	128	--
4	Total Solids (TS)	mg/l	1150	860	--
5	Total Suspended Solids (TSS)	mg/l	200	80	100
6	Total Volatile Solids (TVS)	mg/l	600	360	--

7	Total Coliform (T.C)	cfu/100ml	4600	2000	--
8	Escherichia Coli (E. Coli)	cfu/100ml	1300	100	1000 (Faecal Coliform)
9	Sludge Volume Index	ml/gm	Not detected	Not detected	--
10	Iron (Fe)	mg/l	0.18	0.04	--
11	Nitrate (NO_3)	mg/l	19	1.5	250
12	Phosphate (PO_4)	mg/l	5.65	5.4	35
13	Electrical Conductivity (EC)	(mS/cm)	0.733	0.665	--
14	Temperature	^{0}C	23.3	25.6	30
15	Total Alkalinity (as $CaCO_3$)	mg/l	755	300	--

From Table 4.7 it is seen that, all important parameters are within ECR 1997 limits. Specially among all water quality parameters BOD_5 is most important, then bacterial constituents. From this Table, BOD_5 for influent is 129 mg/L whereas, in effluent the result is only 32 mg/L. So the treated water can be easily released in natural water body. There will be no any hindrances or complexity in releasing the treated effluent. Total Suspended Solids should be within 100 mg/L whereas the treated effluent water displayed 80 mg/L. So amount of Suspended Solids (SS) in the final effluent is near to maximum limit which is a threat for the treatment system. In future more colloidal particles will be clogged in the coco pit filter media and no suspended particles will be further removed.

Again from the Table it is also seen that, E.Coli is also within the satisfactory limits. Bangladesh Environment Conservation limit is maximum 1000 Faecal Coliform whereas the treated water from the coco pit filter is found only 100 cfu coliform per 100 mL sample. Both nitrate and phosphate are within satisfactory limits. None of the values crossed the maximum limit in any case. Temperature was also found in ambient condition at natural atmosphere. From SVI test no settleable solids had been detected. From the following Figures some tests results can be understood which are not identical to results all time.

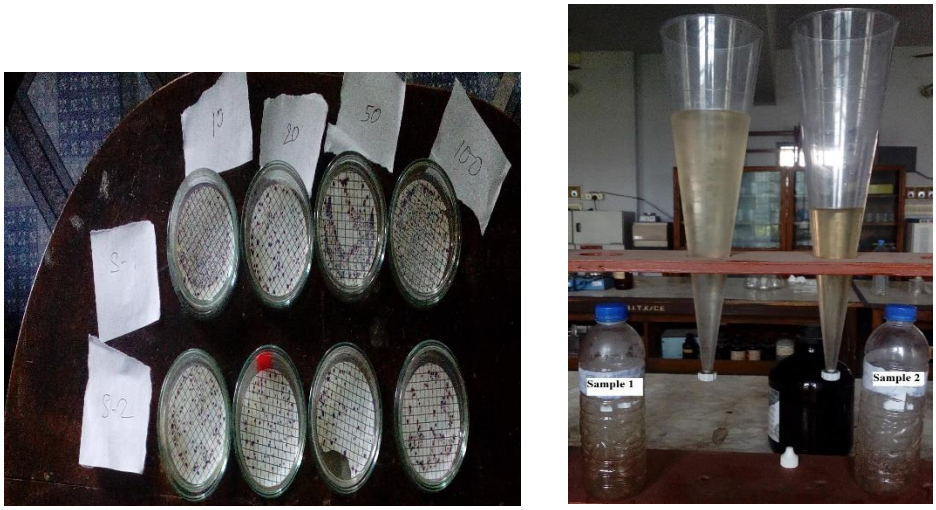


Figure 4.12: Coliform test (T.C and F.C) and SVI test of waste water

4.7 Overall treatment efficiency of the FSTP of Kushtia Municipality

When measuring the treatment efficiency of FS treatment processes, a direct impact is understood in the dewatering process, drying bed and the filter media. One of the main objectives were to determine the overall treatment efficiency of the existing FSTP in Kushtia. Treatment efficiency can be categorized in two parts, one is efficiency of the drying beds and another is efficiency of the filter media or coco pit filter media whatever is said. Two different treatment efficiency of the solid part and liquid part of FS has been described below.

4.7.1 Efficiency of Drying Beds

The faecal sludge (influent) was very high in organic load, nutrients and pathogens. Table 4.8 shows average characteristics of the sludge and percolate as well as the efficiency of the drying beds.

Table 4.8: Drying Bed Dewatering Efficiency

Characteristics	COD	BOD_5	TS	TSS	T.C	F.C	Alkalinity	Phosphate
Raw Sludge	13867	678	43402	40428	93333	68000	6167	604
Percolate	256	129	1150	600	4600	1300	755	5.65
% Removal	98.15	80.96	97.35	98.52	95.07	98.09	87.76	99.06

Dewatering Efficiency (%) = ((numbers in raw sludge- numbers in percolate)/numbers in raw sludge)*100

Through the dewatering efficiency of the beds were highly impressive, where 98.15 % for COD, 80.95 % for BOD_5, 97.35 % for TS, 98.52 for TSS, 95.07 for T.C, 98.09 % for F.C, 87.76 % for alkalinity and 99.06 % for phosphate. pH and temperature were within the recommended guidelines. Thus the drying beds functioned as a pre-treatment system, hence the percolate (influent to the coco pit filter) needs further treatment to meet the requisite discharge guidelines.

4.7.2 Efficiency of the Filter Media

From the drying bed performance, the waste water was needed further treatment. Filtration is also a commonly applied mechanism for secondary treatment in Kushtia FSTP. The parameters that have the greatest impact on slow filtration efficiency are the characteristics of the influent, the type of filtration media, and the filter loading rate (Metcalf and Eddy, 2003). After collection of samples and laboratory experiments, results were analyzed. From influent and effluent water quality the removal efficiency for each parameters were calculated. Table 4.9 shows the overall removal efficiency of the secondary filter media (coco pit filter)

Table 4.9: Removal Efficiency of Coco Pit Filter

Serial No	Water Quality Parameters	Units	Sample 1 (Influent)	Sample 2 (Effluent)	Removal Efficiency (%)
1	Biochemical Oxygen Demand (BOD_5)	mg/l	129	32	75.19
2	Chemical Oxygen Demand (COD)	mg/l	256	128	50.00

3	Total Solids (TS)	mg/l	1150	860	25.22
4	Total Suspended Solids (TSS)	mg/l	200	80	60.00
5	Total Volatile Solids (TVS)	mg/l	600	360	40.00
6	Total Coliform (T.C)	cfu/100ml	4600	2000	56.52
7	Escherichia Coli (E. Coli)	cfu/100ml	1300	100	92.31
8	Iron (Fe)	mg/l	0.18	0.04	77.78
9	Nitrate (NO_3)	mg/l	19	1.5	92.11
10	Phosphate (PO_4)	mg/l	5.65	5.4	4.42
11	Total Alkalinity (as $CaCO_3$)	mg/l	755	300	60.26

Treatment Efficiency (%) = ((numbers in influent- numbers in effluent)/numbers in influent)*100

From Table 4.9, BOD_5 removal efficiency is better than COD removal efficiency. COD is 50.00 % represents that, some organic and inorganic matters are also released in the water body but not harmful for aquatic animals like fish and microorganisms. The decomposition of organic compounds consumes much oxygen and leads to the decrease in BOD level. Percentage of solids removal is not so rich which is only 25.22 %. The need for solids removal must be balanced with the solids concentration of loaded FS and the potential for clogging. Suspended Solids removal is 60.00 % which is in a danger level because if suspended particles are not properly removed the filter media will be clogged. T.C, F.C, Iron, Nitrate, Alkalinity removal percentage are very effective as per result. From Phosphate removal efficiency it can be said that, it can lead to algae bloom, because of the excess nutrients. At the end, it is concluded that, all parameters have reduced its concentration which is safe for releasing in natural water body.

4.8 Quality of the compost

Using FS as a soil amendment has many benefits over using chemical fertilizers alone (Strauss, 2000). Organic matter in FS can increase soil water holding capacity, build structure, reduce erosion and provide a source of slowly released nutrients. As mentioned above, when using FS as a soil conditioner, the fate of and exposure to pathogens and heavy metals needs to be taken into consideration, and social acceptance can be closely linked to potential commercial value. For all consideration and proof, laboratory valid result and decision is needed. Co-composting is the secondary treatment of FS with MSW.

After proper co-composting process compost made for experiment weighed 2.82 K.G where the initial weight was 5.00 K.G. So the reduction in weight was about 43 % indicates that the combination of FS and OSW combined, reduces the percentage of wastes by making a reusable material. Table 4.10 represents the basic parameters of the compost made from the dewatered FS and OSW.

Table 4.10: Basic parameters of the compost with standard limits

Serial no	Characteristics	Result	Standard Range*
1	Colour	Dark Gray	Dark gray to black
2	Odour	Absence of foul odour	Absence of foul odour

3	pH	8.3	6.0 –8.5
4	Moisture (%)	29	Maximum 20 %
5	Total Volatile Solids (%)	25.24	
6	Fixed Solids (%)	74.76	
7	Total Solids (mg/kg)	707797	
8	Total Organic Carbon (%)	14.64	10-25 %
9	Total Organic Nitrogen (%)	2.00	0.5 – 4.0 %
10	C: N	7.3:1	20:1 (maximum)
11	Nitrate nitrogen (mg/kg)	0.4	
12	Electrical Conductivity (mS/cm)	8.09	
13	Total Kjeldahl Nitrogen (mg/kg)	140	
14	Phosphorus (%)	0.5	0.5-1.5
15	Potassium (%)	1.8	1.0-3.0
16	Lead (ppm)	27	Maximum 30 ppm
17	Nickel (ppm)	7	Maximum 30 ppm
18	Sulphur (%)	0.1	0.1-0.5
19	Total Coliform (cfu/100 ml)	1400	
20	Faecal Coliform (cfu/100 ml)	100	≤1000, WHO guideline 1989
21	Helminth eggs (nos/kg)	0	WHO guideline, 1998

(*compost standards, ministry of Agriculture, Bangladesh)

From Table 4.10 it is seen that, color, odor and moisture that was observed is satisfactory which depend on the local climate, constituents of the OSW, local human nature, etc. prototype compost was dark gray in color, absence of foul odor, and dry in combination. Other physiochemical characteristics like pH was observed 8.3 which at the end of maturation level. The pH remained above 8.0 through the composting which shows the alkaline character of the material. There also a high level of Electrical Conductivity (EC) was observed after the end of composting period recorded as 8.09 mS/cm. It needs to be considered that a high conductivity could be due to dissolution of sodium chloride which is not beneficial to plants. This is especially important for application of the compost in agriculture since high soil salinity may inhibit plant germination and growth (Cofie et al, 2009).

Total Volatile Solids (TDS) and Fixed Solids (FS) are respectively 25.24% and 74.76% and Total Solids (TS) found as 707797 mg/ kg. Total Organic Carbon (TOC) found as 14.64 % which is within the standard value (10-25%). Total Organic Nitrogen (TON), Nitrate Nitrogen and Total Kjeldhal Nitrogen were found respectively as 2.00 % which is within the limit of 0.5-4.00%, 0.4 mg/kg and 140 mg/kg. The C/N ratio was used by many authors as one of the indicators of compost maturity. However, it cannot be used as an absolute indicator of compost maturity due to its large variation that is dependent on the starting materials. Nevertheless, (Wong et al. 2001) it was found that, a value around or below 20 is satisfactory (Wong et al, 2001). Bangladesh Ministry of Agriculture set a value of standards for compost where the C/N ratio would be maximum 20:1 and it was found of our compost as 7.3:1. So the C/N ratio after maturation level satisfied the above suggested limits and is suitable for addition to soil.

With the implementation of resource recovery, it is important to evaluate constituents that may impact both humans and the environment. These include the presence of pathogens and heavy metals. The World Health Organization (WHO) guidelines for safe agricultural practice published in 1998 specified one or less helminth egg/g total solids (TS) for unrestricted irrigation (WHO, 1998). The first barrier of using compost is the reduction of pathogen which is clearly seen in the Table. Faecal Coliform (F.C), and Helminth eggs are within standard limits as per WHO guideline. The results of bacteriological analysis in compost found that, the most probable cfu of total coliform and faecal coliform were found respectively 1400 and 100 per 100 mL of sample. On the other hand, no of Helminth eggs was nil by observing through the microscope at 10x and 40x zoom level. So pathogen transmission from compost to soil is reduced here which is achieved during the composting process through high temperatures, and/or length of time.

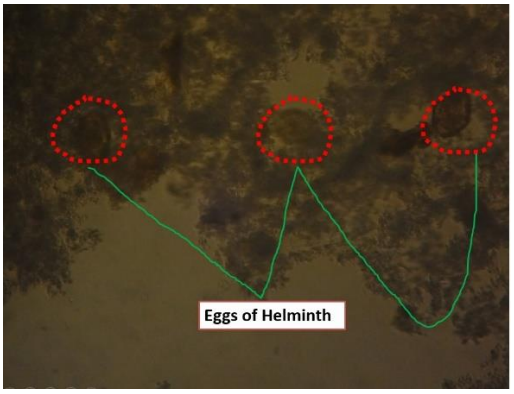


Figure 4.13: Helminth Eggs in a sample

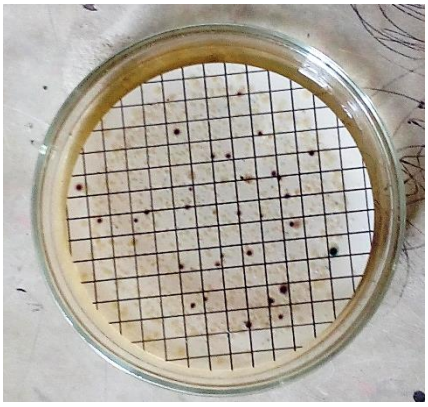


Figure 4.14: Total Coliform and Faecal Coliform test result in compost

Figure 4.13 is a sample of helminth eggs where red circle indicates the egg of bacteria. This type of egg was not found in compost during experiment. Figure 4.14 represents result of T.C and F.C conducted in the KUET Environmental Engg. Laboratory.

Heavy metals are a concern due to their toxicity and long-term negative effects on soils. As organic solid waste is often stored and collected together with other waste fractions, contamination of the organic fraction is easily possible by chemical constituents, heavy metals in particular (Strauss et al, 2003). Heavy metals effect in humans due to toxicity if contaminated production of crops are being taken by human body. That's why, the compost was experimented to ensure the presence of heavy metals. After getting results from SRDI, it is seen that, presence of heavy metals are within tolerable limit. Lead is 27 ppm and Nickel is 7 ppm in range of standard limit of 30 ppm. Other chemical constituents like Phosphorus, Potassium, Sulphur are also within standard limit which are rich sources of nutrient content in compost. Proper percentage of nutrient content enrich the quality of compost. It is important to determine the appropriate rate for the land application of treated sludge to maximize benefits, and to prevent environmental contamination from excessive application of nutrients. The following Figure is the finished product after 40 days co-composting period. At the end it can be said that, use of FS as a soil conditioner or compost whatever is being said, the experimented compost can be a rich commercial product for household level use in horticulture.

Figure 4.15: Finished product (compost, left: after screening and sorting, right: before screening and sorting)

N.B: Hand gloves should be used for shuffling the compost, these pictures are considered only for experiment purpose

Finally, the co-composting of faecal sludge and municipal organic waste could provide an opportunity to increase soil fertility while ensuring a clean environment.

4.8.1 Temperature curve throughout the co-composting process

For achieving a safe attractive product, monitoring of temperature is prime need. Rates of biological degradation are also temperature dependent, and rates increase with warmer temperatures. The co-composting process is a controlled process by which biological decomposition of organic matter occurs by the same organisms that naturally degrade organic matter in the soil. The resulting end product is a dark, rich, humus-like matter that can be used as a soil amendment. That's why, during co-composting period, regular temperature was monitored and recorded. After a 40 days temperature recording, a simple temperature vs. days curve was drawn for better understanding. The following Figure 4.15 is the curve of temperature vs. days of the co-composting period.

