SFD Promotion Initiative

Khulna
Bangladesh

Final Report

This SFD Report was created through field-based research by Sandec (the Department of Sanitation, Water and Solid Waste for Development) at Eawag (the Swiss Federal Institute of Aquatic Science and Technology) as part of the SFD Promotion Initiative.

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SFD Promotion Initiative

SFD Report Khulna, Bangladesh, 2015

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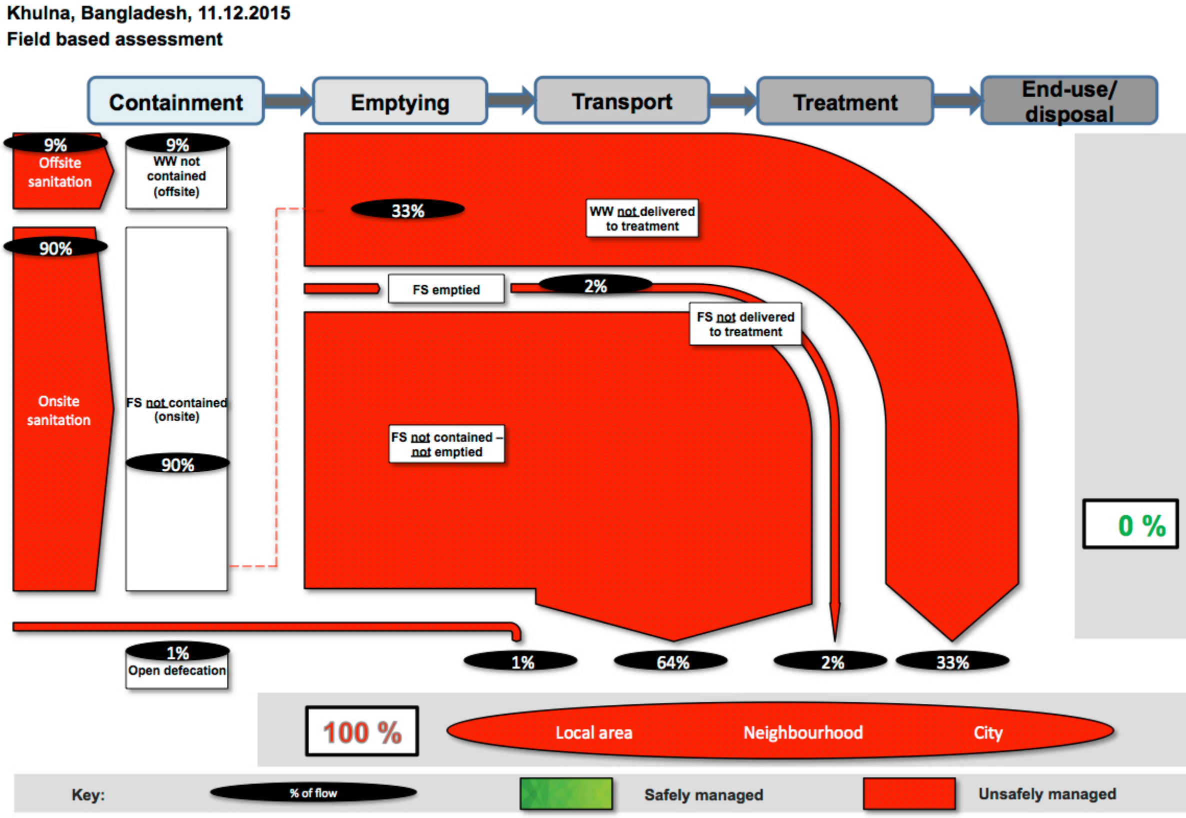
1. The Diagram



Note: In this SFD, offsite sanitation refers to systems without any containment, but not sewers (see 5. Service outcomes)

2. Diagram information

The Shit Flow Diagram (SFD) was created through field-based research by Sandec (Sanitation, Water and Solid Waste for Development) of Eawag (the Swiss Federal Institute of Aquatic Science and Technology)

Collaborating partners:

SNV Netherlands Development Organisation

Khulna University of Engineering and Technology (KUET)

Khulna University

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3. General city information

Khulna is located in the south-western part of Bangladesh, with a population of 1.5 million and a total area of 46 km^2. Khulna is governed by the Khulna City Corporation (KCC), a government institution that is mandated to provide basic sanitation services for all 31 wards.

The topography is relatively flat, with no mountainous features, and is located on the late Holocene-recent alluvium of the Ganges deltaic plain (Adhikari et al., 2006), characterized by Ganges tidal floodplains, rivers, tidal marshes and swamps (Khan and Kumar, 2010). As a deltaic plain, Khulna is very susceptible to climate change (ADB, 2011) and prone to cyclones.

Soils consist of medium to high plastic clay in the top layer and poorly graded sands below. Soil properties in different layers are fairly consistent throughout Khulna, including natural moisture content, specific gravity and mean grain diameter. Within the city area of Khulna, soils are saturated with the groundwater table less than 1m below the surface. (Adhikari et al., 2006)

4. Service delivery context

Regulation of sanitation services started in 1998 when the National Policy for Safe Water Supply and Sanitation was introduced. Current legislation, policies and strategies lack clarity on the roles and responsibilities of various agencies, but the recently published National Strategy for Water Supply and Sanitation (2014) provides an opportunity to develop sound faecal sludge management programmes (Ahsan et al., 2014).

National policy and strategy documents encourage both NGOs and the private sector to actively engage in providing sanitation services. In Khulna, the private sector does not yet have a role in contrast to NGOs and governmental organisations, which have implemented pilot projects to address faecal sludge management and provision of sanitation infrastructure since 1985.

However, until recently the focus has been on provision of sanitation at the household level and reducing open defecation, which has been the key strategy of the government for the last decade. For example, international government agencies (USAID, DFID, UNICEF, UNDP), multilateral organizations and international NGOs (World Vision, WaterAid Bangladesh), and local NGOs (Nabolok Parishad), have been constructing sanitation infrastructure in low-income neighborhoods, with support from the national government and the local government engineering department (LGED) (Roy, 2014).

The Local Government Act allows for KCC to charge taxes for faecal sludge emptying and transportation services, for example through a withholding tax of up to 12%, but this has not yet been implemented.

A trenching ground has been installed where some collected sludge is discharged, and further treatment solutions are being developed under the Demonstration of Pro-poor Market-based Solutions for Faecal Sludge Management in Urban Centres of Southern Bangladesh project, which is a four-year project (2014-2017) being implemented by SNV Netherlands Development Organisation, under the leadership of local authorities KCC, Kushtia and Jhenaidah Paurashava in partnership with Khulna University, Khulna University of Engineering and Technology, Khulna Water Supply and Sewerage Authority and WaterAid Bangladesh.

The Government of Bangladesh is planning to strengthen and expand the capacity of the private sector, specifically in faecal sludge management. Under the National Strategy for Water Supply and Sanitation (2014) it is planned to "provide technical and business support to private sector in sludge management, recycling and sale of compost or other products" (MLGRDC, 2014) p.18. Including "giving priority to the management of faecal sludge from septic tanks and pit latrines, such that all sludge are collected, transported, treated and disposed safely in an environmental friendly manner" (MLGRDC, 2014) p.17.

5. Service outcomes

The SFD assessment has shown that 100% of the excreta in Khulna is not contained and therefore unsafely managed. Due to a significant risk of groundwater pollution throughout the city, all systems, which infiltrate into the ground, are considered to not contain excreta. The vulnerability of the aquifer is high due to sandy soil characteristics, in addition to the groundwater level less than 1 m below the surface (Adhikari et al., 2006).

As far as could be determined, offsite sanitation in Khulna is non-existent other than a pilot project implementation of a Decentralized Wastewater Treatment Plant (DEWATS), serving 0.07% (200 people) of the total population in a low-income community. However, the SFD still reports 9% of the total population being served by offsite sanitation. This is due to the terminology in the methodology, as this 9% consists of systems without any containment structure. Excreta is either discharged to open drains (7%), water bodies (1%) or households do not know where the user interface discharges to (1%). Hanging latrines with excreta being discharged directly to water bodies is particularly visible in low-income areas. Additionally, open defecation is practised by 1% of the population, which significantly decreased from 19% in 2000 (Ahsan et al., 2014, SNV, 2014), through the implementation of sanitation infrastructure projects and a major commitment of the Government of Bangladesh.

In total, 68% of the population in Khulna is connected to septic tanks; of which the vast majority of 48% is connected to open drains and another 8% are directly discharging the effluent to the open ground. Only 5% of the population use septic tanks, which are connected to soak pits, even though the specifications of the BNBC state it is not allowed to discharge the effluent of septic tanks into open water courses and a soak pit shall be installed, including the performance of soil percolation tests to determine the soil and site suitability (Ahsan et al., 2014). Within the SFD matrix, only septic tanks connected to soak pits are regarded as containing faecal sludge, but due to the significant risk of groundwater pollution, all septic tanks in Khulna fall under the category of onsite sanitation technologies that do not contain faecal sludge.

Pit latrines are utilised by 29% of the total population of Khulna. While many different types of pit latrines are constructed within the city, two common types of containment structure could be identified within the city. The majority of these are lined pits with semi-permeable walls and open bottom with no outlet or overflow (22%) in addition to unlined pits with no outlet or overflow (7%). Lined pits were assumed to be VIP latrines and pit latrines with covered slab and pan, as per the definition of SNV (2014). Field observations supported the verification of this information. Unlined pits were assumed to be a direct open pit or pit without cover, which do not have a slab platform or seat and use a whole in the ground for excreta collection. Both systems infiltrate into the ground and due to the identified risk of groundwater pollution contribute to onsite sanitation systems that do not contain faecal sludge.

The 9% offsite sanitation, mentioned above, together with 24% of septic tank effluent contribute to 33% of wastewater not delivered to treatment. Excreta, entering septic tanks, were defined to contribute 50% to liquid effluent and 50% to faecal sludge in the tank that could be emptied.