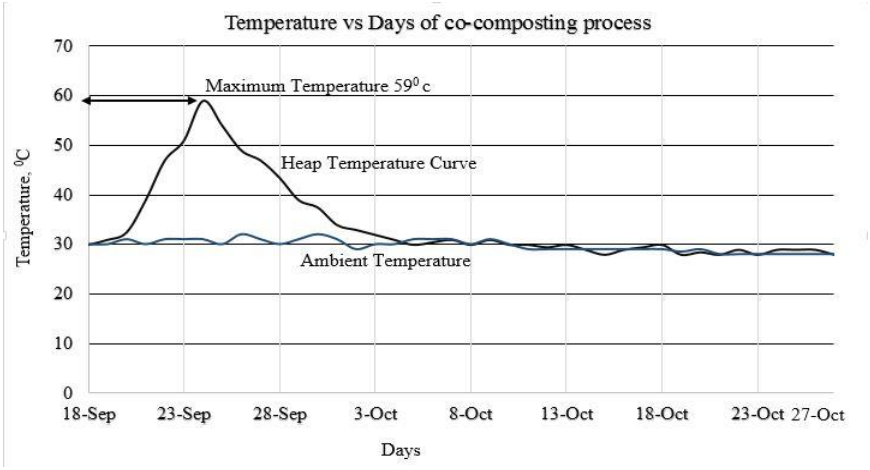


Figure 4.16: Temperature curve of compost within the composting heap

First monitoring of temperature to last monitoring temperature was recorded which is shown in the following Table 4.11.

Table 4.11: Co-composting dates with heap temperature and ambient temperature

Days	Heap Temperature (^{0}C)	Ambient Temperature (^{0}C)	Days	Heap Temperature (^{0}C)	Ambient Temperature (^{0}C)
18-Sep	30	30	8-Oct	30	30
19-Sep	31	30	9-Oct	31	31
20-Sep	32.5	31	10-Oct	30	30
21-Sep	39	30	11-Oct	30	29
22-Sep	47	31	12-Oct	29.5	29
23-Sep	51	31	13-Oct	30	29
24-Sep	59	31	14-Oct	29	29
25-Sep	54	30	15-Oct	28	29
26-Sep	49	32	16-Oct	29	29
27-Sep	47	31	17-Oct	29.5	29
28-Sep	43.5	30	18-Oct	30	29
29-Sep	39	31	19-Oct	28	28.5
30-Sep	37.5	32	20-Oct	28.5	29
1-Oct	34	31	21-Oct	28	28
2-Oct	33	29	22-Oct	29	28
3-Oct	32	30	23-Oct	28	28
4-Oct	31	30	24-Oct	29	28
5-Oct	30	31	25-Oct	29	28
6-Oct	30.5	31	26-Oct	29	28
7-Oct	31	31	27-Oct	28	28

From Table 4.11 it can be seen that, the maximum temperature was recorded in 24 September, 2016 that was 59 ^{0}C and ambient temperature fluctuated between 28 ^{0}C to 32 ^{0}C. So it can be said that, due to proper co-composting, temperature has raised to above 45 ^{0}C and pathogen has been died off at this temperature. On the other hand, temperature was recorded minimum after 19 October due to rain in that time and bad weather. This weather condition had an influence in compost moisture content but not in nutrient content.

Small scale co-composting process and monitoring is very difficult because of proper microbial activity on the compost. Here, a sample experiment was done to justify the temperature variation of the readymade compost. Although weather and rain effect was against the co-composting process but due to proper turning frequency, proper mixing of FS and OSW, proper monitoring a better knowledge about co-composting and microbial activity has achieved.

4.8.2 Comparison of the tests results with the Kushtia FSTP compost

As Waste Concern was the technical support provider of the co-composting project in Kushtia Municipality, so laboratory test of compost parameters were conducted by in the Soil Resource Development Institute (SRDI), Dhaka in 2013. The test result was very positive and it fulfills the entire technical requirement. However, the test report we get from SRDI, Dhaka is given below in Figure 4.16.

ল্যাব নং/ নমুনা নং	সারের নাম	পরীক্ষায় প্রাপ্ত ফলাফল	সরকারী বিনির্দেশ	মন্তব্য
৩৯- ৮২৯৫	জৈব সার	1.Colour= Dark Grey 2.Physical conditions= Non-granular form 3.Odour= Absence of foul odour 4.Moisture= 16.5 % 5.pH= 7.8 6.Organic Carbon= 12.4 % 7.Total Nitrogen (N)= 1.26% 8.C:N= 9.8:1 9.Phosphorus (P)= 0.78% 10.Potassium (K)= 0.96% 11.Sulphur (S)= 0.27% 12.Zinc (Zn)= 0.03% 13.Copper (Cu) =0.005% 14.Chromium (Cr)= 9.70 ppm 15.Cadmium (Cd) = 0.19ppm 16.Lead (Pb) = 7.84 ppm 17. Nickel (Ni) = 11.71 ppm 18. Inert material <1%	1. Colour= Dark grey to black 2. Physical conditions= Non-granular form 3. Odour= Absence of foul odour 4. Moisture=15-20% 5. pH 6.0-8.5 6. Organic Carbon= 10-25% 7. Total Nitrogen (N)= 0.5-4.0% 8. C:N= maximum 20:1 9. Phosphorus (P)= 0.5-3.0% 10. Potassium (K)= 0.5-3.0% 11. Sulphur (S)= 0.1-0.5% 12. Zinc (Zn) maximum = 0.1% 13. Copper (Cu) maximum =0.05% 14. Chromium (Cr) maximum = 50 ppm 15. Cadmium (Cd) maximum =5 ppm 16. Lead (Pb) maximum = 30 ppm 17. Nickel (Ni) maximum = 30 ppm 18. Inert material maximum 1%	-

Figure 4.17: SRDI Test result of compost, 2013 (Picture Source: Ali & Ahmed, 2015)

Later, an action research on to generate evidence for reusing treated faecal sludge as an agricultural input Bangladesh Agricultural Research Council (BARI) started where compost was experimented by BARI. Test result in 2015 by BARI has shown in the following Table 4.12.

Table 4.12: Test result of the compost by BARI, Jessore, 2015 (Source: Mondal, 2017)

Sl No	Parameters	Units	Methods of Analysis	Test Result
1	pH	-	SM 4500-h* B	7.81
2	Biological Oxygen Demand (BOD_5)	mg/gm	SM 5210 B	7
3	Chemical Oxygen Demand (COD)	mg/gm	SM 5220 C	512
4	Total Solids (TS)	mg/gm	SM 2540 B	809
5	Total Volatile Solids (TVS)	mg/gm	SM 2540 E	719
6	Total Coliform (TC)	N/gm	SM 9222 B	2400
7	Escherichia Coliform (E.coli)	N/gm	SM 9222 D	Nill
8	Iron (Fe)	mg/gm	SM 3500FE B	0.3
9	Nitrate (NO_3)	mg/gm	SM 4500-NO_3- E	0.4
10	Phosphate (PO_4)	mg/gm	SM 4500-P E	1.9
11	Electrical conductivity	µS/cm	SM 2510 B	1393
12	Temperature	^{0}C	SM 2550 B	22
13	Total Alkalinity ($CaCO_3$)	mg/gm	SM 2320 B	8.4
14	Helminthes Eggs	N/gm	$ZnSO_4$ Method	Nil

Moreover results of nutrient and heavy metal status have also been tested by BARI which is shown in the following Figure 4.17.

Nutrient status analysis of co-compost

Com.	pH	N %	OC%	P%	K%	S%	B%	Cu %
Source: BARI Soil Science lab, 14 April, 2015								
Status	6.80	2.26	6.70	1.80	1.36	0.84	0.20	0.012

Heavy metal analysis of Co-compost

Sl. No.	Ni (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)
P. Status	16.17	13.15	0.96	29.71
Critical Level	30	30	5	50

Figure 4.18: Nutrient and Heavy metal test result of compost, 2015 (Image Source: Mondal, 2017)

After that, as per research objective the compost from Kushtia FSTP was needed to be laboratory tested for better understanding, to ensure proper dewatering of drying bed. That's why sample was collected and experimented. The Details laboratory test result has been shown in the following Table 4.13

Table 4.13: Laboratory test result of the compost from Kushtia FSTP, 2017

Serial no	Characteristics	Result	Standard Range*
1	Colour	Black	Dark gray to black
2	Odour	Absence of foul odour	Absence of foul odour
3	pH	7.4	6.0 –8.5
4	Moisture (%)	20	Maximum 20 %
5	Total Volatile Solids (%)	24.11	
6	Fixed Solids (%)	75.89	
7	Total Solids (mg/L)	652280	
8	Total Organic Carbon (%)	13.99	10-25 %
9	Total Organic Nitrogen (%)	2.00	0.5 – 4.0 %
10	C: N	7.0:1	20:1 (maximum)
11	Nitrate nitrogen (mg/L)	0.14	
12	Electrical Conductivity (mS/cm)	0.169	
13	Total Kjeldahl Nitrogen (mg/ kg)	170	
14	Phosphorus (%)	1.3	0.5-1.5
15	Potassium (%)	1.6	1.0-3.0
16	Lead (ppm)	10.5	Maximum 30 ppm
17	Nickel (ppm)	7.7	Maximum 30 ppm
18	Sulphur (%)	<0.1	0.1-0.5
19	Chromium (ppm)	13.6	Maximum 50 ppm
20	Total Coliform (nos/100 ml)	1200	

21	Faecal Coliform (nos/100 ml)	100	≤1000, WHO guideline 1989
22	Helminth eggs (nos/L)	0	WHO guideline, 1998

*Compost Standards, Ministry of Agriculture, Bangladesh

From Figure 4.17, Table 4.12, Figure 4.18 and Table 4.13 it is clear that, laboratory experiment of the compost are within standard limits in all case. Compost has been experimented from 2013 to 2017 which has shown excellent result. Moisture is below 20 % in all time and pH is within satisfied limit of 6.0-8.5 recommended by compost standard guideline. C: N ratio is also within satisfactory level such as 9.8:1 in 2013 by SRDI, Dhaka and 7.0:1 in 2017 by KUET Environmental Engg. Laboratory. It is recommended that, maximum 20:1 is the C: N ratio where test results are within this level. If these results are compared with Table 4.7 it is clear that, the readymade compost is similar to the 2013, 2015 and 2017 results.

Figure 4.19: Compost of Kushtia FSTP

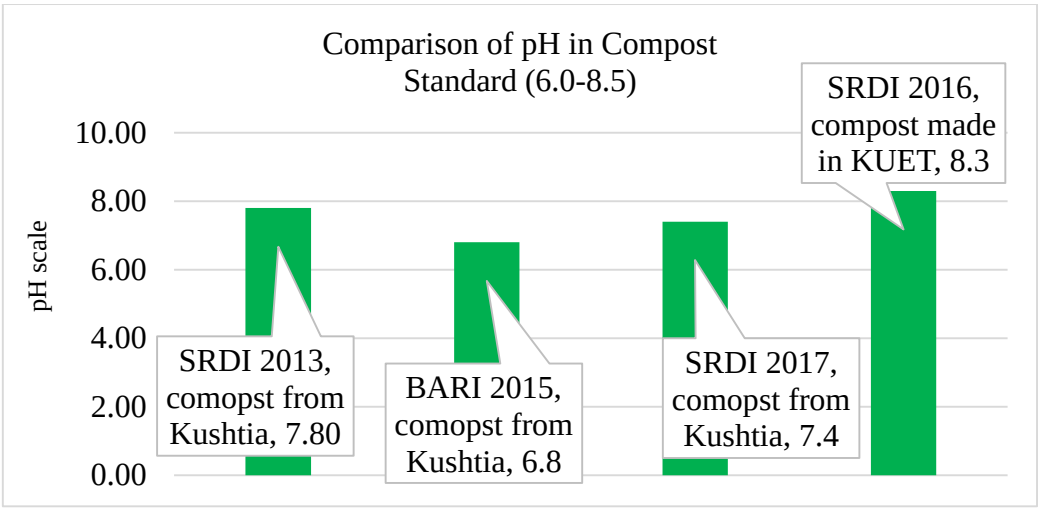


Figure 4.20: Comparison of pH range in compost

From Figure 4.20 it is revealed that, in all cases pH is within control level. A pH outside the range of 6 to 9 indicates an upset in the biological process that will inhibit anaerobic digestion and methane production. This could result from a change in the hydraulic loadings, the presence of toxic substances, a large increase in organic loading, or that the systems are receiving industrial or commercial wastewater.

If common parameters are analyzed it is also seen that, phosphorus is 0.78 % in 2013 result by SRDI, 1.8 % in 2015 result by BARI, 1.3 % in 2017 by SRDI and 0.5 % found in 2016. Figure 4.21 has given for at a glance of the phosphorus content comparison. Again in case of Potassium, results are also within limit (1.0-3.0 %). From 2013 to 2017 all results are shown in Figure 4.22.

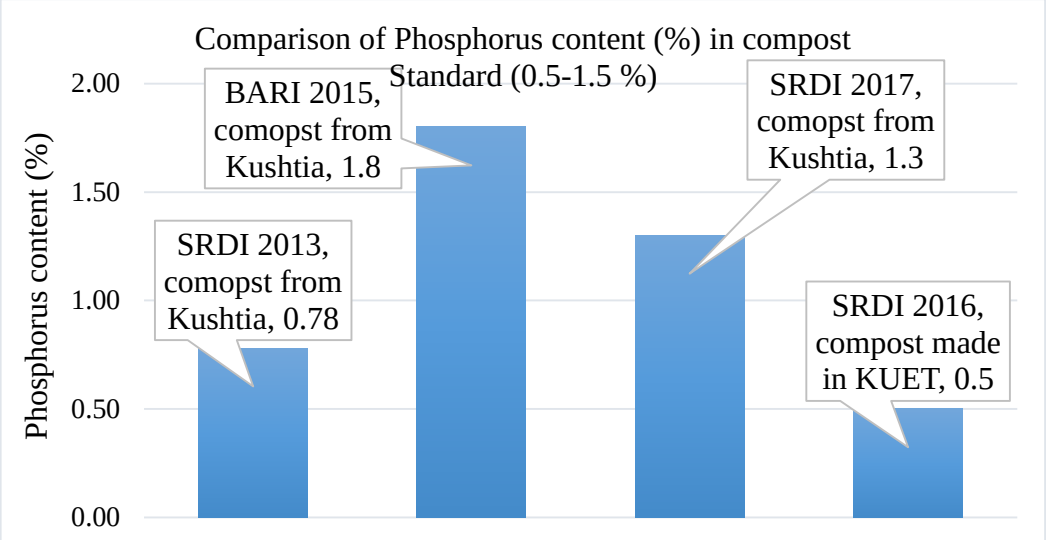


Figure 4.21: Comparison of phosphorus content in compost

In 2015 and 2017 result phosphorus content is same percentage whereas in the compost made in KUET is minimum level. During degradation of organic material, bound phosphates are mineralized and released. Percentage of phosphorus is dependent on the drying bed condition. Since the drying bed of the KUET Waste Management Plant (WMP) was fresh and the sand condition was new, dry, and no plant was seen is the another cause of loss of phosphorus.

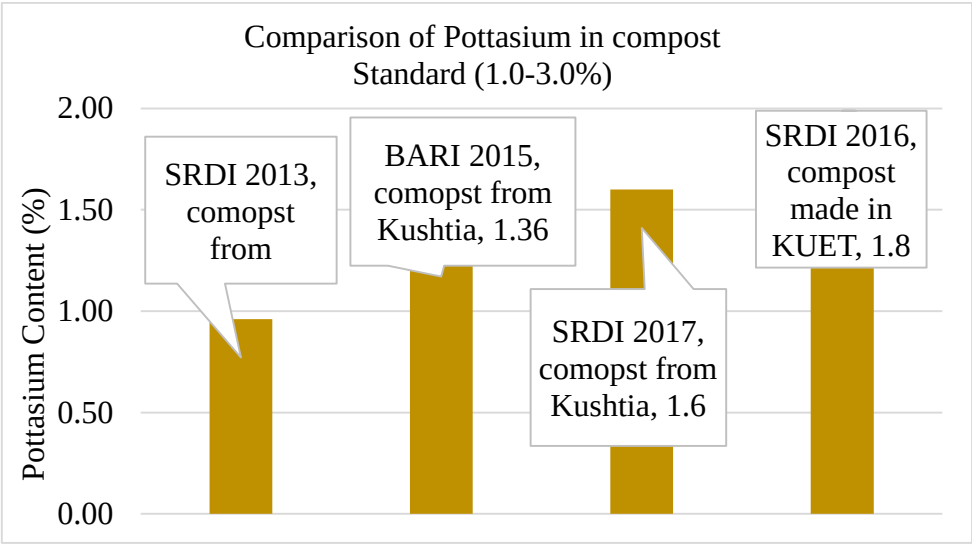


Figure 4.22: Comparison of Potassium content in compost

Since urine contains most of the nutrient content, so a major portion of potassium is lost during dewatering process. That's why percentage of potassium is lower in compost made in KUET. Of the total nitrogen, phosphorus and potassium that is consumed, 10-20% of

nitrogen, 20-50% of phosphorus, and 10-20% potassium is excreted in the faeces, and 80-90% of nitrogen, 50-65 % of phosphorus, and 50-80 % of potassium in the urine (Strande, L., Ronteltap, M. and Brdjanovic, D., 2014).

Total Organic Carbon (TOC) in was found 12.4 % in 2013 by SRDI, 6.7 % in 2015 by BARI, 13.99 % in 2017 and 14.64 % in hand-made compost at KUET. All the values are within satisfactory level (10-25 %) except BARI's result. Organic Carbon (OC) and Total Organic Carbon (TOC) are not similar metrics. OC is heterotrophic, whereas, TOC is autotrophic as well as heterotrophic.

In case of microbial parameters like Total Coliform (T.C), Faecal Coliform (F.C) and Helminth eggs, compost is safe and useable in agricultural sector. In all laboratory tests, compost microbial parameters are within standard level. According to WHO guidelines, F.C should be less than 1000 in cfu per 100 mL. It has seen that, Compost exhibit only 100 nos of F.C per 100 mL of dry sample. So it can be said that, both Kushtia FSTP compost and the compost made in KUET are quite similar in microbial demand.

Heavy metal concentration is another important parameter in compost. From 2013 to 2017 result of compost is clear that, none of specific parameter has crossed its limits. Also compost made in KUET by researcher is also free of toxic elements like nickel, lead, chromium etc. In general, FS does not contain much concentration of heavy metals. So the compost using in farming area, there is no need any headache in heavy metals case. Other parameters like Total Solids (TS), Nitrate nitrogen, Fixed Solids (FS) are not so such difference that may spoil the compost quality. Concentration of TS is typically high in compost as the organic matter, total solids, ammonium, and helminth egg concentrations in FS are typically higher by a factor of ten or a hundred compared to wastewater sludge (Montanegro & Strauss, 2002).

Faecal Sludge was collected to make compost in KUET and comparing it with the Kushtia FSTP made compost. After element comparison and analysis, it can be concluded that, both compost hold and exhibit sound quality which are rich in nutrient content, quality enhancement source of soil, free from pathogens and toxic substances.

4.9 Results of Key Informants Interview (KII)

4.9.1 Interview Details

This report presents a summary of ten KIIs' which mainly focused on the following topics:

1. KII for assessing the condition and practice of the organic compost in Kushtia FSTP.
2. Problems behind the practice of organic compost in agricultural land, its necessary steps for using in farming area and suggestions.

Against this issues, key personals interview some judgments have described in Annex-12.

4.9.2 KII Analysis

From 10 informants, different opinions about the FSM in Kushtia Municipality, treatment condition, and compost using circumstances have been gathered. From their dialogues, It can be said that,

1. The condition of the organic compost is result on basis of laboratory test and preliminary field trial. Practice within farmers is in scattered level and amount is

minor. From the following Table it is cleared that, Laboratory test, field trial and license from government is very necessary.

2. Campaign, awareness, marketing are main problems behind the practice of organic compost in agricultural land.

Table 4.14: Summary of the KII interviews

Serial No	Issues	Nos of person raised the issue
1	Laboratory test, field trial of compost and license from government	4
2	Campaign, awareness, marketing of compost	5
3	Treatment plant and drying beds necessity in FSM operation	2
4	Use of compost in aquaculture and removal of organic loading system during treatment	1

From Table 4.14 it can be explained that, lab test, field trial and license are as important as campaign, awareness and marketing. Although 5 persons have raised or talked about the issue but on basis of importance laboratory test, field trial and license from government is most important. 100 % informant have talked about it, whereas 83 % informant have talked about campaign, awareness and marketing. Figure 4.15 is given below where percentage of important about each issue can be identified.

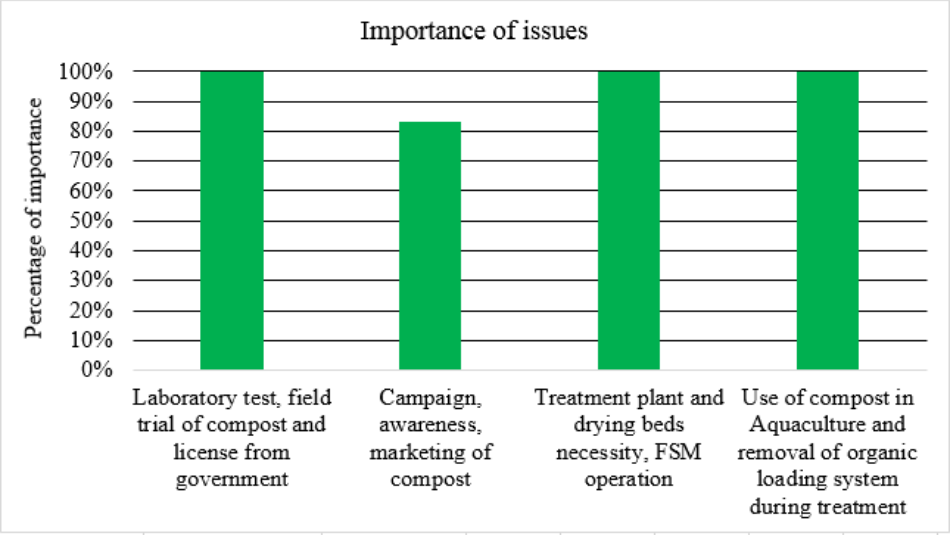


Figure 4.23: Importance percentage of the issues according to KII

(Importance percentage have been considered through raising the individual issue by respected persons in that sector. Importance percentage= people raised the issue/ total person at that sector * 100)

From Figure 4.23, it is seen that, all issues have importance because every informant raised at least one issue according to their FSM knowledge, information. So for better improvement of the compost in the users' level, certificate from ministry and marketing is supreme necessary.

CHAPTER V

Conclusions

5.1 General

This chapter presents overall summary or condensed decisions of the entire thesis work. The study had three major objectives which have been mentioned in Chapter 1. The research aimed on the total FS generation in the municipality, treatment efficiency of the existing FSTP with recommendations for future development and finally assessment of the quality of the compost in case of using agricultural field with recommendations for its quality improvement. Conclusions regarding each objectives are explained in section 5.2 and recommendations for future study are discussed in section 5.3.

5.2 Conclusions

1. Concerning the first objective, total FS generation in Kushtia Municipality is 140,798 m^3/yr. (actual field survey) but 147,457 m^3/yr. (theoretical) by accepting some assumptions. According to Table 4.3 total generation is 498,926 m^3/yr. where septic tank volume has been considered, again considering the standard generation rate of FS it is estimated as 34,232 m^3/yr.
2. All the estimated values are not similar to each other due to different estimation method. Every calculation is based on some assumptions and specific method. So, mainly total FS generation in Kushtia Municipality for treatment and co-composting is a variable figure depending assumptions, regions, factors etc.
3. Treatment efficiency of the existing treatment plant is good and still providing its service. From laboratory experiment it is also seen that, the treated effluent is within the standard limit with satisfactory level for releasing in natural body.
4. pH is within limit disposal range (6.0-8.5), organic loading concentration that is BOD is finally 32 mg/l and COD is 128 mg/l. Nitrate, Phosphate and temperature are at satisfactory limit but need regular monitoring. Results is based on a particular time, but it should be checked for a year round to assess accurate treatment efficiency.
5. After laboratory tests of percolate, it is found that, percentage removal efficiency in the two drying beds possesses good performance. COD, BOD_5, TS, TSS, T.C, F.C, Alkalinity and Phosphate removal from drying beds in percentage is 98.15, 80.96, 97.35, 98.52, 95.07, 98.09, 87.76 and 99.06 respectively. Particular care must be given to sand quality. Sand particles should have a diameter of 0.2-0.6 mm and should not crumble. Crumbling of the sand particles would lead to a rapid clogging of the filter, making sludge dewatering ineffective.
6. Coco pit filter is not regularly operated by municipality itself. Only when the percolate or septic tank in between the drying beds and filter is filled then it is occasionally run by officials. So maintenance and operation is an essential part of any FSM operation which Kushtia Municipality needs to draw more attention.
7. In this research, the compost of Kushtia Municipality is safe and useable in farming area considering the regulations. Research pointed out that heat treatment of 55°- 60° C for several hours will assure a total pathogen inactivation. Physiochemical, microbial and heavy

metals parameters are within standard limits as per ministry of agriculture, Bangladesh and WHO guideline.

8. Comparing test results different times whether performed in SRDI, BARI it is revealed that, compost is still providing good quality with laboratory analysis. Moreover readymade compost in KUET Waste Treatment Plant is as good as Kushtia compost. Ensuring the standard of other parameters, the compost is hygienic and conveys good characteristics with a resource recovery options which reduced volume of mass of solid waste to landfill, good environmental control etc.

9. Kushtia FSTP need ministry permission for running its full business, besides need campaigning, marketing for more public attention. Compost business would be sustainable when more FS will be treated, regularly organic solid waste will be collected and when the finished product will be sold out for using in agricultural land.

5.3 Recommendations for Future Study

1. Germination index can be tested during the different stage of co-composting process.
2. Producing guidance documents on co-composting and marketing for decision makers, planners and engineers is very essential.
3. Setting up collaboration with other institutions wishing to build capacity in R+D of co-composting may be a good options in future.
4. Monetizing the benefits of using co-compost (compost) and conducting financial and economic investigations to justify the subsidizing of co-compost production.
5. In future, it would be a huge achievement for the country with different performers comprising DPHE, many NGOs, research organizations and universities jointly work on possibilities for resource recovery include combustion as fuel, protein production, biogas production, use in building materials, and use in aquaculture.

References

1. DoE, 1997, "Environmental Conservation Rules. Dhaka, Bangladesh". Department of Environment (DoE), Government of Bangladesh.
2. Ahmed, M., 2000, "Small Bore Sewerage System: Applicability in Bangladesh. In Water Supply & Sanitation for Rural & Low income urban communities". Dhaka: ITN-Bangladesh. pp. 175-176.
3. Ahsan, A., 2005, "Generation, Composition and Characteristics of Municipal Solid Waste in Some Major Cities of Bangladesh. Khulna, Bangladesh". Master's thesis, Department of Civil Engineering, Khulna University of Engineering and Technology (KUET).
4. Alamgir, M., 2009, "Municipal Solid Waste and its Management in Least Developed Asian Countries. 12. Comilla, Bangladesh". KeyNote Paper, Technical Seminar, IEB, Comilla Center.
5. Alamgir, M., and Ahsan, A., 2007a, "Municipal Solid Waste and Recovery Potential: Bangladesh Perspective". Iranian J.l of Environment Health, Science & Engg., Vol.4, No.2, pp.67 -76.
6. Ali, A., and Ahmed, R., 2015, "Fecal Sludge Management in Kushtia Municipality: A Co-Compost Fertilizer Approach". Proceedings of the Waste Safe 2015–4th International Conference Solid Waste Management in the Developing Countries Khulna, Elsevier. pp. 148 (1-9).
7. Asia Pacific Division, 2011, "M&E/KM Toolkit-Unpublished materials". Asia Pacific and IFAD, 319-320. Retrieved from http://asia.ifad.org/documents/627927/327cf919-8515-44ed-b40c-e1a32ad7e7e7.
8. Asian Institute of Technology (AIT), 2015, "Feasibility study and design consideration report (Support to the Selection, Design, Construction and Operation of Short-term Treatment Options for Fecal Sludge)". SNVBD.
9. Bangladesh Bureau of Statistics (BBS), 2017, "Bangladesh population and public Index". Department of Bureau of Statistics (BBS), Dhaka, Bangladesh.
10. Bari, Q. H., 1999, "Effect of different modes of aeration on composting of solid waste in a closed system". The University of Hong Kong Libraries, Hong Kong.
11. Byrde, S., 2001, "Co-Composting Plant. Monitoring report". SANDEC, Cau Dien (Hanoi).
12. Clesceri, L., Greenberg, A., and Eaton, A., 1999, "Standards Methods for the Examination of Wastewater 20th Edition". American Public Health Association, American Water Works Association, Water Environment Federation.
13. Cofie, O., 2003, "Co-composting of Faecal Sludge and Solid Waste for Urban and Peri-urban Agriculture in Kumasi, Ghana- Final Report". EAWAG and SANEC, International Water Management Institute.

14. Dasgupta, S., Murali, S., George, N., and Kapur, D., 2016, "Faecal Waste Management in Smaller Cities across South Asia: Getting Right the Policy and Practice". Center for Policy Research, New Delhi: Retrieved July 2017.
15. Diener, S., Semiyaga, S., Niwagaba, C., Muspratt, A., Gning, J., Mbéguéré, M., and Strande, L., 2014, "A value proposition: resource recovery from faecal sludge – can it be the driver for improve sanitation". Resources, Conservation and Recycling, Science Direct, 32-38.
16. Dodane, P., Mbéguéré, M., Ousmane, S., and Strande, L., 2012, "Capital and Operating Costs of Full-Scale Faecal Sludge Management and Wastewater Treatment Systems in Dakar, Senegal". Environmental Science & Technology, 46, p.3705-3711.
17. Eawag and ENPHO., 2014, "Co-composting: Large scale". Sustainable Sanitation and Water Management (SSWM), Switzerland.
18. EAWAG/SANDEC, 2008, "Sandec Training Tool 1.0 – Module 5, Faecal Sludge Management (FSM)". Retrieved, from http://www.sswm.info/sites/default/files/reference_attachments/EAWAG%20and%20S and EC%202008%20Faecal%2. June 1, 2016
19. Enayetullah, I., 2015, "Co-composting of Municipal Solid Waste and Faecal Sludge in Kushtia Bangladesh". ISWA Congress, Antwerp, Belgium.
20. Feachem, R., Bradley, D.J., Garelick, H., and Mara, D., 1983, "Sanitation and Disease. Health aspects of excreta and wastewater management". World Bank studies in water supply and sanitation, John Wiley and Sons, New York.
21. Flint River GREEN, 2011, "Fecal Coliform. Flint River Watershed Coalition". Retrieved from www.FlintRiver.org
22. FSM Survey, 2014, "Draft report on baseline study on fecal sludge management of residential premises, Bangladesh". SNV and Khulna University.
23. FSM Toolbox, 2015, "FSM Situational Assessment Tool: User's Guide". Retrieved from www.fsmtoolbox.com. India, 2017.
24. FSM Toolbox, 2015, "www.fsmtoolbox.com/FSM Situational Assessment Tool: User's Guide". Retrieved from www.fsmtoolbox.com. India, 2017.
25. Gao, X., Shen, T., Zheng, Y., Sun, X., Huang, S., Ren, Q., and Zhang, X., 2002, "Practical manure handbook". Chinese Agricultural Publishing House, Beijing, China.
26. GoB, 2011, "Sector Development Plan (2011-25) of Water Supply and Sanitation". Local Government Division, Government of Bangladesh. Dhaka, Bangladesh.
27. Hafiz, N., & Almagir, M., 2017, "Faecal Sludge Management in Kushtia Municipality and Co-composting with Organic Solid Waste". WasteSafe, 5th International Conference on Solid Waste Management in South Asian Countries, Khulna, Bangladesh.
28. Hafiz, N., Islam, S., & Almagir, M., 2017, "Management of Faecal Sludge through Co-composting approach in Kushtia Municipality". Sardinia symposium, 16th International Waste Management and Landfill Symposium, Padova, Italy.