All onsite sanitation systems in Khulna require regular emptying services. However, only 5% of the total population utilize emptying services, which results in 2% of faecal sludge being emptied. This was based on the assumption that only systems that were emptied within the last three were included as ‘in use with emptying services’. Data on manual and motorized emptying and transport services was collected during key informant interviews (KII), focus group discussions (FGD) and direct observations at the trenching site discharge location. Within Khulna only two 5 m^3 tractors equipped with vacuum pumps and three 1 m^3 vacutugs are available for motorized emptying services. The service provider operating these trucks performs on average only 11 trips per month. The low utilisation results from 98% of the population that receives emptying making use of manual emptying services (SNV, 2014). It was estimated that manual and motorized emptying service providers combined collected on average 100 m^3 faecal sludge per day over the last three years. This, in comparison with a theoretical production of 1,975 m^3/d assessed by AIT (2015), verifies that only 5% of the population utilizes emptying services.

In Khulna, literature and interviews suggested that faecal sludge is being transported to and discharged at a trenching ground, which is located at the sanitary landfill for solid waste. However, field observations and records at the discharge location have shown contradictory results and although some sludge is delivered, it is not discharged to the trenches as designed. Therefore, it was assumed that 100% of the collected faecal sludge is not delivered for treatment.

Of the total population, 64% use systems that do not contain faecal sludge and furthermore do not receive emptying services. Due to the significant risk of groundwater pollution, this percentage fully contributes to unsafely managed excreta.

SNV (2014) identified the enduse of faecal sludge by some households on a very small scale. The study found 99 cases out of a total survey size of 4,367 households. This included energy recovery through the production of biogas and recovery of nutrients through the use in agriculture. However, this percentage was not included in the SFD matrix, because faecal sludge from these systems is not being collected and transported to designated treatment plants, but rather used directly, untreated, at the household level.

6. Overview of stakeholders

Table 1 presents the stakeholders responsible for sanitation service provision in Khulna. The Ministry of Local Government Rural Development and Cooperatives (MLGRD&C) is in charge of overseeing the development of water supply and sanitation sectors (Ahsan et al., 2014). The Local Government Division is responsible for the implementation of policies, strategies, plans and regulations, as well as coordination and monitoring (Ahsan et al., 2014). In Khulna, the mandate of sanitation service provision is with KCC, the Khulna Water Supply and Sewerage Authority (KWASA) and the Khulna Development Authority (KDA).

Key Stakeholders	Institutions / Organizations /
Public Institutions	KCC, KWASA, KDA and MLGRD&C.
Non-governmental Organizations	WaterAid, SNV Bangladesh, Nabolok, Community Development Committee
Private Sector	Manual emptying service provider
International financing institutes	Asian Development Bank, Japan International Cooperation Agency, World Health Organization, Bill & Melinda Gate Foundation.
Others	Khulna University of Engineering Technology and Khulna University

Table 1: Stakeholders delivering sanitation services in Khulna

7. Credibility of data

A variety of data sources were used to determine the most reasonable estimates of percentages of excreta flow for the SFD matrix. SNV (2014) was regarded as a reliable source of information and representative for the whole city, due to the high number of survey participants, recent completion, and statistical distribution of samples. The methods of the survey are clearly described and therefore provided the authors with confidence in quality of the data. In addition, other data sources were used for validation of the existing data. If information varied significantly among data sources, the authors used this information to formulate questions for KIIs or FGDs. Field observation furthermore provided a good methodological approach to assess whether the available information could be confirmed.

8. Process of SFD development

Local government institutions, such as KCC, KWASA and KDA were directly engaged during data collection. In total, six FGDs were conducted with manual emptying service providers, motorized emptying service provider, private household toilet users (women/men separately) and community toilet users (women/men separately). Data for the SFD matrix, collected through eight KIIs and a thorough literature review could be verified. After a draft SFD was produced, it shared with collaborating partners and stakeholders that were actively involved in gathering information, and then revised.

9. List of data sources

A full list of all references used for the SFD diagram can be found in the detailed report.

ADB 2011. Adapting To Climate Change: Strengthening The Climate Resilience of Water Sector Infrastructure In Khulna Bangladesh. The Philippines: Asian Development Bank.

ADHIKARI, D. K., ROY, M. K., DATTA, D. K., ROY, P. J., ROY, D. K., MALIK, A. R. & ALAM, B. 2006. *URBAN GEOLOGY: A CASE STUDY OF KHULNA CITY CORPORATION, BANGLADESH*.

AHSAN, T., AHMAD, I. U., ALAMGIR, M. & HASSAN, K. H. M. 2014. Review of Legal and other Governing Factors related to Faecal Sludge Management in Bangladesh. Khulna, Bangladesh: SNV.

KHAN, M. S. A. & KUMAR, U. 2010. Water Security in Peri-Urban South Asia, Adapting to Climate Change and Urbanization, Scoping Study Report: Khulna. Institute of Water and Flood Management; Bangladesh University of Engineering and Technology.

MLGRDC 2014. National Strategy for Water Supply and Sanitation *In:* DIVISION, L. G. (ed.).

ROY, T. K. Sustainable Options of Sanitation Projects in the Slums of Khulna City. World Town Planning Day 2014, 2014.

SNV 2014. A Baseline Study to assess Faecal Sludge Management of Residential Premises in Selected Southern Cities of Bangladesh.

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Abbreviations

ADB	Asian Development Bank
ADP	Annual Development Program
AIT	Asian Institute of Technology
ASEH	Advancing Sustainable Environmental Health
BMGF	Bill & Melinda Gates Foundation
BNBC	Bangladesh National Building Code
BOD	Biochemical Oxygen Demand
CAP	Community Action Plans
CDC	Community Development Committee
CLTS	Community Led Total Sanitation
COD	Chemical Oxygen Demand
Danida	Ministry of Foreign Affairs of Denmark
DEWATS	Decentralized Wastewater Treatment Plant
DFID	Department for International Development
DPHE	Department of Public Health Engineering
FGD	Focus Group Discussion
FSTP	Faecal Sludge Treatment Plant
GoB	Government of Bangladesh
KCC	Khulna City Corporation
KDA	Khulna Development Authority
KII	Key Informant Interview
KMA	Khulna Metropolitan Area
KWASA	Khulna Water Supply and Sewerage Authority
LGD	Local Government Division
LGED	Local Government Engineering Department
LGIs	Local Government Institutions
MHPW	Ministry of Housing and Public Work
MICS	Multi Indicator Cluster Survey
MLGRD&C	Ministry of Local Government Rural Development and Cooperatives
NGO	Non-Governmental Organisation
NPSWSS	National Policy for Safe Water Supply and Sanitation
NSS	National Sanitation Strategy
OD	Open Defecation
PEHUP	Promoting Environmental Health for the Urban Poor
PGs	Primary Groups
PSU	Policy Support Unit
SDP	Sector Development Plan

SFD	Shit Flow Diagram
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations International Children's Emergency Fund
UPPR	Urban Partnership for Poverty reduction
USAID	United States Agency for International Development
VIP	Ventilated Improved Pit
WASH	Water Sanitation and Hygiene
WATSAN	Water Supply and Sanitation Committee
WHO	World Health Organization
WSS	Water Supply and Sanitation

1 City context

Bangladesh is located in South Asia and has a total estimated population of 155 million inhabitants, covering an area of almost 148,000 km^2. It is one of the most densely populated countries in the world with roughly 1,048 inhabitants per km^2 (UN, 2014). About 30% of Bangladesh's population lives in urban areas and there is an urban population growth rate of 3.0% (UN, 2014).

Bangladesh has had steady economic growth over the past years, with a GDP growth rate of 6.5% in 2012 (UN, 2014). But economic gains are not distributed equally among the population. The main economic drivers for Bangladesh are garment industries and remittances from Bangladeshis abroad (Ahsan et al., 2014). In general, the sanitation service delivery in Bangladesh is improving and the Government of Bangladesh (GoB) has taken the lead to broaden basic hygienic sanitation coverage to more households through Community Led Total Sanitation (CLTS) programs (ADB, 2009).

Khulna is located in the south-western part of Bangladesh and has a total population of 1.5 million[3] and a total area of 45.65 km^2. (KCC, 2015). Khulna is governed by the Khulna City Corporation (KCC), a local government institution that is mandated to provide basic urban services. KCC administers 31 wards, which is the lowest administrative level. As the third largest city in the country, the urban boundaries of Khulna expand beyond the administrative boundary, which is known as the Khulna Metropolitan Area (KMA). Khulna lies in the axis of Kolkata (India) and Dhaka (capital city of Bangladesh), which gives it numerous advantages for development. The city has the potential to be a transit hub if Khulna and Bangladesh in general can solve infrastructure bottlenecks.

The topography of Khulna is relatively flat without mountainous features. Khulna is located on the late Holocene-recent alluvium of the Ganges deltaic plain (Adhikari et al., 2006) characterized by Ganges tidal floodplains, rivers, tidal marshes and swamps (Khan and Kumar, 2010). As a deltaic plain, Khulna is very susceptible to climate change (ADB, 2011) and prone to cyclones.

The climate in Khulna is hot in summer with mild winters. During 2004-2009, the average annual rainfall was 1,924 mm with peak rainfalls between May and October (ADB, 2011). The maximum temperature is 35.5°C and the lowest temperature is 12.5°C (KCC, 2015).

A study by the Urban Partnership for Poverty Reduction (UPPR) in 2011 revealed that 8.4% of households in Khulna live in poor settlements.[4] The area of poor settlements is 8.6 km^2 or 18% of the total KCC area (Fortuny et al., 2013).

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[3] http://khulnacity.org/Content/index.php?pid=30&id=32&page=About_KCC. There are different figures of total population in Khulna. The Statistic Bureau states that the total population in Khulna in 2011 is 751,000 inhabitants (BBS, 2011) and Opel and Bashar (2013) write that the total population is 1,728,760 (in 2011).

[4] A group of households living in a geographically identifiable area which is characterized by one or more of the following: (i) houses constructed of temporary materials that do not adequately protect occupants from the elements; (ii) danger from flooding; (iii) lack of access to potable water and bathing facilities; (iv) lack of sanitation facilities; (v) insecurity of tenure; (vi) high density slums in the inner city areas; (vii) inadequate solid waste management; (viii) lack of electricity; and (ix) lack of access roads and drainage (Fortuny et al., 2013).