29. Harir, A., Kasim, R., & Ishiyaku, B., 2015, "Exploring the Resource Recovery Potentials of Municipal Solid Waste: A review of solid wastes composting in Developing Countries". International Journal of Scientific and Research Publications, Volume 5, Issue 4 (2).
30. Heinss, U., Larmie, S., and Strauss, M., 1994, "Sedimentation Tank Sludge Accumulation Study". EAWAG/SANDEC.
31. Heinss, U., Larmie, S., & Strauss, M., 1998, "Solids Separation and Pond Systems for the Treatment of Faecal Sludges in the Tropics. Lessons learnt and recommendations for preliminary design". Swiss Federal Institute for Environmental Science and Technology (EAWAG), Accra/Ghana.
32. http://www.susana.org/en/about/vision-mission, 2017, Retrieved from Susana.org: http://www.susana.org
33. Ingallinella et al., 2002, "The challenge of faecal sludge management in urban areas – strategies, regulations and treatment options". Water Science and Technology, 46(10), p.285-294.
34. Jahan, H., and Al-Muyeed, A., 2015, "Faecal sludge management in Bangladesh. Dhaka". The Daily Observer. Thursday, June 11, 2015.
35. Jönsson, H., Baky, A., Jeppsoon, U., Hellström, D., and Kärrman, E., 2005, "Composition of urine, faeces, greywater and biowaste for utilization in the URWARE model". Urban water Report of the MISTRA Programme, Report 2005:6, Chalmers University of Technology Gothenburg, Sweden. Available at: www.urbanwater.org.
36. Kabir, A., and Salahuddin, M., 2015, "A Baseline Study to Assess Faecal Sludge Management of Residential Premises in Selected Southern Cities of Bangladesh. WASH-Bangladesh. Retrieved from: http://www.snvworld.org/ Bangladesh.
37. Kadafa, A., Latifah, A., Abdullah, H., and Sulaiman, W., 2013, "A Comparative Assessment of the Municipal Solid Waste Management Services". Life Science Journal, 10 (7s).
38. Katukiza et al., 2012, "Sustainable sanitation technology options for urban slums". Biotechnology Advances, 30(5), p.964-978.
39. Kengne, I., Kengne, S., Akoa, A., and Bemmo, N., 2011, "Vertical-flow constructed wetlands as an emerging solution for faecal sludge dewatering in developing countries". Journal of Water, Sanitation and Hygiene for Development, 01(1), 13-19.
40. Kim, S., 1981, "Gemeinsame Kompostierung von Kommunalen Faekalien und Abfaellen in der Republik Korea. (Co-composting of faecal sludges and municipal solid waste in the Republic of South Korea; in German)". PhD thesis, Nr. 51. Gewaesserschutz, Wasser, Abwasser: TH Aachen.
41. Klingel, F., Montangero, A., Koné, D., and Strauss, M., 2002, "Faecal Sludge Management in Developing Countries: a planning manual". EWAGE. Retrieved from http://www.eawag.ch/forschung/sandec/publikationen/ewm/dl/FSM_planning_manual.pdf
42. Koné, D., 2010, "Making urban excreta and wastewater management contribute to cities' economic development: a paradigm shift". pp. 12(4): 602–10.

43. Koné, D. and Peter, S., 2008, "Faecal Sludge Management (FSM): Sandec Training Tool 1.0 – Module 5. Eawag/Sandec (Department of Water and Sanitation in Developing Countries), P.O. 611, 8600. Dübendorf, Switzerland.
44. Koné, D., and Strauss, M., 2004, "Low-cost Options for Treating Faecal Sludges (FS) in Developing Countries – Challenges and Performance". 9th International IWA Specialist group conference on wetlands systems for water pollution control and to the 6th International IWA Specialist Group Conference on Waste Stabilization Ponds. Avignon, France, 27th Sept. - 1st Oct.
45. Koottatep, T., Surinkul, N., Polprasert, C., Kamal, A.S.M., Koné, D., Montangero, A., Heinss, U., and Strauss, M., 2005, "Treatment of septage in constructed wetlands in tropical climate: lessons learnt from seven years of operation". Water Science & Technology, 51(9), p.119-126.
46. Lentner, C., Wink, A., and Lentner, C., 1981, "Units of Measurement, Body Fluids, Composition of the Body, Nutrition". Geigy Scientific Tables. CIBA-GEIGY Ltd. Basle, Switzerland. ISBN 0-914168-50-9.
47. Mara, D., 1978, "Sewage Treatment in Hot Climates". John Wiley & Sons, Chichester.
48. Metcalf and Eddy, 2003, "Wastewater Engineering: treatment, disposal, reuse. Tchobanoglous, G., Burton, F.L. eds., McGraw-Hill Book Company.
49. MGD: Bangladesh Progress Report, 2016, "Millennium Development Goals (MDG): Bangladesh Progress Report". General Economics Division (GED), Bangladesh Planning Commission/ Government of the People's Republic of Bangladesh. Dhaka, Bangladesh.
50. Ministry of Rural Development, 2012, "Rural Housing Knowledge Network: Eco-san toilets for individual households". Government of India, New Delhi. Retrieved from: http://www.ruralhousingnetwork.in/technical/eco-san-toilets-for-individual-households construction.
51. Mondol, S., 2017, "1st draft- review of laws, regulations, policies, strategies and institutional arrangements governing use of faecal sludge as an agricultural input". Prepared for SNV Netherlands Development Organization, Ins Dev Consulting, Dhaka, Bangladesh.
52. Montanegro, A., and Strauss, M., 2002, "In Faecal Sludge Treatment". Swiss Federal Institute for Environmental Science and Technology. (pp. 1-2).
53. Ministry of Agriculture, 2006, "Compost Standards for use in the agricultural purposes". Government of Bangladesh.
54. Nelson, K., Cisneros, B., and Tchobanoglous, G., 2004, "Sludge accumulation, characteristics, and pathogen inactivation in four primary waste stabilization ponds in central Mexico". Water Research vol. 38, no 1, 111–27.
55. NWSC, 2008, "Kampala Sanitation Program (KSP) - Feasibility study for sanitation master in Kampala, Uganda". National Water and Sewerage Corporation.
56. Nzeadibe, T., and Ajaero, C., 2010, "Informal waste recycling and urban governance in Nigeria: Some experiences and policy implications". Handbook of environmental policy.

57. O'Riordan, M., 2009, "Investigation into methods of pit latrine emptying". Partners in development.

58. Obeng, L., and Wright, F., 1987, "The Co-composting of Domestic Solid and Human Wastes". UNDP/World Bank Integrated Resource Recovery Series GLO/80/004, GLO 80/0/007, Report No. 7. World Bank Technical Paper (ISSN0253-7494) No.57.

59. Opel et al., 2012, "Faecal sludge management in Bangladesh: Faecal sludge management in Bangladesh". Asia Regional Sanitaion and Hygiene Practitioners Workshop. Dhaka, Bangladesh.

60. Rahman, M., 2009, "Sanitation Sector Status and Gap Analysis: Bangladesh". Global Sanitation Fund, WSSCC.

61. Raj, R., 2015, "Addressing the challenge of solid waste". International Water Management Institute (IWMI), India.

62. Robbins, D., Strande, L., and Doczi, J., 2012, "Sludge Management in Developing Countries: experiences from the Philippines". Water 21, Issue 4.

63. Saha, S., & Alamgir, M., 2015, "Compare the Performance of Two Different Dewat Plants in Khulna". Proceedings of the Waste Safe 2015, 4th International Conference on Solid Waste Management in the Developing Countries. Khulna, Bangladesh.

64. Schouw, N., Danteravanich, S., Mosbaek, H., and Tjell, J., 2002, "Composition of human excreta – a case study from Southern Thailand". Science of the Total Environment Journal 286(1-3), p.155-166.

65. Shuval, H., Gunnerson, C., and Julius, D., 1981, "Night Soil Composting". The World Bank. Appropriate Technology for Water Supply and Sanitation No. 10.

66. SNV, 2015, "Conducting Rapid Technical Assessments (RTAs) for Fecal Sludge Management Services in Southern Bangladesh". SNV-Bangladesh.

67. Strande, L., Ronteltap, M. and Brdjanovic, D., 2014, "Faecal Sludge Management: Systems Approach for Implementation and Operation". IWA Publishing, London.

68. Strauss et al., 2003, "Co-composting of Faecal Sludge and Municipal Organic Waste". EWAGE and SANDEC, Switzerland.

69. Strauss et al., 1997, "Treatment of Sludges from On-Site Sanitation: Low-Cost Options". Water Science and Technology, 35, 6.

70. Strauss et al., 2002, "Economic Aspect of Low-cost Faecal Sludge Management – Estimation of Collection, Haulage, Treatment and Disposal/Reuse Cost". Eawag/Sandec. Retrieved from www.eawag.ch/organisation/abteilungen/sandec/publikationen/publications_ewm/downloads_ewm/FSM_cost_report.pdf

71. Strauss, M., Heinss, U., and Montangero, A., 2000, "On-Site Sanitation: When the Pits are Full – Planning for Resource Protection in Faecal Sludge Management". In. Proceedings, Int.

Conference, 20-24 Nov. 1998. Bad Elster, IWA Publishing House and WHO Water Series, Germany.

72. Tilley, E., Ulrich, L., Luethi, C., and Reymond, P., 2014, "Compendium of Sanitation Systems and Technologies". 2nd Revised Edition, Sustainable Sanitation and Water Management (SSWM), Duebendorf, Switzerland.
73. UCLA, 2016, "Key Informant Interviews". UCLA Center for Health Policy Research, Health DATA Program – Data, Advocacy and Technical Assistance, California, Los Angeles. Retrieved from healthpolicy.ucla.edu/programs/health-data/trainings/Documents/tw_cba23.pdf.
74. USEPA, 1977, "Treatment and disposal of wastes pumped from septic tanks". Environmental Protection Agency, USA.
75. USEPA, 1994, "Guide to Septage Treatment and Disposal". Washington D.C. 20460.
76. Vinnerås, B., Palmquist, H., Balmér, P., Weglin, J., Jensen, A., and Andersson, Å., 2006, "The characteristics of household wastewater and biodegradable waste - a proposal for new Swedish norms". Urban Water 3, p.3-11.
77. Waste Concern, 2015, Kushtia, Bangladesh- City Overview, Unescap. Retrieved from: http://www.unescap.org/sites/default/files/1.%20Kushtia.pdf.
78. WHO, 1998, "Guidelines for safe agricultural practice: Safe Use of Wastewater, Excreta and Greywater in Agriculture". World Health Organization, Switzerland.
79. Wong et al., 2001, "Co-composting of soybean residues and leaves in Hong Kong". Bioresource Technol, 76, 99–106.
80. Wright, A., 1997, "Toward a Strategic Sanitation Approach: Improving the Sustainability of Urban Sanitation in Developing Countries". UNDP-World Bank Water and Sanitation Program, The World Bank, UNDP, Washington.
81. Yen-Phi et al., 2010, "Pathogens in Septage in Vietnam". Science of the Total Environment, 408 (9), p.2050-2053.

Annex-1

	DATA REQUIREMENTS FOR SITUATIONAL ASSESSMENT TOOL (SAT)		
Sl. NO.	**BACKGROUND INFORMATION - Introduction Sheet**		
1	Name of Organization (Municipality/ pouroshova etc.)	Kushtia Municipality	
2	Country	Bangladesh	
3	State/ Division	Khulna	
4	District	Kushtia	
5	City	Kushtia	
6	Ward/Sector/Suburb	21	
7	Postal code	7000	
8	Respondent's name and email ID and Mobile No.	Noman Al- Hafiz, nomanrumon_007@yahoo.com, KUET, 01729577585	
	Overall information on FSM - General sheet		
A.	**Open ended questions related with Demography/Geography**	**Units**	**Input Data**
1.	Total population in the coverage area	persons	375149
2.	Recognized slum population	persons	30000
3.	Total number of households	persons	83926
4.	Number of slum households	number	8000
5.	Number of non-slum households	number	75926
6.	Average number of persons per household	persons	4.50
7.	Number of municipal wards	number	21
8.	Number of commercial establishments in the coverage area (*Note: Commercial establishments include recognized number of shops, cinemas, theaters, hotels and restaurants)	number	1450
9.	Number of institutional establishments in the coverage area (*Note: Institutional establishment include recognized number of schools, universities, hospitals, government office and private office)	number	Educational- 84, Hospital- 85, G. Offices+ P. Offices- 135, Total= 304
10.	Nature of area	Urban/Peri-urban/Rural	Urban
11.	Total land area	km^2	42.79
12.	Average population growth rate	%	1.69

13.	Estimated annual FS generation rate per capita (*average quantity of faecal sludge that a person generate annually; Thailand : 0.25 m3 /capita/year)	m^3/capita/year	0.09 m^3/capita/year
14.	Average water consumption per month for households	cubic meter/day/household	0.225 cubic meter/day/ household
15.	Coverage of sewerage system in the area	a) Full (100%) b) Partial (30-99%) c) Poor (0-29%)	c) Poor (0-29%)
16.	Percentage of population covered by (centralized) sewerage system in the area	%	3.9
17.	Percentage of population practicing Open Defecation in the area	%	1
18.	Percentage of population covered by On-site Sanitation (OSS) system in the area	%	95.1
B.	**Legal framework and enforcement related questions (Open ended question)**	**Document's Name and Responsible body - Enforcement and Monitoring of FSM**	**Responsible body-FSM**
(a)	At National Level	National Sanitation Strategy, 2014	Public Works Department
(b)	At State Level		
(c)	At City/ Municipality Level	Local Government Act	Local Authority
C.	**Questions on financial aspects of FSM for existing FSM projects and future plans to undertake FSM projects**	Yes/In-process/No	
1	Annual operating expenses for FSM project	local currency/annum	**600000 tk/annum (approximate)**
2	Does the current sanitation fees include charges for FSM?	No	
3	Is there willingness to pay for the improvement of FSM services?	No	

4	Does the city/municipality have financial statements for its FSM operations?	Yes	Solid Waste and sanitation management strategy
5	Does the city/municipality need technical and/or financial assistance in the preparation of FSM project concepts/studies?	Yes	Donar Agencis like SNV
D.	**Questions on FSM advocacy activites, types of materials and methods used.**	Yes/In-process/No	
1	Type of Advocacy Materials used if advocacy activities till date or in process	a)Publications b)Audio c)Video d) Multimedia e) Others, please specify:	a) b) c)
2	Type Advocacy Methods	a) Advertising b) Campaigning c) Events: organizing FSM events d) Media-Press release, press conferences, TV interviews	a) b) c)
3	Advocacy successful or not	a) Yes b) No	a)
E.	**Questions on socio-cultural aspects of FSM regarding presence of socio-cultural barriers, FSM manuals in local language and information on organization involved in improving services.**	Yes/In-process/No	
	Are the FSM manuals and processes introduced in the local language?	Yes	
	Are there any socio-cultural barriers to adoption of FSM in your locality/city/town?	Yes	
	Are there any NGOs, community help groups that will help break FSM taboos?	Yes	FAIR N.G.O
F.	**Questions on monitoring aspects of FSM such as monitoring financial apects of FSM, presence of monitoring strategy/plan, inclusion of FSM in Management Information System (MIS), monitoring of stakeholders.**	Yes/In-process/No	
1.	Interest rate per annum (bank loan)	%	
2.	Repayment period (bank loan)	years	
3.	Grace period (bank loan)	years	
4.	Inflation rate	%	

5.	Cost of equity	%	
6.	Corporate income tax	%	
G.	**CONTAINMENT SHEET**	**Units**	**Input Data**
A.	**Questions which reflect Containment situation in the area (Includes Yes/In-process/No questions on permits requirement, specification for OSS construction, inspection, penalties, availability of subsidy for OSS construction and advocacy materials on septic tanks.**	Yes/In-process/No	
	Other open-ended questions:		
B.	Institutional organization issuing the permits for construction of OSS, if permit is needed	Open ended	Local Government/ Municipality
1	Institutional body who checks compliance during/after construction, if the specifications for construction of OSS is clearly identified in the national building code or similar document	Open ended	
2	Type of toilet used	a)Dry Toilet b)Urine Diverting Dry Toilet (UDDT) c)Urinal d) Pour Flush Toilet e) Cistern Flush Toilet f) Urine Diverting Flush Toilet (UDFT) g)Others, please specify _____	d) Pour Flush Toilet e) Cistern Flush Toilet
3	Percentage of toilets used in the area (based on above answer)	_____ %	d)-90% e)-10%
4	Percentage of Containment area flood prone or not	Flood prone area _____% Non flood prone area _____%	Flood prone area 0%
5	Groundwater table in the containment area	a) High (Pit bottom<1.5 m GWT) b) Low (pit bottom >1.5m GWT)	b) Low
6	Percentage of containment area that has low groundwater table	_____ % area with high GWT	1%

a)	Percentage of containment area that has low groundwater table	_____% area with low GWT	99%
b)	Soil type in the containment area	a)Clayey b) Silty c) Sand d) Gravel e) Rocky f) Others, please specify _____	Clayey but some are loamy to clay loam
7	Percentage of above selected soil types	(a)Clayey _____ % (b) Silty _____ % (c) Sand _____ % d)Gravel _____ % (e) Rocky _____ % f) Other, _____ %	Clay-40% Silt-15% Sand-45%
8	**Household OSS**		
a)	Percentage of HH with Septic tanks	%	50.1
b)	Percentage of HH with Single pit latrine	%	9.7
c)	Percentage of HH with Twin pit latrine	%	34.0
d)	Percentage of HH with more than two pit	%	2.3
e)	Percentage of HH with without any connection i.e. public/community toilet	%	
a)	**Commercial OSS**		
	Percentage of commercial establishments with septic tanks	%	99
a)	**Institutional OSS**		
	Percentage of institutional establishments with septic tanks	%	99
a)	**Average volume of OSS**		
9	**For Household:**		
	a) HH septic tanks b) HH single pit latrine c) HH twin pit latrine d) HH cesspool	_____ m^3 _____ m^3 _____ m^3 _____ m^3	15.33 2.58
	For Commercial establishments:		
	a) Commercial Septic tanks	_____ m^3	20.00
	For Institutional establishments:		
	a) Institutional Septic tanks	_____ m^3	15.00

H.	Emptying Sheet	Units	Input Data
A.	**Questions which reflect Emptying situation in the area (Includes Yes/In-process/No on desludging, permits for emptying, different operating regualtions, penalty for non-complaince, awareness program on desludging and availability of advocacy materials for FSM workers.**	Yes/In-process/No	
B.	**Other open-ended questions:**		
	Frequency of desludging	a)3 years b)4 years c)5 years d)Other, please specify _____	Over three years 94%
1	**Percentage of OSS Desludging**		
2	a) Percentage of household septic tank that can be desludged b) Percentage of household single pit latrines that can be desludged c) Percentage of household twin pit latrines that can be desludged d) Percentage of household cesspool that can be desludged	% % % %	a) 80% b) 90% c) 90%
	e) Percentage of commercial septic tank that can be desludged	%	80%
	f) Percentage of institutional septic tank that can be desludged	%	80%
	% of Accessibility		
3	% of household OSS that are accessible	%	80%
	% of commercial OSS that are accessible	%	100%
	% of institutional OSS that are accessible	%	100%
	Institutional body that provides the emptying services, if any permit or license is required	(a)Private (b)Public (c)Public-Private Partnership (PPP) (d)Others, please specify:	b) public-conservancy office issue bill and permits vacutag operators for emptying
4	The most common method of emptying fecal sludge	a) Manual b)Mechanical c)Both d)Other, please specify:____	b)Mechanical

5	a) Fee for manual emptying **(If manual)** b) Organization who checks the compliance for manual emptying	local currency Open ended	a)Manual-800 taka/ septic tank b) none
6	a) Fee for mechanical emptying **(If mechanical)** b) Percentage of collection efficiency of FSM tariff c) Organization who checks the compliance for mechanical emptying	local currency % Open ended	Rate for Septic Tank: 4000 L: 1200+15% vat, then 500+15% vat 2000 L: 1000+15% vat, then 300+15% vat 1000 L: 500+15% vat, then 200+15% vat b) Conservancy dept, kushtia municipality
	Transportation Sheet	**Units**	**Input Data**
A.	**Questions which reflect Transportation situation in the area (Includes Yes/In-process/No on operation areas/FS disposal areas, permits for disposal, transportation rules and regulations, schedules of trucks, monitoring of trucks, inspection of equipments, penalty for non-complaince, awareness and availability of advocacy materials for FSM workers.**	• **disposal areas** • **permits for disposal** • **transportation rules and regulations** • **schedules of trucks** • **monitoring of trucks** • **inspection of equipments** • **penalty for non-complaince** • **awareness and availability of advocacy materials for FSM workers**	**Yes** **Yes** **Yes** **Yes** **Yes** **No** **Yes**

B.	**Other open-ended questions:**		
	Institutional body which checks the compliance of environmental standards & regulations specific	Open ended	**N/A**
1	Type of transport are used for FSM	a)Manual transport b)Motorised Transport c)both d)others, please specify: _____	b)Motorised Transport
2	Type of motorized transport used	a) Tractor with tankers b) mini lorries mounted with tanks c) Vactung toed with pick-up d) lorries e) speciallised desludging truks f) other____	a) Tractor with tankers b) mini lorries mounted with tanks c) Vactung toed with pick-up
3	Average number of trips/day (*Note: If in 1 week 1 trip is made, then 1/7 trips/day)	Trips/day	3 Trips/day (average)
4	Number of trucks based on truck capacity and their accessibility for FS transportation:-		
5	a) Number of 4 m^3 trucks allocated for FS transportation b) % area of location accessible by this truck size	Number %	1, 60%
	c) Number of 2 m^3 trucks allocated for FS transportation d) % area of location accessible by this truck size	Numbers %	1, 80%
	e) Number of 1.0 m^3 trucks allocated for FS transportation f) % area of location accessible by this truck size	Numbers %	1, 90%
	g) Number of other truck size (if any) allocated for FS transportation h) % area of location accessible by this truck size	Numbers %	500 litres, 1 no, 90%
	FSM tariff charged to the clients	Local currency/m^3	75 taka/ m^3
	Treatment Sheet	**Units (**Yes/In-process/No)	**Input Data**
A.	**Questions which reflect Treatment situation in the area (Includes Yes/In-process/No on existing treatment plant (TP), disposal procedures, geography of treatment area, monitoring of treatment area, permits for treatment, penalty for non-complaince.**	• **existing treatment plant (TP)** • **disposal procedures** • **geography of treatment area** • **monitoring of treatment area** • **permits for treatment**	Yes Yes Yes Yes Yes Yes No

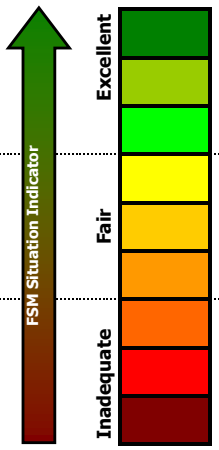
		• **effluent standards** • **Flood prone**	
B.	**Other open-ended questions:**		
1	Groundwater table in the treatment area	a) High (bottom<1.5 m GWT) b) Low (bottom >1.5m GWT)	a) Low
2	Soil type in the treatment area	a) Clayey b)Silty c)Sand d)Gravel e)Rocky f) Other, please specify _____	Clay and Sand
a)	Percentage of that particular soil type in treatment area (based on above answer)	(a)Clayey _____ % (b) Silty _____ % (c) Sand _____ % d)Gravel _____ % (e) Rocky _____ % f) Other _____ %	(a)Clay-50% (c) Sand-40% (b) Silt-10%
	% FS untreated	%	60- 70% according to collection
3	Accessibility of the treatment site	(a)Difficult to reach (b)Moderate (c)Easy to reach	(c)Easy to reach
4	Land availablity for construction of TP	a)Large b)Medium c)Small	c)Small
5	Total land available for construction of treatment plant	Area (hectares)	N/A
6	Cost of land available for treatment	Local currency/area	N/A
7	Organization who issues the permit for treatment of FS, if permit is needed	Open Ended	Municipality
8	Institutional body that does the compliance checking of environmental standards & regulations	Open Ended	Ministry of agriculture and ministry of Environment
10	Institution that does the compliance checking of standards for design and construction of TP	Open Ended	Municipality and NGOs
10	Are there any penalties for non-compliance of environmental standards & regulations?		N/A

11	Existing TP enough to meet the demand of generated FS in the city	a) Yes b) No	b) No
	Reuse Sheet	**Units** (Yes/In-process/No)	**Input Data**
A.	**Questions which reflect Reuse situation in the area (Includes Yes/In-process/No regulations for sludge reuse, on operation areas/FS disposal areas, permits for disposal, transportation rules and regulations, schedules of trucks, monitoring of trucks, inspection of equipments, penalty for non-complaince, awareness and availability of advocacy materials to highlight untreated FS.**	• **regulations for sludge reuse** • **FS for reuse purposes**	Yes Yes
B.	**Other open-ended questions:**		
	Organization that is responsible for checking the compliance of standards for reuse (quality)	Open Ended	Ministry of agriculture
1	Total quantity of treated septage (manure) derived from treatment facility per year (Based on above answer)	m^3/year	730 m^3/year
2	Amount of treated septage reused currently	m^3/year	700 m^3/ year
3	The users of end product	Open Ended	farmers
4	Percentage of raw fecal sludge (FS) directly sold to farmers	%	N/A
5 (a)	Unit price of raw fecal sludge	Local currency/m^3	N/A
(b)	Yield of dried FS from raw FS	% TS/m^3 of FS	70%
6 (a)	Price of dried FS	Local currency/ton	N/A
(b)	Percentage of dried FS sold	%	N/A
c)	Yield of liquid effluents from raw FS	%	100%
7 (a)	Price of liquid fertilizer	Local currency/ton	N/A
(b)	Percentage of liquid fertilizer sold	%	N/A
c)	Biogas yield from the raw FS	m^3 biogas/m^3 of FS	N/A
8(a)	Electricity produced from biogas	kWh/m^3 of biogas	N/A
(b)	Electricity price per KWh	Local currency/kWh	N/A
(c)	Percentage of electricity from biogas sold	%	N/A

SCORECARD

Brief Description: Scorecard is an assessment tool providing a snapshot of the FSM Situation Indicators. It represents the status of FSM along the service delivery pathway and provides a foundation for the comparison of each service option's performance. It enables user to identify the gaps in the FSM service.

The score ranges from 0 (inadequate case) to 1 (excellent case) in response to a set of questions with three color coding i.e. red, yellow and green indicating Inadequate, Fair and Excellent FSM situation, respectively. And each indicator is represented in the form of different shades of same color to have a deeper understanding on FSM situation.

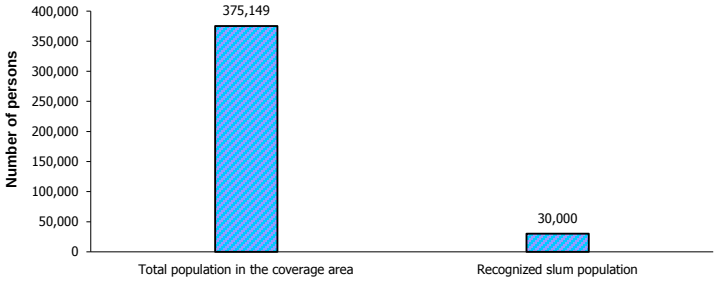


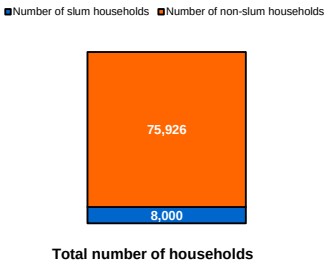
COLOR	RANGE	Indicators of FSM Situation
Excellent	0.90 - 1.00	The score for Excellent Indicator ranges from (0.68 - 1.00). It indicates very low risk situation of FSM and further suggests that the service delivery is largely on place.
	0.79 - 0.89	
	0.68 - 0.78	
Fair	0.56 - 0.67	The score for Fair Indicator ranges from (0.34 - 0.67). It indicates moderate risk situation of FSM and further suggests that there is a need of awareness to increase the service delivery performance level.
	0.45 - 0.55	
	0.34 - 0.44	
Inadequate	0.22 - 0.33	The score for Inadequate Indicator ranges from (0.00 - 0.33). It indicates very high risk situation of FSM and further suggests that there is a need of an immediate attention to reform the service delivery performance level.
	0.11 - 0.21	
	0.00 - 0.10	

FSM Service Chain Report

GENERAL | CONTAINMENT | EMPTYING | TRANSPORTATION | TREATMENT | REUSE/DISPOSAL

DEMOGRAPHY / GEOGRAPHICAL





Av. Number of persons per HH	Nature of the area	Total land area (km^2)	Av. Population Density (persons/km^2)
4.47	Urban	43	8,767.21

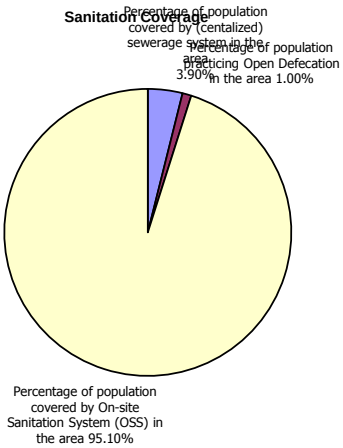
Municipal wards/districts Number	Commercial Establishments Number	Institutional Establishments Number
21	1,450	304

Av. Population Growth Rate (%)
1.69 %

Estimated annual FS generation per capita (m^3)
0.09

Av. Water consumption (cubic meter per day per HH)
0.23

Coverage of sewerage system
Poor (0-29%)



Population with (centralized) sewerage system in the area	Population practicing Open Defecation	Population with OSS in the area
3.9%	1%	95.1%

LEGAL FRAMEWORK and ENFORCEMENT

	Is FSM part of the legislation or legal framework, policies, strategies or development plans?		
	National Level	State Level	City/Municipal Level
Document's Name	Bangaldesh Water Act, 2013	Water Supply and Sewerage Act, 1996: Environment Conservation Act, 1995: Environemt Conservation Rules, 1997	Local Government Act, 2009: Local Government Amendment Act for pouroshovas 2010 anc CCs 2011
Responsible body - Enforcement and Monitoring	National Water Research Council	Department of Environment (DoE)	Kushtia Municipality
Documents pending	N/A	N/A	
Responsible body-FSM	Bangaldesh Water Research Council, Water Supply and Sewerage Authority (WASA), Department of Environment (DoE) and Bangaldesh Natioal Building Code (BNBC)	Department of Environment (DoE)	Kushtia Municipality