2 Service delivery context description

2.1 Policy, legislation and regulation

Bangladesh distinguishes between the terms policy and strategy in the sanitation sector. Policies aim to provide guidelines in a broad sense, whereas strategies focus on the actions that are required to deliver what has been stated in policy documents. Sanitation service provision and water service provision are tied together in the documents. There are two national policies that play a significant role in guiding sanitation service provision, the National Policy for Safe Water Supply and Sanitation (1998) and the National Water Policy (1999). In addition to these, there are several national strategies, which have been promulgated to safeguard that all people of Bangladesh have the access to the same basic minimum sanitation services.

2.1.1 Policy

The effort of regulating sanitation service provisions started in 1998 when the National Policy for Safe Water Supply and Sanitation (NPSWSS) was introduced. Current legislation, policies and strategies lack clarity on the roles and responsibilities of various agencies, but the recently published National Strategy for Water Supply and Sanitation (2014) provides an opportunity to develop sound faecal sludge management programmes (Ahsan et al., 2014).

The National Strategy was guided by the Policy Support Unit (PSU) under the Local Government Division (LGD) and a consultant company to support the development. The PSU provides technical assistance for the LGD and is supported by the Ministry of Foreign Affairs of Denmark (Danida). A working group was formed which consists of members of the Department of Public Health Engineering (DPHE), Water Supply and Sewage Authorities (WASAs), Non-Governmental Organisations (NGOs) and international financing institutions, such as the Asian Development Bank (ADB). Strategy 5 of the National Strategy outlines nine strategic directions, which shall support the development of appropriate faecal sludge management (MLGRDC, 2014).

According to the strategy, a national workshop involving all stakeholders for improved faecal sludge management was supposed to be organized in December 2014 and guidelines for faecal sludge management are expected to be prepared June 2016. A technical proposal to demonstrate faecal sludge management is expected by December 2016, while by-laws or regulations, including periodic emptying of septic tanks and pit latrines shall be prepared by June 2017 (MLGRDC, 2014).

It is furthermore proposed to institutionalize service delivery arrangements and promote strategic partnerships between the central and local governments. The documents also acknowledge the importance of a long-term framework for the adoption and implementation of the government's action plan (MLGRDC, 1998).

An interesting development is that the local government is expected to contribute to capital costs for sanitation infrastructure, while in most cases this was is funded by public sector investments, revenue from urban utilities, cost sharing, private investment and NGOs (Ministry of Local Government, 2011).

Furthermore, the national policy is encouraging people to participate in the sanitation planning process plan and during the implementation stage, and clearly provides space for NGOs and private sector involvement to develop the urban sanitation sector. Sanitation programs are initiated by the central government even though decentralized decision making is strongly encouraged in national policies.

2.1.2 Institutional roles

The Ministry of Local Government Rural Development and Cooperatives (MLGRD&C) is in charge of overseeing the development of the water supply and sanitation sectors (Ahsan et al., 2014). The institutional arrangement for delivering sanitation and faecal sludge management services in Bangladesh is slightly different from city to city and depends on the type of local government institutions.[5] In the case of Khulna, this mandate is vested in two institutions, KCC and Khulna Water Supply and Sewerage Authority (KWASA). Both are part of the LGD of the Ministry of Local Government Rural Development and Cooperatives (MLGRD&C). The Khulna Development Authority (KDA) is situated under the Ministry of Housing and Public Works (MHPW). At the national level, the LGD is responsible for the planning of policies, strategies, plans and regulations, as well as coordination and monitoring (Ahsan et al., 2014). (See Figure 1)

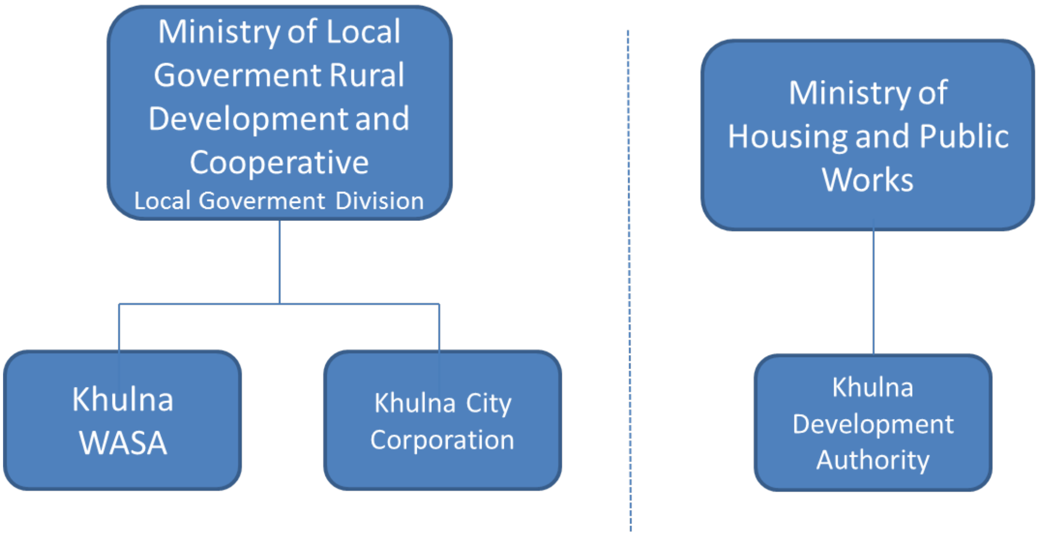

Figure 1: Institutional Arrangement for Sanitation Service Delivery in Khulna. Adapted from Ahsan et al. (2014)

Below are the roles and responsibilities of the related institutions:

1. KCC is a local government entity with the mandate to deliver sanitation and faecal sludge management services at city-wide scale. This is granted through the Local Government Act of 2009. KCC provides faecal sludge emptying and transportation services for residents. Additionally, it has established an official faecal sludge discharge location. A sanitation plan exists at the national level, but strategies on how to execute this plan on a local level are lacking (Jabbar, 2015a).
2. KWASA is a utility that has two main functions, to provide: (1) a clean water supply and (2) sewerage networks in Khulna. KWASA is focused on offsite sanitation systems. However, since the inception of KWASA in 2008, no sewerage network has been implemented. This year, a feasibility study for the implementation of a sewerage network will be performed.
3. The KDA is in charge of managing urban growth through implementing various development agendas (e.g., residential projects and infrastructure projects). It is responsible for developing

[5] Local government in Bangladesh is differentiated into urban and rural area institutions. In urban areas, Bangladesh has 11 city corporations and 325 City *Paurashavas* or municipalities. Meanwhile in rural area, Bangladesh has 64 *Zila Parishad* or District Councils, 482 *Upazila Parishad* or Sub-district councils and 4,466 Union Parishad

a master plan for land-use zoning and a detailed area plan. In regards to faecal sludge management, KDA is the apparatus that enforces the Bangladesh National Building Code (BNBC), which makes it compulsory to install a septic tank or Imhoff tank when building a residential unit. The residents must comply with these regulations in order to get a building permit. After the specifications of the BNBC, it is not allowed to discharge the effluent of septic tanks into open water courses and a soak pit shall be installed, including soil percolation tests to determine the soil and site suitability (Ahsan et al., 2014). However, in Khulna only 27% of the households constructed their septic tank together with the building and only 11% of the total households using septic tanks have ever been visited by the authority (SNV, 2014).

Regarding this institutional set-up, coordination between the institutions is challenging, as there is no horizontal relationship between them. Additionally, the involvement of different vertical government agencies without clear coordination will hinder the delivery of the basic minimum level of services due to complex bureaucracies, overlapping roles, and not well defined roles and responsibilities (Ministry of Local Government, 2011).

2.1.3 Service provision

The national policy and strategy documents encourage both NGOs and the private sector to actively engage in providing sanitation services. In Khulna, the private sector does not yet have a role in contrast to NGOs and governmental organisations, which have implemented pilot projects to address faecal sludge management and provision of sanitation infrastructure since 1985.

However, until recently the focus has been lying on provision of sanitation infrastructure at the household level and decreasing open defecation (OD), which has been the key strategy of the government for the last decade. For example, for more than ten years, World Vision has been engaged in supporting the construction of latrines and low cost houses in low-income areas.

Another example is the Advancing Sustainable Environmental Health (ASEH) project, which funded by WaterAid Bangladesh and implemented by Nabolok Parishad, a local NGO working with KCC (Roy, 2014). Nabolok Parishad was established 25 years ago and provides services in all areas that are leading to development and poverty reduction. This ASEH project put a stronger focus on community participation, empowerment, governance, advocacy and sustainability.

However, in a study of sanitation projects in Khulna Roy et al. (2014) found that many of the latrines were not sustainable, and found that “communal and shared latrines are found nearly abandoned, unhygienic and in poor condition due to absence or lack of community participation for repairing and maintenance whereas twin pit latrines used mostly by individual families are found in good condition.” p.2. The study was conducted during 2008-2009 in three low-income areas of Khulna with a total participation of 384 households. Figure 2 shows an abandoned and newly constructed community toilet in the low-income area of Basthuhara. Even though Roy at al. (2014) show that private latrines appear to be more sustaining than communal toilets, households often cannot afford to build their own latrine. However, the GoB encourages “the use of double pit latrines to enable proper in-situ composting of sludge and for its safe disposal or to be used as fertilizer” (MLGRDC, 2014) p. 17.

Figure 2: Abandoned community toilet (front) and newly constructed community toilet (back) in the low-income area of Basthuhara. Open drain on the right. Photo: Lars Schoebitz

Another project implemented by Nabolok Parishad and aiming at provision of sanitation infrastructure is the Promoting Environmental Health for the Urban Poor (PEHUP) project. It is supported by WaterAid Bangladesh and started in 2011 for a duration of five years. The main activities in this project include to install, construct, repair, renovate and up-grade water source and sanitation options, in addition to knowledge and skill development, as well as capacity building trainings on Water, Sanitation and Hygiene (WASH) (Parishad, 2015).