FINANCE

Existing FSM services	Annual Operating Expense
Yes	600,000.00

Sanitation fees	Sanitation fees	FSM tariff collection
No		

Willingness to pay
No

FSM projects plan
No

Funding Allocation	Annual Budgetary
No	

Financial Statements	Type of Financial Statement
Yes	All

Need assistance on FSM project
Yes

SOCIO-CULTURAL

FSM manuals and processes introduced in the local language	Socio-cultural barriers to adoption of FSM in locality/city/town	NGOs, community help groups that will help break FSM taboos
Yes	Yes	Yes

ADVOCACY

Advocacy activities till date	Advocacy Successful or not
Yes	Yes

Type Advocacy Methods
Advertising, Campaigning, Events: Organizing FSM events

Type of Advocacy Materials
Publications, Audio, Video, Multimedia

MONITORING

City run a database (online) or management information system (MIS)	City-wide monitoring strategy/plan in place that covers FSM-related issues	FSM included in the MIS	Rating system for government or private operators
No	Yes	In-process	No

Financial aspects (e.g. price of emptying, cost-recovery level, valorisation of FS-products etc.) along the FSM service chain currently monitored on a city-wide level (in practise)	Aspects of the satisfaction of stakeholders (e.g. communities) currently monitored on a city-wide level (in practise)
Yes	No

Multiple stakeholders (e.g. communities) regularly involved in the monitoring process	People aware of monitoring of potential hygiene and health risks on a city-wide level (in practise)
No	Yes

FSM Service Chain Report

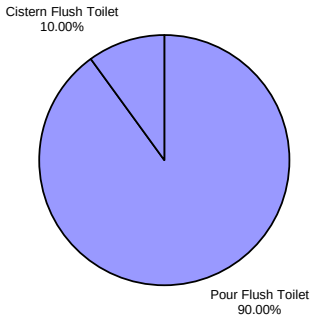
CONTAINMENT

Permits required	Organization issues the permits
Yes	Local Government/ Municipality

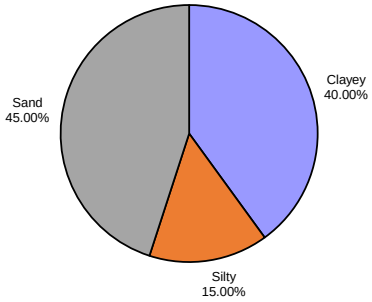
Clear identification for Specifications of OSS construction
Yes

Ground Water Table
Low (pit bottom >1.5m from Groundwater table)

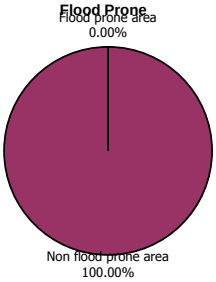
Toilet Type



Soil Type

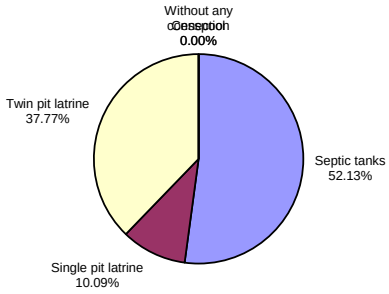


Flood Prone

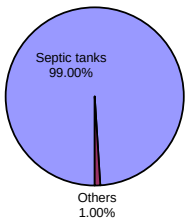


Coverage of On Site Sanitation(OSS)

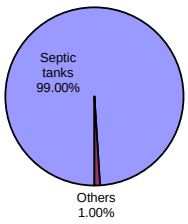
Household



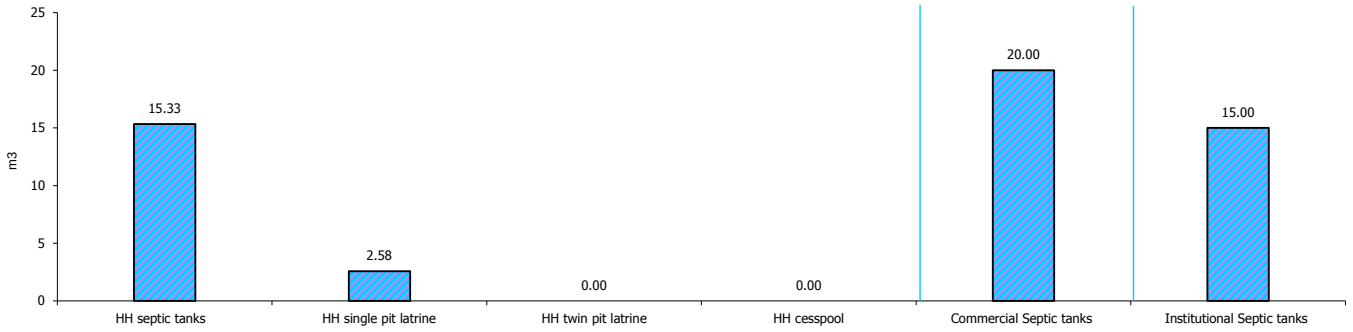
Commercial Establishment



Institutional Establishment



Average volume of OSS



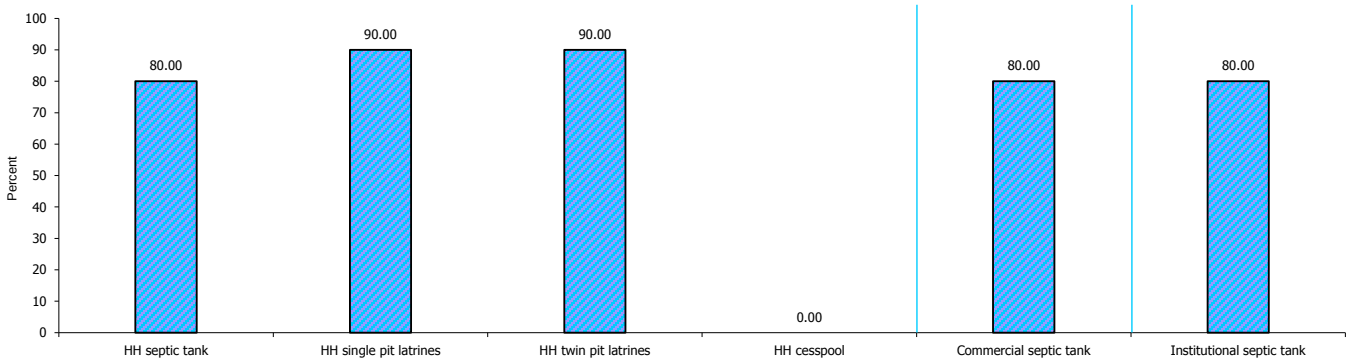
Subsidies for OSS Construction	Aware of proper use and maintenance	Enough Advocacy material
No	In-process	Yes

FSM Service Chain Report

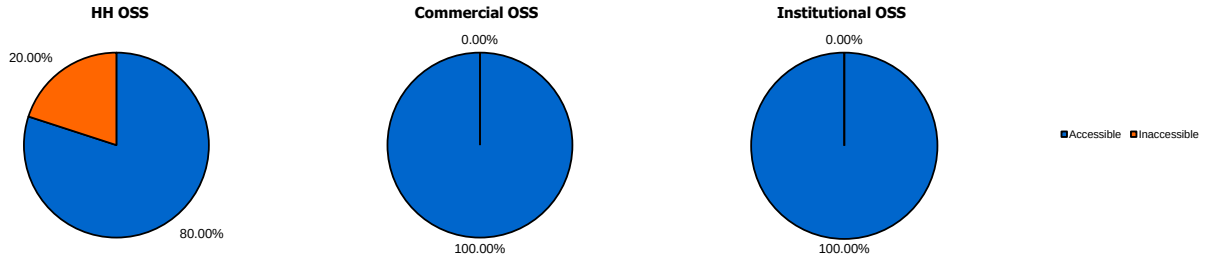
EMPTYING

Mandate in desludging	Awareness on mandatory desluging	Frequency of Desludging
In-process	No	over 3 years 94.00%

Percentage of OSS that can be desludged



Percentage of Accessibility



Permits required for emptying
No

Common Emptying method
Both

Awareness program on desludging process	FSM advocacy material on desludging provided or not	Health awareness program for service providers	FSM advocacy material for FSM workers
Yes	Yes	Yes	Yes

FSM Service Chain Report

TRANSPORTATION

Clear identification of registered area of operation	Clear identification of FS disposal area	Certification/permits for disposal	Clear transportation rules and regulations	schedules and routing of the trucks clearly conducted
Yes	Yes	In-process	Yes	Yes

Inspection and testing of cleaning equipment	Inspection and testing of safety gadgets	Organization checking environmental standards	Penalties for non-compliance
Yes	Yes	None	No

Ensuring right number of trucks	Type of transport used
No	Motorised Transport

Average number of trips per day	Awareness on hazards from poor transportation services	Campaign on illegal handling of FS	Advocacy material for improper practices
3.00	Yes	Yes	Yes

FSM Service Chain Report

TREATMENT

TP existence in city
Yes

Land available for construction of TP in future
In-process

Permits required or not for treatment	Organization issuing permits
In-process	

Organization for compliance checking	
Environmental standards & regulations	Standards for design and construction
Department of Environment (DoE) and Ministry of Agriculture, Bangladesh	Both Kushtia Municipality and Ministry of Agriculture check the standards

Penalties for non-compliance
Yes

FSM Service Chain Report

REUSE

Regulations/standards for sludge re-use	Organization for compliance checking
Yes	Ministry of Agriculture, Government of Bangladesh for use in the agricultural purposes

FS treated for reuse purpose
Yes

Total quantity of treated septage
730.00

Amount of end product reused (m^3/year)	The users of end products
730.00	Farmers

Selling raw fecal sludge to farmers/farmers' organizations	Raw fecal sludge (FS) directly sold (%)	Unit price (Local currency/m3)
	0.00	0.00

Selling dried fecal sludge (biosolids) as soil conditioner/fertilizer	Yield of dried FS from raw FS (% TS/m^3 of FS)	Price of dried FS (Local currency/ton)	Dried FS sold (%)
	100.00	10,000.00	5.00

Selling liquid effluent as liquid fertilizer	Yield of liquid effluents from raw FS (%)	Price of liquid fertilizer	Liquid fertilizer sold (%)
	100.00	0.00	0.00

Selling biogas as electricity source	Biogas yield from the raw FS (m^3 biogas/m^3 of FS)	Electricity produced from biogas (kWh/m^3 of biogas)	Electricity price per KWh (Local currency/kWh)	Percentage of electricity from biogas sold (%)
	0.00	0.00	0.00	0.00

Awareness program on ill effects of untreated FS	Campaign on the ill effects
Yes	Yes

Awareness among consumers for having those agricultural products	Presence of advocacy materials for potential hazards from untreated FS
No	Yes

FSM Situational Assessment Tool

Note: This sheet includes general questions on Demography/Geography, Legal framework and Enforcement,Finance, Advocacy, Socio-cultural and Monitoring.

The general questions serves as a baseline for assessing the FSM situation, so this section needs to be filled up at the beginning of the assessment.

DEMOGRAPHY / GEOGRAPHICAL

1. Total population in the coverage area	375,149	persons
2. Recognized slum population	30,000	persons
3. Total number of households	83,926	households
3.1 Number of slum households	8,000	households
3.2 Number of non-slum households	75,926	households
4. Average number of persons per household	4.47	persons per household
5. Number of municipal wards/districts	21	Number
6. Number of commercial establishments in the coverage area (*Note: Commercial establishments include recognized number of shops, cinemas, theaters, hotels and restaurants)	1,450	establishments
7. Number of institutional establishment in the coverage area (*Note: Institutional establishment include recognized number of schools, universities, hospitals, government office and private office)	304	institutions
8. Nature of the area	☑ Urban ☐ Peri-urban ☐ Rural	
9. Total land area	43	km^2
10. Average population density	8,767.21	person/km^2
11. Average population growth rate	1.69	%
12. Estimated annual FS generation rate per capita (*average quantity of faecal sludge that a person generate annually; Thailand : 0.25 m^3/capita/year)	0.09	cubic meter/capita/year
13. Average water consumption per day per household	0.23	cubic meter/day/household
14. Coverage of sewerage system in the area	○ Full (100%) ○ Partial (30-99%) ◉ Poor (0-29%)	
15. Percentage of population covered by (centalized) sewerage system in the area	3.90	%
16. Percentage of population practicing Open Defecation in the area	1.00	%
17. Percentage of population covered by On-site Sanitation System (OSS) in the area	95.10	%

LEGAL FRAMEWORK and ENFORCEMENT

1. Is FSM part of the legislation or legal framework, policies, strategies or development plans at the national level? ○ Yes ◉ In-process ○ No

   1.1 Name of the document

   Bangaldesh Water Act, 2013

   1.2 Which institutional body is responsible for enforcement and monitoring?

   National Water Research Council

   1.3 Which document is pending to be published?

   N/A

   1.4 Which institutional body is responsible for FSM at the national level?

   Bangaldesh Water Research Council, Water Supply and Sewerage Authority (WASA), Department of Environment (DoE) and Bangaldesh Natioal Building Code (BNBC)

2. Is FSM part of the legislation or legal framework, policies, strategies or development plans at the state level? ○ Yes ◉ In-process ○ No

   2.1 Name of the document

Water Supply and Sewerage Act, 1996: Environment Conservation Act, 1995: Environemt Conservation Rules, 1997

2.2 Which institutional body is responsible for enforcement and monitoring?

Department of Environment (DoE)

2.3 Which document is pending to be published?

N/A

2.4 Which institutional body is responsible for FSM at the state level?

Department of Environment (DoE)

3. Is FSM part of the legislation or legal framework, policies, strategies or development plans at the city/municipality level? ◉ Yes ○ In-process ○ No

3.1 Name of the document

Local Government Act, 2009: Local Government Amendment Act for pouroshovas 2010 anc CCs 2011

3.2 Which body is responsible for enforcement and monitoring?

Kushtia Municipality

3.4 Which institutional body is responsible for FSM at the city/municipality level?

Kushtia Municipality

FINANCE

1. Does the city/municipality provide FSM services? ◉ Yes ○ In-process ○ No

1.1 How much is the annual operating expenses for the FSM services? 600,000.00 Local currency/ annum

2. Does the current sanitation fees include charges for FSM? ○ Yes ○ In-process ◉ No

3. Is there willingness to pay for the improvement of FSM services ? ○ Yes ○ In-process ◉ No

4. Does the city/municipality have financial statements for its FSM operations? ◉ Yes ○ In-process ○ No

4.1 What financial statements does a city/municipality have? ○ Cash flows ○ Income statements ○ Balance sheet ◉ All

5. Does the city/municipality plan to undertake FSM projects? ○ Yes ○ In-process ◉ No

6. Is there funding allocation for proposed FSM projects? ○ Yes ○ In-process ◉ No

7. Does the city/municipality need technical and/or financial assistance in the preparation of FSM project concepts/studies? ◉ Yes ○ In-process ○ No

SOCIO-CULTURAL

1. Are the FSM manuals and processes introduced in the local language? ◉ Yes ○ In-process ○ No

2. Are there any socio-cultural barriers to adoption of FSM in your locality/city/town? ◉ Yes ○ In-process ○ No

3. Are there any NGOs, community help groups that will help improve the prevailing FSM desludging services? ◉ Yes ○ In-process ○ No

ADVOCACY

1. Have there been any FSM advocacy activities conducted? ◉ Yes ○ In-process ○ No

1.1 What types of advocacy materials were used, please select from the list: ☑ Publications ☑ Audio ☑ Video ☑ Multimedia ☐ Others, plese specify:

1.2 What types of advocacy methods were used, please select from the list: ☑ Advertising ☑ Campaigning ☑ Events: Organizing FSM events ☐ Media- Press release, Press conferences, TV interviews

1.3 Are the advocacy activities successful? ◉ Yes ○ In-process ○ No

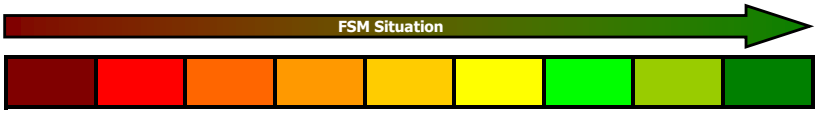
MONITORING

1. Does the city run a database (online) or management information system (MIS)? ○ Yes ○ In-process ◉ No

2. Is there a city-wide monitoring strategy/plan in place that covers FSM-related issues? ◉ Yes ○ In-process ○ No

2.1 Is FSM included in the MIS? ○ Yes ◉ In-process ○ No

3. Is there a rating system for government or private operators? (*Note:Rating system means performance measurement system)	○ Yes	○ In-process	◉ No
4. Are financial aspects (e.g. price of emptying, cost-recovery level, valorisation of FS-products etc.) along the FSM service chain currently monitored on a city-wide level (in practise)?	◉ Yes	○ In-process	○ No
5. Are aspects of the satisfaction of stakeholders (e.g. communities) currently monitored on a city-wide level (in practise)?	○ Yes	○ In-process	◉ No
6. Are multiple stakeholders (e.g. communities) regularly involved in the monitoring process?	○ Yes	○ In-process	◉ No
7. Are people aware of monitoring of potential hygiene and health risks on a city-wide level (in practise)?	◉ Yes	○ In-process	○ No



Fair

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?

   Local Government/ Municipality

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

   2.1 Are the new installations of OSS inspected upon completion - for compliance with building codes, tested for leaks or damages? ○ Yes ◉ No

   2.2 Which institutional body checks for the compliance during/after construction?

   Local Government/ Municipality

   2.3 Are there penalties for non-compliance? ○ Yes ◉ 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	90.00	%
☑ Cistern Flush Toilet	10.00	%
☐ Urine Diverting Flush Toilet (UDFT)		%
☐ Others, please specify		%

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

Flood prone area	0.00	%
Non flood prone area	100.00	%

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? 99.00 % area with low GWT

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

☑ Clayey	40.00	%
☑ Silty	15.00	%
☑ Sand	45.00	%
☐ 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)	50.10	%
b) Single pit latrine (a sinlge pit dug into the ground which is used to contain excreta)	9.70	%
c) Twin pit latrine (double pits dug into the ground which is used to contain excreta)	36.30	%
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 99.00 %

b) Others 1.00 %

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

7.3 % of institutional establishments with :

a) Septic tanks 99.00 %

b) Others 1.00 %

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

8. Average volume of OSS

8.1 For Household:

a) HH septic tanks 15.33 m^3

b) HH single pit latrine 2.58 m^3

c) HH twin pit latrine m^3

d) HH cesspool m^3

8.2 For Commercial establishments:

a) Commercial Septic tanks 20.00 m^3

8.3 For Institutional establishments:

a) Institutional Septic tanks 15.00 m^3

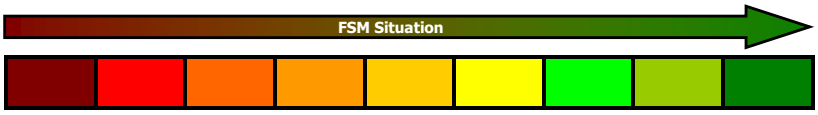
9. Are there subsidies for households to construct proper OSS? ○ Yes ○ In-process ◉ No

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



Excellent

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: over 3 years 94.00%

3. % of Desludging

   3.1 a) % of household septic tank that can be desludged 80.00 %

   b) % of household single pit latrines that can be desludged 90.00 %

   c) % of household twin pit latrines that can be desludged 90.00 %

   d) % of household cesspool that can be desludged %

   3.2 % of commercial septic tank that can be desludged 80.00 %

   3.3 % of institutional septic tank that can be desludged 80.00 %

4. % of Accessibility

   4.1 % of household OSS that are accessible 80.00 %

   4.2 % of commercial OSS that are accessible 100.00 %

   4.3 % of institutional OSS that are accessible 100.00 %

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? Local currency/m^3 for households

   Local currency/m^3 for slums

   6.1.2 Who checks the compliance of these safety standards?

   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? 575.00 Local currency/m^3 for households

   575.00 Local currency/m^3 for slums

   6.2.2 What is the % collection efficiency of FSM tariff? 15.00 %

   6.2.3 Who checks the compliance of these safety standards? Kushtia Muicipality and Conservancy Department

   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 **Excellent**

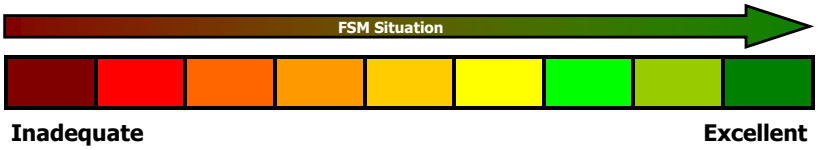
Excellent

FSM Situational Assessment Tool

TRANSPORTATION

1. Are the registered area of operation for each operator clearly identified? ◉ Yes ○ In-process ○ No
2. Are the FS disposal areas clearly identified for the designated operators? ◉ Yes ○ In-process ○ No
3. Are the operators provided with certification/permits for disposal of FS? ○ Yes ◉ In-process ○ No
4. Are the transportation rules and regulations (road rules, time for operation) clearly defined for operators? ◉ Yes ○ In-process ○ No
5. Are the schedules and routing of the trucks clearly conducted to avoid congestion at the treatment site? ◉ Yes ○ In-process ○ No
6. Are the trucks monitored regularly for durability issues? (leakage) ○ Yes ◉ In-process ○ No
   - 6.1 Are the emptying equipment clearly inspected and tested during the registration process and also checked for compliance with standards? ◉ Yes ○ No
   - 6.2 Are the safety gears and equipment clearly inspected and tested during the registration process also checked for compliance with standards? ◉ Yes ○ No
   - 6.3 Which institutional body does the compliance checking of environmental standards & regulations specific for FS transportation?

     None
   - 6.4 Are there penalties and revocation of permits and licenses in case of non-complaince? ○ Yes ◉ No
7. Do the authorities account for the adequate number of trucks needed for collection (based on the collection rates) to ensure the right no. of truck registration? ○ Yes ○ In-process ◉ No
8. What type of transport is used for transporting FS to the nearest TP or dumping site? ○ Manual transport ◉ Motorised Transport ○ Both ○ Other, please specify:
   - 8.1 What type of motorised transport is used in the city? ☐ Tractor with tankers ☐ Mini lorries mounted with tanks ☑ Vactung toed with pick-up ☐ Lorries ☐ Speciallised desludging trucks ☐ Other, please specify:
   - 8.2 How many trucks with capacity 10 m^3 are allocated for FS transporation? 0 Number
     - 8.2.1 What % area of location accessible by truck size? %
   - 8.3 How many trucks with capacity 5 m^3 are allocated for FS transporation? 0 Number
     - 8.3.1 What % area of location accessible by truck size? %
   - 8.4 How many trucks with capacity 2.5 m^3 are allocated for FS transporation? 0 Number
     - 8.4.1 What % area of location accessible by truck size? %
   - 8.5 How many trucks with capacity other than ones mentioned above are allocated for FS transporation? 4 Number
     - 8.5.1 What % area of location accessible by truck size? 80.00 %
9. What is the average number of trips per day? *NOTE: If there are no trips on a daily basis, then convert the trip frequency into per day ratio. For example, In 1 week if 1 trip is made, then 1/7=0.14trips/day) 3.00 trips/day
10. Is there enough awareness about the potential hazards of inappropriate Fecal Sludge transportation services? ◉ Yes ○ In-process ○ No
11. Is there any campaign on illegal dumping, spillage of fecal sludge? ◉ Yes ○ In-process ○ No
12. Is there any advocacy materials on laws, regulations and improper practices of fecal sludge transportation? ◉ Yes ○ In-process ○ No



Excellent

FSM Situational Assessment Tool

TREATMENT

1. Are there any existing TP in the city? ◉ Yes ○ In-process ○ No

   1.1 Are the procedures for disposal at the treatment facilities clearly mentioned in the manuals? ◉ Yes ○ No

   1.2 Are there regulations in place for Treatment Plant(TP) Design standards? ◉ Yes ○ No

   1.3 Are there any effluent standards? ◉ Yes ○ No

   1.4 Is electricity available for the treatment plant in the coverage area? ◉ Yes ○ No

   1.5 Is the treatment area flood prone? ○ Yes ◉ No

   1.6 What is the groundwater table in the treatment area? ○ High (depth <1.5m from Groundwater table)
   ◉ Low (depth >1.5m from Groundwater table)

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

☑ Clayey	50.00	%
☑ Silty	10.00	%
☑ Sand	40.00	%
☐ Gravel		%
☐ Rocky		%
☐ Others, please specify		%

   1.8 Is the existing TP enough to meet the demand of generated FS in the city? ○ Yes ◉ No

   1.8.1 What % FS is untreated? 65.00 %

   1.9 Does treated septage meet the treatment standards? ◉ Yes ○ No

   1.10 How accessible is the treatment site? ○ Difficult to reach ○ Moderate ◉ Easy to reach

   1.11 Does the TP have proper safety standards? ◉ Yes ○ No

   1.11.1 Are the safety standards monitored? ◉ Yes ○ No

   1.12 Are the waste haulers weighed? (*Note: Waste hauler means septage holding tank used for transporting) ○ Yes ◉ No

   1.13 Are the waste haulers paid at the site? ○ Yes ◉ No

   1.14 Does the treatment cost differ for FS that comes from households, commercials, industries or from other means? ○ Yes ◉ No

   1.15 Does the operator recover the cost by fees? ◉ Yes ○ No

2. Is the land available for construction of TP in the city for future? ○ Yes ◉ In-process ○ No

   2.1 What is the land availablity for construction of TP? ○ Large ○ Medium ◉ Small

   2.2 What amount of land is available for construction of TP? ..... Hectares(ha)

   2.3 What is the cost of land available for treatment? ..... Local currency/area

3. Are permits required for treatment? ○ Yes ◉ In-process ○ No

   3.1 Who issues the permit for treatment of FS? .....

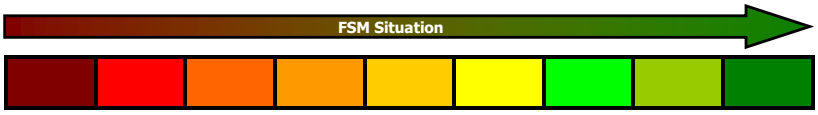
4. Which institutional body does the compliance checking of environmental standards & regulations in specific to treatment?

   Department of Environment (DoE) and Ministry of Agriculture, Bangladesh

5. Which institution does the compliance checking of standards for design and construction of TP?

   Both Kushtia Municipality and Ministry of Agriculture check the standards

6. Are there any penalties for non-compliance? ◉ Yes ○ In-process ○ No



Excellent

FSM Situational Assessment Tool

REUSE

1. Are the regulations in place that outline the requirements / standards for sludge re-use? ◉ Yes ○ In-process ○ No

2. Which organization is responsible for checking the compliance of standards for reuse? (quality)

   Ministry of Agriculture, Government of Bangladesh for use in the agricultural purposes

3. Is FS treated for reuse purpose? ◉ Yes ○ In-process ○ No

   3.1 What is the total quantity of treated septage (manure) derived from the treatment facility per year? 730.00 m^3 / year

   3.2 What amount of treated septage is being reused currently? 730.00 m^3 / year

   3.3 Who uses the end product? Farmers

   3.4 Revenues from FS reuse

   a) Selling raw fecal sludge to farmers/farmers' organizations

Percentage of raw fecal sludge (FS) directly sold to farmers	0.00	%
Unit price of raw fecal sludge	0.00	Local currency/m^3

   b) Selling dried fecal sludge (biosolids) as soil conditioner/fertilizer

Yield of dried FS from raw FS	100.00	% TS/m^3 of FS
Price of dried FS	10,000.00	Local currency/ton
Percentage of dried FS sold	5.00	%

   c) Selling liquid effluent as liquid fertilizer

Yield of liquid effluents from raw FS	100.00	%
Price of liquid fertilizer		Local currency/ton
Percentage of liquid fertilizer sold	0.00	%

   d) Selling biogas as electricity source

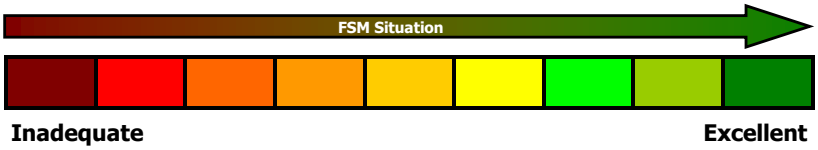
Biogas yield from the raw FS	0.00	m^3 biogas/m^3 of FS
Electricity produced from biogas		kWh/m^3 of biogas
Electricity price per KWh		Local currency/kWh
Percentage of electricity from biogas sold	0.00	%

4. Is there awareness about the ill effects of untreated fecal sludge? ◉ Yes ○ In-process ○ No

5. Is there any campaign on ill effects of untreated fecal sludge? ◉ Yes ○ In-process ○ No

6. Are consumers aware that the agricultural products they consume are contaminated with untreated fecal sludge? ○ Yes ○ In-process ◉ No

7. Are there any advocacy materials that highlight the hazards of untreated fecal sludge? ◉ Yes ○ In-process ○ No



Excellent

কৃষিই সমৃদ্ধি

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি মন্ত্রণালয়
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
আঞ্চলিক গবেষণাগার, দৌলতপুর, খুলনা।

নং- ১২.০৩.৪০৪৭.০৭১.৫৭.১০১.৯৫ /৭৮৬

তারিখ ঃ ৩৫/১১/২০১৬ খ্রিঃ।

প্রাপক ঃ জনাব নোমান আল হাফিজ
পুরকৌশল বিভাগ
খুলনা প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়
খুলনা।

বিষয় ঃ সারের নমুনা পরীক্ষার ফলাফল প্রেরণ প্রসংগে।

সূত্র ঃ তাঁর ২০/১০/২০১৬খ্রিঃ তারিখের আবেদন।

উপর্যুক্ত বিষয় ও সূত্রের প্রেক্ষিতে জানানো যাচ্ছে যে, আপনার প্রেরিত ১ (এক) টি জৈব সারের নমুনা পরীক্ষার ফলাফল এতদসংগে প্রেরণ করা হলো ।

সংযুক্তঃ ১। পরীক্ষার ফলাফল - ১ (এক) টি ।

৩০/১১/১৬

(ড. মোঃ জালাল উদ্দিন)
প্রধান বৈজ্ঞানিক কর্মকর্তা (চঃ দাঃ)
ফোন ঃ ০৪১-৭৭৪৩০২।
E-mail: srdiklab13@gmail.com

অনুলিপিঃ
১। অফিস কপি।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি মন্ত্রণালয়
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
আঞ্চলিক গবেষণাগার, দৌলতপুর, খুলনা।

জনাব নোমান আল হাফিজ, পুরকৌশল বিভাগ, খুলনা প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়, খুলনা কর্তৃক প্রেরিত জৈব সারের নমুনা পরীক্ষার ফলাফল।

সূত্র ঃ তাঁর ২০/১০/২০১৬খ্রিঃ তারিখের আবেদন।

ল্যাব নং/ কোড নং	সারের নাম/ বাণিজ্যিক নাম	পরীক্ষায় প্রাপ্ত ফলাফল	সরকারী বিনির্দেশ	মন্তব্য
সিএফ- ৭৯৩৬	জৈব সার	১। ফসফরাস (P) ০.৫%। ২। পটাশিয়াম (K) ১.৮%। ৩। সালফার (S) ০.১%। ৪। লেড (Pb) ২৭ পিপিএম। ৫। নিকেল (Ni) ৭ পিপিএম।	১। ফসফরাস (P) ০.৫-১.৫%। ২। পটাশিয়াম (K) ১.০-৩.০%। ৩। সালফার (S) ০.১-০.৫%। ৪। লেড (Pb), সর্বোচ্চ ৩০ পিপিএম। ৫। নিকেল (Ni), সর্বোচ্চ ৩০ পিপিএম।	-

বিশ্লেষণ পদ্ধতিঃ
১। ফসফরাস - Spectrophotometric molybdo-vanadate method.
২। পটাশিয়াম- Flame photometric method.
৩। সালফার- Turbidimetric method.
৪। লেড ও নিকেল - Atomic absorption spectrophotometric method.