The Local Government Act of 2009 and its amendment for City Corporation 2011 mandated KCC with faecal sludge management as one of its municipal services (Ahsan et al., 2014, Chowdhry and Kone, 2012). However, since 2000, KCC has had two 5 m^3 tank lorries towed by tractors and equipped with suction pumps, obtained through an ADB funded project. Three 1 m^3 vacutugs have also been provided to the Community Development Committee (CDC) by the Urban Partnership for Poverty Reduction Project, a UNDP funded project.

A critical aspect for the sustainable service provision is that the KCC must have the ability to set tariffs accordingly. The Local Government Act gives KCC the possibility to charge taxes for faecal sludge emptying and transportation services, for example through a water tariff, but this has not been implemented yet. Fees for emptying and transportation services have not increased since 2000 when the first motorized emptying truck was introduced in Khulna, as it is considered to be an unpopular move (Tasaduzzaman, 2015).

A trenching ground has been installed where collected sludge is supposed to be deposited and further treatment solutions are being developed under the Demonstration of Pro-poor Market-based Solutions for Faecal Sludge Management in Urban Centres of Southern Bangladesh project, which is a four-year project (2014-2017) being implemented by SNV Netherlands Development Organisation, under the leadership of local authorities KCC, Kushtia and Jhenaidah Paurashava in partnership with Khulna University, KUET, KWASA and WaterAid Bangladesh (Ahsan et al., 2014).

2.1.4 Service standards

Monitoring and evaluating the performance of sanitation services is critical to assess on-going projects or interventions. The NPSWSS (1998) and the National Sanitation Strategy (NSS) 2005 have recognized the need for a critical institutional setup to monitor and evaluate what is being executed within the National Sanitation Secretariat. At the local level, the Water Supply and Sanitation Committee (WATSAN) proposes to tackle all issues related to sanitation, including the implementation of monitoring strategies.

The implementation of monitoring mechanisms by the National Sanitation Secretariat is poor (Rahman, 2009, Ministry of Local Government, 2011). However, UNICEF and GoB have collected data regarding sanitation in 2006, 2009 and 2012 from the Bangladesh Bureau of Statistics[6] on sanitation coverage and the use of hygienic or unhygienic toilets. Below is the setup of the National Forum for Water Supply and Sanitation, which has the responsibility to perform the coordination and monitoring tasks (See Figure 3).

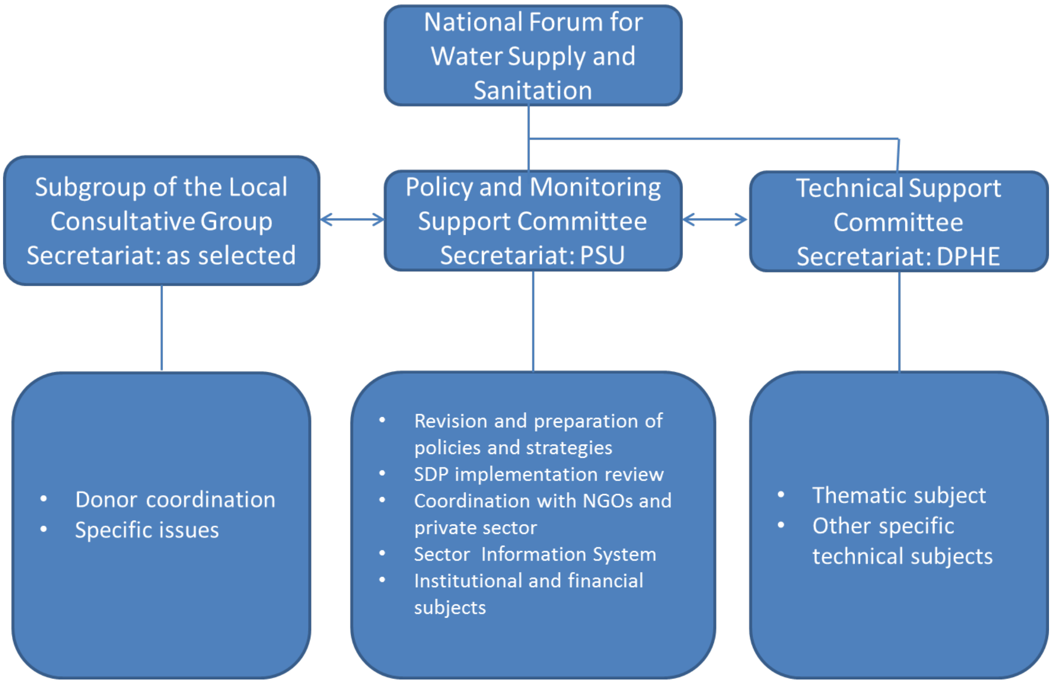

Figure 3: Coordination and monitoring arrangement for sanitation provision (Ministry of Local Government, 2011)

Another difficulty in performing reliable monitoring of sanitation service provision is poor data recording by service providers. For example, information on faecal sludge emptying and transportation service providers is recorded in a logbook at the official discharge location, but only the number of trucks per day is recorded and there is no information about the source or volume of the faecal sludge.

[6] See http://www.unicef.org/bangladesh/knowledgecentre_5023.htm for the reports. Detailed information can be found under environment chapter.

2.2 Planning

As the city is expanding, the need of planning for urban sanitation infrastructure has become more obvious. The implementation of sanitation infrastructure is clearly lagging behind the present need. In addition, urbanization will place great pressure on the already insufficient sanitation infrastructure (MLGRDC, 2014). Hence, planning for essential sanitation infrastructure to support faecal sludge management is critical.

In addition to government efforts, faecal sludge management has gained momentum due to numerous NGO initiatives to develop the sanitation sector, including the planning of a faecal sludge treatment plant pilot project implemented by local stakeholders, SNV Netherlands and Water Aid Bangladesh under the project outlined in section 2.1.3.

Additionally, KWASA is preparing a feasibility study for the construction of the first sewerage network in Khulna. Funding is provided by the Asian Development Bank through a loan program. GoB will contribute 20 to 30% of the costs, mostly through human resources and tax exemptions. The feasibility study started in July 2015 and is planned to be finalised by December 2015. It is planned to construct a wastewater treatment plant, which may also be designed to receive faecal sludge. Information such as scale and type of technology are not yet available, as the development of this project will be based on the feasibility study (Abdullah, 2015).

At the national level, GoB plans to improve sanitation conditions gradually with its water supply and sanitation sector development plan. The plan includes three time frames. The short term goal from 2011 to 2015 is to provide at least the basic level of services. The medium term goal from 2016 to 2020 is to provide improved service levels and capacity building for relevant institutions. The long-term goal from 2021 to 2025 will further improve the service levels and further strengthen the relevant institutions (Ministry of Local Government, 2011)

2.2.1 Service targets

A comprehensive sanitation plan, specifically for Khulna, does not exist. Therefore, KCC focuses on pursuing the target set by the national government. The target was to reach 100% access to sanitation services by 2010 (MLGRDC, 2005), but the timeframe was revised to 2013 (Rahman, 2009). However, currently 8% of residents in Khulna rely on unimproved sanitation technologies or have no access at all (SNV, 2014).

Projects implemented by the local NGO Nabolok Parishad, such as the ASEH or the PEHUP project outlined in section 2.1.3, focus on the provision of sanitation infrastructure in urban areas to reach the targets of the national government. However, they are mostly concerned with containment, the first step of the sanitation service chain without fully integrating the whole sanitation service chain. However, KCC is keen to scale up these projects and integrate faecal sludge management services (Jabbar, 2015b)

2.2.2 Investments

Budgets for sanitation services have increased substantially over the past years (Ministry of Local Government, 2011). However, the increased budget does not fully cover the need of future investments. Table 2 provides a breakdown of the different scenarios for the development of the sanitation sector and the total investment needed[7].

> "…there remains a significant gap between the current level of investment and the investment that will be required during the next five years period to achieve full coverage (Rahman, 2009) p.5"

The most apparent result from the on-going sanitation program is the decrease of OD from 19% in 2000 to 3% in 2014 (Ahsan et al., 2014). Achieving "100% Sanitation" has been a key strategy of the government since a baseline survey was conducted in 2003 (Rahman, 2009). A comprehensive definition of "100% Sanitation" can be found in the National Sanitation Strategy (2005), which states that the term will mean to include all of the following:

- No open defecation
- Hygienic latrines available to all
- Use of hygienic latrines by all
- Proper maintenance of latrines for continual use, and
- Improved hygienic practice

[7] See Sector Development Plan (FY 2011-2025) Water Supply and Sanitation Sector in Bangladesh: Working Document Number 19 for detailed breakdown of the total investment.

Table 2: Total investment cost for different scenarios for the development of the sanitation sector and the total investment needed (Ministry of Local Government, 2011)

Scenarios	**Short-term** **FY 2011-2015 (in million USD)**	**Medium-term** **FY 2016-2020 (in million USD)**	**Long-term** **FY 2021-2025** **(in million USD)**	**Total** **FY 2011-2025 (in million USD)**
Scenario 1 (Base case)	3,865	5,407	6,788	16,060
Scenario 2 (Moderate)	5,434	7,486	8,016	20,936
Scenario 3 (High)	6,662	9,086	9,355	25,063

Apart from the governmental programs, NGOs with funding from international funding agencies (e.g., the UPPR program[8]), have made remarkable improvements in sanitation service provision, especially in low-income communities. Through the UPPR, 7,347 twin pit latrines have been built, with an investment of 604,700 USD[9]. Additionally, three vacutugs have been purchased and provided to the CDC, equalling 63,172 USD, with an additional 111,559 USD for capacity building (UPPR, 2015). More information about the setup of CDCs can be found in section 3.1.4.

2.3 Reducing inequity

In Khulna, 8.4% of total households are living in poor settlements and do not have adequate access to basic services, e.g., electricity and sanitation. The GoB has promulgated the Pro Poor Strategy for Water and Sanitation Sector in 2005 and the Poverty Reduction Strategy Paper in 2013. These documents are very important for the design of a suitable action plan that would address the lack of basic sanitation services in low-income areas. Furthermore, the GoB has a yearly national budget detailed in the Annual Development Program (ADP). The ADP budget allocation for the sanitation sector has increased from 2.34% of the total national budget in 2006 to 4.86% in 2010 (Rahman, 2009). Additionally, 20% of the ADP budget to *Upazila* (Sub-district) is allocated for sanitation service provision, of which 75% will be allocated to the provision of subsidies for sanitation infrastructure in low-income households (Ministry of Local Government, 2011, Rahman, 2009).

2.3.1 Current choice of services for the urban poor

The major challenge when providing sanitation services in urban poor settlements is the issue of land tenure. Normally, public service providers do not operate in areas where the land's legal status is not clear. Fortunately, GoB has recognized that it is important to "delink service provisions from land tenure ship to allow service providers to extend their services to low-income communities" (MLGRDC, 2014) p. 22.

Direct observation in Khulna and the Focus Group Discussion (FGD) sessions revealed that low-income dwellers have access to faecal sludge emptying and transportation services, such as the services performed by CDCs with 1 m^3 vacutugs. However, lack of promotion and the preferred use of manual emptying techniques, result in vacutug services not being used to capacity.

[8] See http://www.upprbd.org/ for detailed information.
[9] 1 USD = 77.69 BDT and 1 BDT = 0.013 USD

When the community was involved in the implementation of sanitation projects, services appear to be more sustainable. For example, low-income dwellers have been encouraged to contribute at least 5-10% of the shared sanitation infrastructure costs in order to use the facility (Mamun, 2015). This creates a sense of ownership and results in better use of the system.

2.3.2 Plans and measures to reduce inequity

The NPSWSS 1998 has the aim to ensure that all people have affordable access to equitable and sustainable sanitation services. Therefore, delivering the basic minimum level of service[10] to hard-core[11] poor people is non-negotiable. Eligible groups will be provided with subsidies for the construction of latrines.

The 'National Sanitation Fund' (Rahman, 2009) has tried to provide new funding mechanisms for the poor and the hard-core poor. The fund can be used to purchase hardware for the implementation of sanitation infrastructure in urban poor communities. KCC has the mandate to thoroughly address the urban poor's sanitation problem but is not able to due to a limited budget (Jabbar, 2015b)

2.4 Outputs

Although KCC's limited budget makes it impossible to fully implement faecal sludge management, it does make it possible to increase the number of people who use hygienic latrines (Jabbar, 2015b) especially since the population is highly dependent on onsite sanitation technologies. From a technical point of view, KCC and local government organisations in general are in the learning process of implementing faecal sludge management (Jabbar, 2015b).

2.4.1 Capacity to meet service needs, demands and targets

Currently, there is little capacity to keep up with future demand beyond the provision of sanitation infrastructure at the household level. However, many international NGOs are working on implementing faecal sludge management in Khulna, which is having a positive impact.

The priority of NGOs working in Khulna is the provision of sanitation infrastructure at the household level, as this is part of the poverty alleviation programs. Through the UPPR program, sanitation infrastructure has been provided to low-income communities. However, two to three times more funding is required compared to what has been invested by the UPPR program to entirely cover Khulna with adequate onsite sanitation technologies (Ahmed, 2015a).

2.4.2 Monitoring and reporting access to services

Monitoring and reporting access to sanitation services in Khulna is weak. There is inadequate law enforcement and not enough resources to oversee the jurisdiction processes of KDA (Ahmed, 2015b). Additionally, there are no existing laws covering workers of the CDC who use the motorized emptying equipment, which results in the practice of illegal faecal sludge dumping (Rashid and Moslima, 2015).

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[10] Sanitation basic minimum level of service is defined as having a hygienic latrine for each household whereas the hygienic latrine is defined as confinement of feces; sealing of the passage between the squat hole and the pit; preventing venting out of foul gases (Pro poor strategy for water and sanitation, 2005).

[11] Eligibility criteria: landless households; homeless; head of the family owns less than 50 decimal of agriculture land or rents a premise lesser than 200 square feet and has no fixed source of income; Households headed by disabled or females or old aged (more than 65 years old) person (Pro poor strategy for water and sanitation, 2005).

2.5 Expansion

The Sector Development Plan (SDP) 2011-2025 provides details of what the GoB wants to achieve in the long-term; the target is to provide 100% of the population with sanitation services, ranging from sewerage systems to pit latrines (Ministry of Local Government, 2011). The possibility of building a sewer is daunting, as KWASA will be in charge of offsite sanitation, and currently has a budget gap[12] of 70% for these services (Ministry of Local Government, 2011).

2.5.1 Stimulating demand for services

Health education and hygiene promotion is key to improve the demand for sanitation services. When people understand the benefits derived from improved sanitation conditions, hopefully they will self-initiate upgrades to their sanitation technologies to sustain their hygienic conditions (MLGRDC, 2005). Furthermore, making low-cost sanitation technologies available is necessary to stimulate the demand for sanitation services, especially in low-income communities.

In addition, there should be a system in place for regulated and enforced desludging in order to maximize the role of the existing emptying service providers (MLGRDC, 2005). Another way GoB is stimulating demand for sanitation services is through media campaigns. The omnipresence of sanitation campaigns in local neighbourhoods will familiarize people with hygienic sanitation practices, and GoB has proclaimed October as the sanitation month since 2003 (Rahman, 2009).

2.5.2 Strengthening service provider roles

As described in section 2.1.3, governmental organizations and NGOs have been the key players in sanitation service provision. However, the GoB is planning to strengthen and expand the capacity of the private sector, specifically in faecal sludge management. Under the National Strategy for Water Supply and Sanitation (2014) it is planned to “provide technical and business support to private sector in sludge management, recycling and sale of compost or other products” (MLGRDC, 2014) p.18, next to “giving priority to the management of faecal sludge from septic tanks and pit latrines, such that all sludge are collected, transported, treated and disposed safely in an environmental friendly manner” (MLGRDC, 2014) p.17.

Detailed plans on how this will be implemented are not yet available, but the importance of faecal sludge management is being acknowledged and strategies are in place to provide such services in a sustainable manner.

[12] Required public sector investment for the short term (5 years) is 7,069,000,000 BDT or 91,897,000 USD whereas the available budget is 2,100,000,000 BDT or 27,300,000 USD.

3 Service Outcomes

3.1 Overview

This section presents the range of infrastructure/technologies, methods and services designed to support the management of excreta through the sanitation service chain in Khulna. For details on quantitative estimations, refer to section 3.2.

3.1.1 Offsite Sanitation Technology

In Khulna no centralized sewer system exists (Abdullah, 2015). However, there is one Decentralized Wastewater Treatment Plant (DEWATS) pilot project serving about 200 households who live in two 5-storey buildings in a former jute factory (SNV, 2014). WaterAid, with the local NGO Nabolok, installed the treatment infrastructure. The project focuses on poor urban sanitation programs in densely populated low-income areas. Although this is an appropriate and definitely improved solution, the implementation of DEWATS is relatively expensive for local communities, and the effluent Chemical Oxygen Demand (COD) is still above discharge limits. As stated above, plans are in existence for the construction of a sewer systems by KWASA (Abdullah, 2015).

3.1.2 Onsite Sanitation Technology

Besides the above mentioned DEWATS, Khulna relies 100% on onsite sanitation technologies, such as septic tanks or pit latrines. Most of the septic tanks are not connected to a soak pit, but to open drains or the open ground. In informal settlements simple pit latrines are common, but with the high water table they frequently overflow during the rainy season (Roy, 2014). However, pit latrines are still promoted by NGOs in these areas. The average volume of a septic tank is 14.4 m^3 and the average volume of a pit latrine is 3.13 m^3 (Opel et al., 2012) In some low-income communities, excreta is directly released into ponds by the use of hanging latrines or by connecting pipes directly to open drains without any containment (SNV, 2014, BBS and UNICEF, 2007).

Septic tanks are dominant in the city centre where most people live in multi-storey buildings, whereas people who live in peri-urban areas and low-income communities utilize mainly pit latrines. Septic tanks are constructed watertight, but are generally connected to open drains or open ground (Islam et al., 2010, SNV, 2014, Rahman, 2009).

3.1.3 Open Defecation

A strong political commitment from GoB to reduce OD through the implementation of critical interventions and policies has resulted in OD not being widely practiced anymore (Rahman, 2009). Pressure within the communities plays an important role in the decrease of OD. In addition, Khulna is an urbanized city and there is little space available to practice OD. Even though it is not categorized as OD, hanging latrines above rivers and water bodies are still prevalent, especially in low-income areas.

3.1.4 Emptying and Transport Service Provision

Emptying services in Khulna include manual and motorized service provision, however, as presented in Figure 4, 81% of the services are performed manually and another 17% are a combination of motorized and manual services (SNV 2014, Opel 2012 and Chowdhry and Kone 2012). The main reason households use manual emptying services is because it is readily available (75%), followed by affordability (23%), and flexible timing (10%) (Opel, 2012). This highlights the limited demand for motorized emptying services.