০৩/১১/১৬
ড. মোঃ জালাল উদ্দিন
প্রধান বৈজ্ঞানিক কর্মকর্তা (চঃ দাঃ)
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
আঞ্চলিক গবেষণাগার
দৌলতপুর, খুলনা।

কৃষিই সমৃদ্ধি

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি মন্ত্রণালয়
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
আঞ্চলিক গবেষণাগার, দৌলতপুর, খুলনা।
www.srdi.gov.bd

নং- ১২.০৩.৪০৪৭.০৭১.৫৭.১০১.৯৫/ ৩৪৬ তারিখ ঃ ২৯/০৯/২০১৭ খ্রিঃ।

প্রাপকঃ জনাব নোমান আল হাফিজ
পুরকৌশল বিভাগ
খুলনা প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়
খুলনা।

বিষয় ঃ সারের নমুনা পরীক্ষার ফলাফল প্রেরণ প্রসংগে।

সূত্র ঃ তাঁর ১৫/০৫/২০১৭ খ্রিঃ তারিখের আবেদন।

উপর্যুক্ত বিষয়ে সূত্রেয় পত্রের প্রেক্ষিতে আপনার সদয় অবগতির জন্য জানানো যাচ্ছে যে, আপনার প্রেরিত ২ (দুই) টি জৈব সারের নমুনা পরীক্ষার ফলাফল এতদসংগে প্রেরণ করা হলো ।

সংযুক্তঃ সার পরীক্ষার ফলাফল - ১ (এক) পাতা।

২৯/৯/১৭
(ড. মোঃ জালাল উদ্দিন)
প্রধান বৈজ্ঞানিক কর্মকর্তা
ফোন ঃ ০৪১-৭৭৪৩০২।
E-mail: srdiklab13@gmail.com

সদয় জ্ঞাতার্থে অনুলিপিঃ
১। পরিচালক, মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট, কৃষি খামার সড়ক, ঢাকা-১২১৫।
২। মূখ্য বৈজ্ঞানিক কর্মকর্তা, মৃত্তিকা পরীক্ষা বিভাগ, মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট, কৃষি খামার সড়ক, ঢাকা।
৩। অফিস কপি।

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি মন্ত্রণালয়
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
আঞ্চলিক গবেষণাগার, দৌলতপুর, খুলনা।

জনাব নোমান আল হাফিজ, পুরকৌশল বিভাগ, খুলনা প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়, খুলনা কর্তৃক প্রেরিত জৈব সারের নমুনা পরীক্ষার ফলাফল।

সূত্র ঃ তাঁর ১৫/০৫/২০১৭ খ্রিঃ তারিখের আবেদন।

ল্যাব নং/ কোড নং	সারের নাম/ বাণিজ্যিক নাম	পরীক্ষায় প্রাপ্ত ফলাফল	সরকারী বিনির্দেশ	মন্তব্য
সিএফ- ৮১৬৯ নমুনা-১	জৈব সার	রাসায়নিক বৈশিষ্ট্যঃ ১। ফসফরাস (P) ১.৩%। ২। পটাশিয়াম (K) ১.৬%। ৩। সালফার (S) <০.১%। ৪। ক্রোমিয়াম (Cr) ১৩.৬ পিপিএম। ৫। লেড (Pb) ১০.৫ পিপিএম। ৬। নিকেল (Ni) ৭.৭ পিপিএম।	রাসায়নিক বৈশিষ্ট্যঃ ১। ফসফরাস (P) ০.৫-১.৫%। ২। পটাশিয়াম (K) ১.০-৩.০%। ৩। সালফার (S) ০.১-০.৫%। ৪। ক্রোমিয়াম (Cr), সর্বোচ্চ ৫০ পিপিএম। ৫। লেড (Pb), সর্বোচ্চ ৩০ পিপিএম। ৬। নিকেল (Ni), সর্বোচ্চ ৩০ পিপিএম।	-
সিএফ- ৮১৭০ নমুনা-১	জৈব সার	রাসায়নিক বৈশিষ্ট্যঃ ১। ফসফরাস (P) ১.৯%। ২। পটাশিয়াম (K) ০.৮%। ৩। সালফার (S) <০.১%। ৪। ক্রোমিয়াম (Cr) ৬.৮ পিপিএম। ৫। লেড (Pb) ৩.২ পিপিএম। ৬। নিকেল (Ni) ২.৯ পিপিএম।	রাসায়নিক বৈশিষ্ট্যঃ ১। ফসফরাস (P) ০.৫-১.৫%। ২। পটাশিয়াম (K) ১.০-৩.০%। ৩। সালফার (S) ০.১-০.৫%। ৪। ক্রোমিয়াম (Cr), সর্বোচ্চ ৫০ পিপিএম। ৫। লেড (Pb), সর্বোচ্চ ৩০ পিপিএম। ৬। নিকেল (Ni), সর্বোচ্চ ৩০ পিপিএম।	-

বিশ্লেষণ পদ্ধতিঃ
১। ফসফরাস - Spectrophotometric molybdo-vanadate method.
২। পটাশিয়াম- Flame photometric method.
৩। সালফার- Turbidimetric method.
৪। ক্রোমিয়াম , লেড ও নিকেল - Atomic absorption spectrophotometric method.

২৯/৫/১৭

ড. মোঃ জালাল উদ্দিন
প্রধান বৈজ্ঞানিক কর্মকর্তা
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
আঞ্চলিক গবেষণাগার
দৌলতপুর, খুলনা।

KII/in-depth-interview

KII with Dr. Nazmul Ahsan

- **Compost use and problems:** Compost is used for aquaculture to see the growth rate, survival of fish and effects of FS on the pond plankton community. According to informant, *"Pathogen contamination is not the main issue here, because compost is already pathogen free. So compost is mainly used as a feed of Tilapia which is the main issue."* Problem in the compost is seen mainly people's perception and deal with the tradition that is mentality. There is no any problem in nutrient uptake and it can be said supplementary diet, not 100 % artificial diet. Moreover according to him, "s*ince the compost is pathogen free which is several times proved, then the compost can be easily used in aquaculture."*
- **Suggestion:** According to Dr. Nazmul Ahsan, *"Since the waste water after treatment is released in the pond and natural body beside the plant, I think if fish can be used in the pond to reduce the organic loading, but his fish are not for our eating. Even you can eat it, but nothing will be hampered, since fish already digest the food and organic matter itself so I think no serious damage will occur."*

KII with Ranver Ahmed

- **FSM operation, treatment and Compost:** Kushtia Municipality town planner is a resourceful person in overall FSM in the municipality and has profound knowledge about their management, treatment, compost use etc. According to him, *"Kushtia Municipality's at present area is about 42.79 km^2, so at present everyday minimum 3, 4 maximum septic tanks or pit latrines are being emptied than before. Each drying bed is capable of 2000 liters of FS capacity per day, and 60000 liters in a month. Sludge is collected 12000-16000 liters per day. Due to limited treatment capacity, three fourth raw sludge are being dumped in natural body outside the town area, but we consider it as a big problem. Although there are three vacutags are in service all time but sometimes we feel more number of vacutags. Compost is produced in a limited amount, but recently the production of compost and its license has been given to ERAS and Aaprokasi organization to marketing the compost. So municipality has no future plan regarding compost production at this moment. Our only concern is to prevent the open dumping of FS."*
- **Expectations:** From Town planner some potential words have been also collected. Since the municipality has only one treatment plant, another small scale treatment could minimize more problems. According to him, *"We face difficulties for FSM operation, and we know that due to only two drying beds, we cannot dump so much FS that we collect, But I think if another treatment plant can be made outside the town, but at other end, not the end where existing FSTP is located, then some problems can be solved, Then we will be able to cover the whole municipality. Another solution may be implemented like increasing the number of drying beds. If two drying beds can be newly made, then it will be also helpful because population day by day is increasing."*
- **The reason behind:** Although treatment plant is operated by Kushtia Municipality but, properly compost is not sold to farmers which is the main end-use option. Another problem is that, coco pit filter is not regularly run by officials. Kushtia Municipality has no any action plan regarding this two issues. According to town planner, *"coco pit filter is mainly used to treat the waste water, and when the percolate of septic tanks where the waste water are stored after coming from the drying beds are filled then coco pit filter is run by officials. Moreover we have*

no any valid certificate to sell fertilizer, that's why we have no any plan regarding the compost production and selling."

KII with Md. Selim Hossain

- **Use of compost:** Compost is being used to increase the nutrient value in the soil and plant. Kushtia Agricultural Extension Department, Kushtia sadar has no any goal or target regarding this compost that come from FSTP. According to Md. Selim Hossain, *"Kushtia Agricultural Extension Department has no any mandate to use any compost. We only recommend to farmers to use fertilizers according to ministry of agriculture, Bangladesh. If ministry does not give permission then, we only reach the compost whether chemical or organic to the farmers' field. Laboratory and research is related to SRDI. We have no any issue or information regarding it."*

From the point of view, it can be said that, organic compost has not got any attention so importantly to farmers through government officials.

- **Suggestion:** According to him, *"When you want to sell your organic fertilizer, first you should arrange a campaign along with agricultural related organization. Moreover you need marketing and selling, need to arrange mini fair, etc. for showing up your activity related to business. The first and most important thing is field trial for which you should persuade your farmers."*

KII with Md. Masud Hossian Palash

- **Practice and Suggestion:** Show off something is very important for gaining public attention. According to officer MD. Masud Hossain Palash, *"When you need something getting public attention the first thing is show off. If you want to spread your organic compost in the farmers level, then you can discuss with them, rent them money for making an plot of land for field trial whether it is official or not."*

KII with Vhabananda Basak

- **Application and Permission:** Assessing something is very important before giving any decision, to give full power use the materials. It can be said that, before field trialing you need to analyze the fertilizer in laboratory. According to this senior scientific officer, *"Compost is being tested in SRDI office in Khulna and Jessore and in BARI, Jessore. We only test the soil where your fertilizer will be used. We call it fertilizer recommendation guideline, 2012. Here you can find details in this guideline. From this guideline, we recommend farmers how amount of fertilizer will they use for different types of crops. So you need to test both your compost and soil. So field trial is very important which Bangladesh Agricultural University give permission for both compost and soil."*

KII with Shimul mondal

- **Compost field trail:** Gaining acknowledgement is very important for use compost in household level, farmers level whatever said. BARI, Jessore is running an action research on compost which is review of laws, regulations, policies, strategies and institutional arrangements governing use of faecal sludge as an agricultural input. According to Shimul Mondol, *"Jessore BARI is running action research on co-composting of faecal sludge and municipal organic waste*

for sustainable crop production considering health issues. This research will justify the safe usage of co-composting from FS and municipal organic waste in crop production and offer the ideal co-composting proportion in terms of both agronomic and economic perspective. For this case Cabbage, Cauliflower, Sweet gourd, and Okra, Gladiolous and Marigold have been chosen. We are using the compost of Kushtia for field trial. So I think quality of the compost is not the main issue after so long time, main issue is to get national certificate that is the clearance from the ministry."

- **Compost use problems reason behind:** Many people consider this organic compost as a negative item like garbage. But according to Shimul Mondol, *"we are also working on human health issue of using co-composting for vegetable production. So I think that, in several times the compost is proved as pathogen free, but it is our fault that we could not change our mind and culture."*
- **Suggestion:** He suggested that, *"Apart from the individual encouragement, a national level workshop can be organized to clarify the pertaining issues in the existing rules, laws and regulations, to promote increased awareness, persuading conduce environment by making a national consensus to overcome limiting factors of using faecal sludge in agriculture. Moreover I think print and electronic media campaign can be arranged among stack holders."*

KII with Md. Jahurul Islam

- **Compost context and selling:** Treatment and its final outcome is not so important for conservancy department of Kushtia Municipality. Only FS collection in a proper way from household and disposal in the drying bed is the main responsibility. According to the informant, *"conservancy department only focuses on the collection of FS from town area by vacutug and dumping the collected sludge in FSTP outside the town. Sometimes people from here and there to buy compost. We sell per kilogram compost at ten taka rate and this money is spent in FSM operation, maintenance."*

According to conservancy department record book some buyers have found who bought compost for various reasons. Some of them are, Md. Saiful Islam from civil surgeon office of Kushtia took 190 kilogram, Sheikh Riajul Islma from Khulna University took 400 kilogram, Md. Liton from payara tola, of Kushtia for aquaculture purpose and BARI, Jessore took 1300 kilogram compost for their own purpose. Sometimes city dwellers also take compost for flower pot but amount is negligible like two to five kilogram average. So co-composting in FSTP is less important to them but they are aware about it.

According to him, *"selling of compost is not seen so much, that's why we have no any plan about it. Authority give us task to complete, so we have no any headache in this issue."*

KII with Md. Ashifur Rahman

- **Compost production:** Compost is produced in a way of trico-compost, sometimes vermi-compost in Kushtia FSTP named as Aaprokashi organic fertilizer. According to production manager, *"ERAS is only production in trico-compost, sometimes vermi-compost, with dried FS where saw dust, cow dung are used as a third party materials. In the FS-OSW mixed compost or co-compost what is said, is seen sometimes sandy type texture by visual, but our trico-compost is not that type. I think when FS is removed from the drying beds some sand is automatically come along with dried FS, that's why sandy mood exists."*

Conferring to Md. Ashifur Rahman (Ashib), daily production of trico-co-compost is from 10 kilogram to 100 kilogram, but this amount is variable dependent on the workers, time, etc. Moreover ERAS is not watching the waste water treatment, they only bother about the compost production. According to informant, *"coco pit filter is not run regularly by municipality or officials, when septic waste water is full then I use our motor system to pump out the water from the percolate into the filter media, then it treated and goes out from the outer pipe."*

KII with Md. Nazrul Islam

- **Compost marketing and selling:** Marketing and selling is very important to run business. ERAS is a business organization in regarding organic fertilizer, named Aaprokashi organic fertilizer. According to informant, "when is started marketing about the organic compost, first I made campaign with farmers to use the compost. I understood farmers the beneficial side of the organic fertilizer. So farmers are using the fertilizer in pepper tree, moth, paddy field, Cauliflower and radish production. I noticed tremendous positive result in Eri paddy."
- **Suggestion:** According to him, *"awareness is very important if you want to sell your compost. I have sold compost by making sub-farmers in different locations. Now 20 farmers know this organic fertilizer out of 100 farmers in Modhupur, Kumarkhali and its surroundings villages. You have to invest fund to encourage them using the organic compost."*

KII with Jalal Mia

- **Compost customer:** User's satisfaction and demand is one of the prime criteria in business level. Stakeholders are the main key of urban level framework. According to informant, *"I bought 100 kilogram organic compost from the plant for gourd cultivation in my own land. The compost is good for farmers but we do not proper dose, how much amount will we use for different types of crops."*

Suggestion: Public awareness and campaign with farmers is very important for achieving the success of this organic compost. According to him, *"many of our farmers in villages do not know about it, its advantages. If press meeting, campaign with farmers can be arranged then they will be encouraged using the fertilizer.*