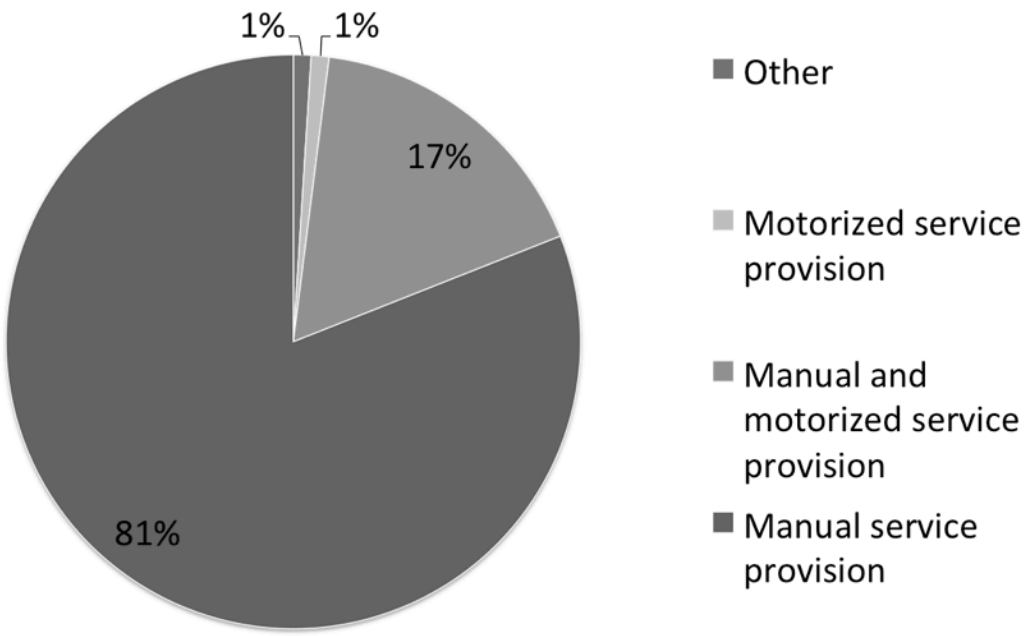

Figure 4: Percentages of manual and motorized emptying of faecal sludge in Khulna (SNV, 2014)

Manual emptiers do not feel any competition or rivalry with the motorized service provider (FGD with Manual Emptier, 2015). Manual emptying of onsite sanitation technologies mainly takes place during the night. A manual emptier, also known in Khulna as a sweeper, first pours kerosene into the containment to reduce odours. Simple tools, such as a hoe or a shovel, a bamboo stick and a bucket, are used to perform the job. In many cases, the manual emptier has to climb into the containment structure to thoroughly empty the system. It is common to find solid waste in the containment systems, and broken glass often results in injuries. This is another reason why motorized emptying services are not effective, as hosepipes and pumps get blocked from solid waste. On average, each manual emptier collects around 0.5 m^3 faecal sludge per day from various sources, e.g., households, schools, madrasas, multi-storey buildings, and markets (FGD with Manual Emptier, 2015).

There are approximately 150-200 active manual emptying service providers in Khulna (Tasaduzzaman, 2015). However, there is no official record regarding the exact number of active manual emptiers. The emptying services are informal due to the fact that they are not paying taxes, nor are they registered (Kome, 2011). Manual emptying has been practised in Khulna for decades and, despite the social stigma faced by manual emptiers, the demand for these services is high.

An interesting finding is that groups of manual emptiers have established a “contractor mechanism” to empty septic tanks collectively, whereas one person acts as the contractor and organises the emptying event. On average, the manual emptier group will earn 103-126 USD per job, but the biggest share of the money goes to the contractor (FGD with Manual Emptier, 2015).

Table 3 provides an overview of the capacity, price and usage of manual and motorized emptying service provision in Khulna. One manual emptier works an average of 20 days per month and can empty around 0.5 m^3 faecal sludge per day, which results in around 68.7 m^3 of faecal sludge collected per day. The price for the emptying services can vary depending on how many trips need to be performed. Manual emptying service providers report that they empty as much faecal sludge as the owner requests, which often depends on the amount of money that is available. Due to the low capacity, vacutugs often perform several trips to fully empty a system, which increases the costs for the household. Motorized services are performing below capacity with around 10 trips/month on average, collecting on average 1.6 and 1 m^3 faecal sludge per day.

Table 3: Types of faecal sludge collection and transport service providers operating in Khulna. (FGD Manual Emptier, 2015. FGD CDC drivers and workers, 2015)

Service Provider	Capacity	Price (USD/trip)	Average FS collection (m^3/d)	Trips/month
Motorized KCC	Two 5 m^3 tractor	26	1.6	10
Motorized CDC	Three 1 m^3 Vacutugs	6-8	1.1	11
Manual Emptier	200 people	13	66	20

Two formally established operators provide motorized emptying services in Khulna (i.e. KCC and CDCs). KCC has provided motorized emptying services since 2000 under the management of the Conservancy Department. In 2000, two motorized emptying trucks were introduced in Khulna and KCC is providing motorized emptying services under the management of the Conservancy Department (Rahman, 2015). The trucks are a retrofitted tractor with a 5 m^3 container tank and a suction pump (see Figure 5). The tractor is slow and cannot handle a terrain with an incline above 3%, which leads to increased costs for the emptying and transportation process (Opel and Bashar, 2013). Narrow roads are difficult to access and repairs and maintenance of the tractor is challenging (Opel and Bashar, 2013). Out of two tractors that are existing, only one is currently being operated (Tasaduzzaman, 2015).

Figure 5: Tractor with 5 m^3 container tank used for motorized emptying services. Photo: Arief Gunawan

The Conservancy Department is in charge of managing the trucks. The customers of KCC's services are mostly commercial and office buildings and to some extent households with spacious road connections. In order to use the KCC service, people have to apply for it beforehand and pay the fee in advance. Normally, it takes two to three days to process the application and KCC will send an officer to check the containment condition one day prior to the emptying event. KCC charges about 26 USD per trip of a 5 m^3 tractor. As there are many narrow roads in Khulna, which the trucks cannot access, they do only ten trips per month on average. Considering that the population of Khulna is 1.5 million, it is surprising that this service is not more utilized. Revenue generated from KCC motorized emptying services does not cover the daily operation and maintenance costs (Tasaduzzaman, 2015). The average volume of faecal sludge collected by KCC is around 1.6 m^3 per day.

In addition to emptying services provided with the 5 m^3 tractor, KCC provides six 1 m^3 bogeys for transportation of faecal sludge. These bogeys, as shown in Figure 4, are used by manual emptying service providers and are aimed to provide services to individual households in areas with narrow lanes. However, in these cases there is no need for the bogey as the collected sludge often gets dumped in the nearby environment. Manual emptiers use the bogey to collect sludge from commercial buildings or apartment blocks, as there is no space nearby for discharge. KCC rents out three bogeys for a fee of 300 BDT. This fee has not been adjusted since 1984. During the process of transportation, the bogey can be connected to a mini van.

Figure 6: A 1 m³ towable bogey that is no longer in operation.
Photo: Arief Gunawan

Under the UPPR program, urban households in low-income areas of Khulna were mobilized by joining so called Primary Groups (PGs). About 20 households represent one PG, which UPPR worked with in direct collaboration. The program focuses on women empowerment, which results in almost all members being women. These PGs formed the CDCs, which came together and engaged in the development of Community Action Plans (CAP) to identify the needs of their communities and design solutions to tackle them and improve living conditions and reduce poverty. Each CDC represents about 200 to 300 households and is supported to prepare and manage community contracts to deliver infrastructure and services to meet the needs of the community. Several CDCs were put together to form Cluster Committees, which allow the sharing of experiences, lessons learned and the establishment of networks between the CDCs. At the highest level, these clusters are organized in CDC Federations, which provide training, establish partnerships and linkages, and furthermore mobilize resources from Local Government Institutions (LGIs) (UPPR, 2015).

In early 2014, three CDC clusters have been supported by the program with one vacutug each (Rashid and Moslima, 2015). The vacutug is a mini pick-up truck fitted with a small suction pump and a 1 m^3 tank for faecal sludge collection (see Figure 7). The vacutug is more practical than full-sized trucks in Khulna because it has the ability to manoeuvre narrow roads. Nonetheless, a shortcoming of the vacutug is the small tank size. Therefore, it needs several trips to completely empty a containment system, which increases the costs for the household. The emptying service fee is 6 USD - 8 USD per trip. There is no strict rule regarding the fee because the vacutug also targets low-income areas where the majority of people may not be able to afford the services.

Figure 7: Vacutug operating in Khulna. Photo: Arief Gunawan.

The vacutugs operate in three clusters. Cluster one covers wards 1-10, cluster two covers wards 11-20 and cluster three covers wards 21-31. Demand for emptying services increases during the rainy season, especially for the users of pit latrines. On average, every vacutug does 11 trips per month (FGD with CDC driver and worker, 2015) (Abeysuriya et al., 2014).

During the FGD with all three vacutug CDC drivers and workers, the reported number of trips in during the rainy season (July-August) is 10-12 times, which is not higher compared to the dry season and could be explained by faecal sludge being directly "flushed out" into the environment.

3.1.5 Treatment

There is no faecal sludge treatment plant for the discharge and treatment of faecal sludge in Khulna (Opel et al., 2012). However, there is a trenching ground where emptying service providers can legally discharge faecal sludge, as shown in Figure 8. The trench is approximately 2.4 m deep, 1.8 m wide and 60 m long, with a total volume of 260 m^3. It is located in Rajbandh next to the sanitary landfill for municipal solid waste, which is 10 km from the city centre of Khulna and too far of a transport distance from the areas served by vacutugs under CDCs (Abeysuriya et al., 2014). Therefore, it can be assumed that faecal sludge is being illegally discharged to avoid prohibitive transportation costs. This assumption is also supported by records at the discharge location, which show that on average only two vehicles discharge faecal sludge per month. However, the record keeping may not be performed regularly and during observations of the discharge site, it was also observed that faecal sludge is being discharged at the surrounding area and not directly into the trenching ground. During a FGD with CDC operators, illegal practices were denied.

Figure 8: Trenching ground for discharge of faecal sludge. Photo: Arief Gunawan

Under the Demonstration of Pro-poor Market-based Solutions for Faecal Sludge Management in Urban Centres of Southern Bangladesh project, implemented by SNV Bangladesh, a feasibility study to support the selection, design, construction and operation of treatment solutions was produced in collaboration with the Asian Institute of Technology (AIT) in 2015. The study includes three different design options C for future construction, which has been scheduled to start in late 2015 (AIT, 2015).

3.1.6 End Use/Disposal

Due to the absence of a faecal sludge treatment plant, safe disposal of faecal sludge is not possible in Khulna. However, some end-use activities could be identified at the household level and are described in section 3.2.6.

3.2 SFD Matrix

Presented in Table 3 is a summary of different terminology for sanitation systems used by the references in compiling this report. Understanding the different terminology was key to interpreting the data. The SNV Baseline Survey and MICS (2007) have adopted the sanitation system definitions from the WHO/UNICEF Joint Monitoring Programme.

Table 4: Different terminologies used between SNV Baseline Report (SNV, 2014) and SFD Report

Terminology in (SNV, 2014)	**Definition**	**Terminology in SFD**	**Definition**
Hanging Latrine	A toilet built over the sea, a river, or other body of water, into which excreta directly drops.	No onsite container, user interface connected to water body	A fully functioning UI discharging directly to a water body. The excreta are raw, untreated and hazardous.
Direct open pit/pit without cover	A pit latrine without a slab uses a hole in the ground for excreta collection and does not have a squatting slab, platform or seat.	Unlined pit	An unlined pit with permeable walls and base through which infiltration can occur.
Latrine connected to open space or drain	Refers to excreta being deposited in or nearby the HH environment (not to pit, ST or sewer).	No onsite container, user interface directly discharges to open drains	A fully functioning user interface discharging directly to an open drain or a storm sewer. The excreta are raw, untreated and hazardous.
Don't know where it goes after flushing	Indicates that the household sanitation facility is improved and that the respondent might not know if their toilet is connected to a sewer or a septic tank.	No onsite container, user interface directly discharges but user does not know to where	A fully functioning user interface discharging directly to 'don't know where'. The excreta is raw, untreated and hazardous
Covered Pit Latrine	A system that flushes excreta to a hole in the ground or a leaching pit (protected, covered)	Unlined pit	An unlined pit with permeable walls and base, through which infiltration can occur.
Pit Latrine with covered slab and pan	A dry pit latrine where the pit is fully covered by a slab or platform that is fitted either with a squatting hole or a seat	Lined pit with semi permeable walls and open bottom category	A pit with semi-permeable lined walls and an open, permeable base through which infiltration can occur.
Ventilated Improved	A dry pit latrine ventilated by a pipe that extends	Lined pit with semi permeable walls and open	A pit with semi-permeable lined walls and an open,

Pit Latrine	above the latrine roof	bottom category	permeable base, through which infiltration can occur.
Septic Tank	An excreta collection device consisting of a watertight settling tank. The treated effluent usually seeps into the ground through a leaching pit.	Septic tank	A watertight chamber made of concrete, brickwork or blockwork, fibreglass, PVC or plastic through which Blackwater and Greywater flows for primary Treatment. Septic Tanks should have at least two chambers. A Septic Tank has an Outlet from the second chamber to a sub-surface infiltration system (such as a Soak Pit) or to a Sewer.
Open Defecation	No facilities, bush or field, excreta is deposited on the ground or in surface water.	Open Defecation	A situation where no User Interface is in use; people defecate in fields, forests, bushes, bodies of water or other open spaces.

3.2.1 Risk of groundwater pollution

The SFD assessment includes the risk of groundwater pollution as an important factor in determining whether excreta is contained or not contained. If the risk of contamination to groundwater is low, then faecal sludge is considered “contained”. The type of onsite sanitation technology in use also has an influence on infiltration of liquid into the groundwater and therefore on the potential risk of groundwater and ultimately drinking water pollution. Pit latrines can be fully lined, partly lined or unlined, septic tanks can have an open bottom, discharge effluent into a soak pit or into open drains. The SFD methodology and tools define these parameters and additionally include other context specific factors, such as:

- Groundwater level
- Soil characteristics / rock type
- Distance between containment and drinking water sources
- Percentage of drinking water produced from groundwater sources
- Water production technology

Within the SFD calculation tool, a combination of these factors result in whether there is a significant or low groundwater pollution risk level. Some types of onsite technologies never contain faecal sludge (e.g. septic tank connected to open drain), while others always contain faecal sludge (e.g. fully lined tank (sealed)) even if there is a significant risk of groundwater pollution. Within the context of one city, there could be multiple different scenarios existing. For example, in Dar es Salaam, Tanzania, 28 different scenarios were identified (Eawag/Sandec, 2015).

In Khulna, it was decided to characterize all existing sanitation containment systems as having a significant risk of groundwater pollution due to the high groundwater table. Based on the available literature, it was assumed that this situation accounts for all system in the whole city of Khulna. Presented in the following sections are all assumptions that were made to create the SFD diagram, based on available literature and the research carried out during this project.

1. <u>Vulnerability of aquifer</u>

The outcome for vulnerability of aquifer to groundwater pollution results in “significant risk”, based on the following two questions.

What is the rock type in the unsaturated zone?

A study undertaken by the University of Rajhasi and the University of Khulna have shown the soil sequences to consist of medium to high plastic clay at top and poorly graded sand below. Up to a depth of 5 m, the percentage of sand varies from 4 to 38 (average 10.2%), silt from 20% to 70% (average 57.9%) and clay from 6% to 75% (average 31.9%). Soil types at the site of engineering boreholes very greatly with sand varying from 15% to 92% (average 69.8%), silt from 8% to 69% (average 26.3%) and clay from 12% to 36% (average 3.9%). Soil properties in the Khulna area have shown a broad similarity at different sites and depth, including parameter, such as natural moisture content, specific gravity and mean grain diameter (Adhikari et al., 2006). For the purpose of the assessment on groundwater pollution risk, it was therefore decided to select “fine sand, silt and clay” as the option for the whole Khulna area.

What is the depth to the groundwater table?

Within the city area of Khulna, soils are occurring in a saturated condition with groundwater table lying less than 1 m below the surface. Soils up to 5 m are sensitive to liquefaction at different degree (Adhikari et al., 2006). As the topography of Khulna is relatively flat, it can be assumed that these conditions prevail within the whole study area. For the purpose of the assessment on groundwater pollution risk a depth of <5m for the groundwater table was chosen. During the rainy reasons, these conditions further worsen the situation, as sanitation systems such as pit latrines frequently overflow, which results in excreta being directly discharged to the environment.

2. Lateral separation

The outcome for lateral separation to groundwater pollution results in “significant risk”, based on the following two questions.

What is the percentage of sanitation facilities that are located <10m from groundwater sources?

No data sources could be identified that provide sufficient information on the distance between sanitation facilities and groundwater sources. However, due to the result of significant risk for the vulnerability of the aquifer, it was decided to select “greater than 25%”. Even though it may be possible that less than 25% of the sanitation facilities are actually located <10m from groundwater sources, this parameter has a significant impact on the overall groundwater pollution risk. To not underestimate the groundwater pollution risk that results from the existing sanitation containment systems, the study team decided to classify all systems as having a significant risk.

Without any further assessment of the remaining three questions the outcome for groundwater pollution risk in Khulna is classified as significant at this stage. However, available information was analyzed and reported.

What is the percentage of sanitation facilities, if any, that are located uphill of groundwater sources?

The topography of Khulna has a level surface and it can be assumed that “less then 25%” of sanitation facilities are located uphill of groundwater sources (Adhikari et al., 2006). However, this also results in stagnation of water and does not allow for run-off, which can have an equal negative impact due to not contained excreta.

3. Water supply

Percentage of drinking water produced from groundwater sources

KWASA is the public utility for water supply and provides piped water for 47.5% of the total piped water supply in the city. Water comes from tube wells without water treatment and the limited distribution system has a total length of 268 km (Fahmida et al., 2013). Sufficient information on sources of drinking water was not available, while traditional water sources were mainly ponds, dug wells and canals before the independence of Bangladesh in 1971 (MLGRDC, 2011). Therefore, it could be assumed that still today, demand for water and drinking water is supplied through these sources. For the purpose of the assessment on groundwater pollution risk the percentage of drinking water produced from groundwater sources was selected as “greater than 25%”, which furthermore contributes to the result of “significant risk” for the groundwater pollution risk level.

4. Water production

Water production technology

Water supply comes from deep tube wells without water treatment. Reliable sources on whether or not these tube wells are sufficiently protected was not available. However, a study implemented by Fahmida et al. (2013) found that 67% and 100% of all samples analyzed exceeded the permissible limit for *E.coli* and Total Coliforms. The study furthermore revealed that water is already contaminated at the source but contamination further occurs and increases within the water distribution network up the household. The study acknowledges that cross contamination could occur by leaking pipes, which supports the overall assumptions of significant risk for the groundwater pollution risk level. For the purpose of the assessment on groundwater pollution risk the water production technology was selected as “Protected boreholes, protected dug wells or protected spring where adequate sanitary measures are in place”. However, this does not have an impact on the overall existing significant risk of groundwater pollution.

3.2.2 Sanitation Systems in Use

The following sections summarize and describe the types of systems currently in use in Khulna, and the percentages of the population using these systems. For interpretation of different terminologies in use, refer to Table 4. All existing onsite sanitation systems are summarized in Table 5, including the Tab 1 reference of the SFD calculation tool and the sanitation containment systems reference. These two references provide more detailed information on the definition of the systems in use.

Table 5: Final estimations for the SFD matrix calculations on containment.

Tab 1 reference	Description of sanitation containment system	Sanitation containment systems schematic reference	% of pop using this system
T1A1C4	User interface discharges directly to a decentralised foul/separate sewer	Reference L2	0%
T1A1C6	User interface discharges directly to open drain or storm sewer	Reference L4	7%
T1A1C7	User interface discharges directly to water body	Reference L5	1%
T1A1C9	User interface discharges directly to 'don't know where'	Reference L5	1%
T2A2C5	Septic tank connected to soak pit, where there is a 'significant risk' of groundwater pollution	Reference S2	5%
T1A2C6	Septic tank connected to open drain or storm sewer	Reference L8	48%
T1A2C8	Septic tank connected to open ground	Reference L9	8%
T2A5C10	Lined pit with semi-permeable walls and open bottom, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	Reference S4	22%
T2A6C10	Unlined pit, no outlet or overflow, where there is a 'significant risk' of groundwater pollution	Reference S4	7%
T1B11 C7 TO C9	Open defecation	Reference L20	1%

Offsite Sanitation Systems

As described in section 3.1.1, the only existing treatment plant for wastewater in Khulna is the DEWATS facility in the Kalishpur area. The system is used by 0.07% of the population or about 200 households (SNV, 2014). For the assessment of percentages contributing to the SFD Matrix, it was decided to not include the DEWATS system for offsite sanitation, as 0.07% of the total population is negligible.

Septic Tanks

In total, 61.7% of the population utilize septic tanks (SNV, 2014). Septic tanks can be connected to soak pits, open drains or the open ground. Even though the BNBC prescribes the installation of soak pits for septic tank effluent during the construction of a new building, only 5% of the total population has septic tanks that are connected to soak pits (SNV, 2014). The likelihood of overflowing soak pits during the rainy season could be the main reason for this noncompliance (Islam et al., 2010). The PEHUP project has installed 130 community toilets connected to septic tanks with soak pits. These systems serve 2,973 households, which are living in low-income areas without private household sanitation systems. A total of 0.8% of the total population is using these systems. For the SFD Matrix, it was assumed that a total of 6% of the population is connected to septic tanks with soak pits. Even though the survey undertaken by SNV (2014) is considered a reliable source of information and representative for the city, the use of such systems at non-residential building is increasing. As it can be expected that newly constructed community toilets are equipped with septic tanks following the BNBC, it is assumed that soak pits are installed for the effluent leaving the tank. This was furthermore confirmed during field observations in the low-income area of Basthuhara. Septic tanks with soak pits are furthermore installed at commercial and office buildings, primary schools, bazar/markets and dormitory/hostels. A study performed by Islam et al., (2010) assessed a total of 375 septic tanks in Khulna. The percentage of these systems being connected to a soak pit is presented in Table 6.

Table 6: Percentage of septic tanks connected to soak pits. Adapted from Islam et al., (2010).

Type of building	No. of systems	Connected to soak pit / %	Not connected to soak pit / %
Residential	247	13	87
Commercial/Office	53	34	66
Primary school	50	20	80
Market/Bazar	16	28	72
Dormitory/Hostel	9	33	67

Septic tanks not connected to soak pits are generally connected to open drains. Based on results by Islam et al. (2010), 39% of the population in residential buildings have septic tanks connected to an open drain. SNV (2014) concluded that 52% of the total population use septic tanks that are not connected to soak pits, however, this report did not further analyze whether these systems are connected to open drains or directly to open ground. The study undertaken by SNV (2014) was considered most representative, and hence for the SFD Matrix 48% was used for this type of system.

Septic tanks connected to open drains are defined as not containing excreta by default. The significant risk of groundwater pollution in Khulna cannot be ignored. Even if septic tanks function properly and can contribute to a significant reduction of organic material, nutrients and solids in the final effluent, it cannot be assumed that pathogens are adequately removed. This highly contaminated water is flowing through open drains in most of the residential neighborhoods of Khulna.

Even though it is not very common, some septic tanks in Khulna also directly discharge to open ground. This is practiced in areas where no soak pits were installed, are damaged, and/or no open drains are available to connect to. Islam et al. (2010) report 6% of the total population in residential buildings are using this technology, while SNV (2014) have not differentiated whether the septic tank is connected to the open ground or open drain. However, observations have shown this to be a relatively common practice, and hence for the SFD Matrix, 8% of the total population with septic tanks connected to the open ground was used.

Pit Latrines

Pit latrines are used by 29% of the total population in Khulna. While many different types of pit latrines are constructed, the two most common scenarios were identified for the purpose of the SFD matrix.

In Khulna, unlined pits are characterized as direct open pits or covered pits. In this context, covered pits are defined as a system that flushes excreta to a hole in the ground or a leaching pit (protected, covered), while direct open pits are defined as a pit latrine without a slab that uses a hole in the ground for excreta collection and does not have a squatting slab, platform or seat (see Figure 9). Even though, there is a key difference between these systems in terms of hygienic separation of excreta from human contact, both systems fall under the category of unlined pits, which do not contain excreta and in combination with a significant risk for groundwater contamination are regarded as inappropriate in terms of human and environmental health. In 2006, a multi indicator cluster survey implemented by the Bangladesh Bureau of Statistics and UNICEF evaluated that 19.6% of the population use unlined pits to meet sanitation needs, which at that time was one of the major systems in use (BBS and UNICEF, 2007). However, SNV (2014) reports that 7% of the population utilise this system, which is the percentage used for the SFD matrix. Due to infiltration of the liquid phase into the ground, unlined pits are expected to have lower desludging intervals than lined pits or septic tanks. However, during the rainy season, unlined pits fill up faster, which results in overflow of excreta into the local area and frequently also excreta flushed out by digging trenches from the pit latrine to drain it.

Figure 9: Manual emptying (transferring) of faecal sludge from unlined pit latrine. Photo: Arief Gunawan

VIP latrines and pit latrines covered with slabs and pans are assumed to be lined pit latrines with semi-permeable walls and open bottom. Lined pits provide a better containment structure than unlined pits. The reinforcement structure provides a solid foundation and allows the liquid to infiltrate through the open bottom. Hence, excreta in these systems ranked as not contained at due to the significant risk of groundwater pollution with the open bottom. In 2014, this system was utilized by 22% of the total population in comparison to 6.8% in 2007 (BBS and UNICEF, 2007, SNV, 2014). It can be assumed that unlined pit latrines were replaced by this technology, and 22% was used to generate the SFD diagram.

No containment

In total, 10% of the population of Khulna utilise sanitation systems that have no containment structure at all. Excreta is either directly discharged to open drains (8%) (see Figure 10), water bodies (1%) or households do not know where the user interface discharges to (1%). Additionally, OD is practised by 1% of the population.

Direct discharge of excreta without containment to water bodies is practised in low-income areas through the use of hanging latrines (see Figure 11). The excreta directly falls into a river or pond system, which are often used a source of water for bathing or washing activities, while it also cannot be excluded that these water bodies provide a source of drinking water, regarding that only 47.5% of the demand is covered by a piped water system (Fahmida et al., 2013). In 2007, the use of hanging latrines was practised widely with 12.6%, while major efforts of the GoB and Nabolok Parishad (local NGO, see section 2.1.3) have resulted in a decrease to 0.1% (SNV, 2014). However, field observations and key informant interviews have revealed that this number appears too low, and hence, 1% was used for the SFD matrix.

Figure 10: Public toilet connected to open ground (left) and community building blocks connected to open drain (right). Photos: Arief Gunawan (left), Lars Schoebitz (right).

Figure 11: Hanging latrine (left) and latrine without containment (right) directly discharging excreta into water body. Photos: Lars Schoebitz

In some cases, respondents in household surveys do not know where their user interface discharges to. This result was found within the SNV (2014) study and contributes 1% of the total population to the SFD matrix. It could be assumed that these households are connected to septic tanks, but are unaware of this fact.

Direct discharge of excreta to the open drain without containment is practiced by 8% of the total population of Khulna (SNV, 2014). The user interface is directly connected to open drains or the open ground through a pipe.

Through the implementation of sanitation infrastructure projects and a major commitment of the GoB, OD could be reduced from 19% in 2000 to 3% in 2014 (Ahsan et al., 2014), SNV (2014) have shown OD to be as low as 1.33% in Khulna. For the SFD matrix, OD was set to 1% of the total population.

3.2.3 Emptying

The next step for the SFD Matrix calculations concerns whether or not a system gets emptied. As the SFD is not a mass flow diagram, but rather illustrates percentages based on available information of the current situation of a city, there is no defined timeframe for a system being emptied or not emptied. This decision is highly context specific and familiarity with the local emptying and transport services is required to make an estimate that reflects reality. The assumptions and decisions can be based on very different types of data sets and between two cities; there may be a completely different approach in how to estimate the percentage of systems that have been emptied. For the Khulna context and based on the available information in literature, it was decided to use an approach that considers the frequency of emptying services as the base for calculation, for which the following assumptions were made:

Assumption 1: Data on manual and motorized emptying and transport services collected during KIIs, FGDs and direct observations is a reliable source of information for daily volumes of faecal sludge being collected (compare Table 3).

Assumption 2: Systems that were emptied within the last three years are included as systems that are in use with emptying services.

Assumption 3: Systems not emptied with the last three years are regarded as systems that do not receive emptying services.

As assessed in section 3.2.1, Khulna has a significant risk of groundwater pollution and furthermore experiences frequent flooding during the rainy season. The SFD methodology follows an approach, which assess whether or not excreta is contained. Based on this definition and the local context, it was decided that only systems that have been emptied within the past three years are regarded as receiving emptying services. A similar definition was used by a household survey implemented SNV (2014), and described as “Level 1. Criteria: Unsafe FSM emptying or conveyance: Faecal sludge is discharged directly to the environment or pits/tanks older than three years have not been emptied within the last three years.” p. 41. Overall SNV (2014) defines five different levels for safety of pit emptying and collection. For the SFD assessment, the difference between level 1 and level 2 is of importance, being described as: “Level 2. Partially safe FSM emptying or conveyance: Faecal sludge is not discharged directly to the environment, and pits/tanks older than three years have been emptied within three years, but emptying requires someone to enter the pit and no protective gear is worn.” p.41. The SFD assessment does not include occupational risk factors within the definition of whether excreta is contained or not. Therefore, systems falling under level 2 and higher are regarded as systems receiving emptying services and therefore at the stage of emptying contain excreta.

However, the definition by SNV (2014) only includes information on emptying services of systems that are older than three years, but no information is available on systems that have been built within the past three years. Systems built during the last three years will also require emptying on a cycle of every three years.

Presented in Table 7 are the results of the survey, which overall assessed 4,366 households in Khulna and is regarded as representative for the whole city. Based on this information and the assumptions outlined above, for the SFD matrix it was determined that 3% of the total population receives emptying services, while 97% do not receive any emptying services.

Table 7: Safety level of emptying services in Khulna after SNV (2014)

Level	No. of respondents
Level 4	5
Level 3	13
Level 2	145
Level 1	3,695
Level 0	508
Total respondents	4,366

Another study on emptying services in Khulna, performed by (Opel et al., 2012) in 2011 and interviewing a total of 348 households found that 35% of the population receive emptying services between five and ten years, while for 18% the emptying frequency is above 10 years. Table 8 presents the results of this study. In contradiction to SNV (2014), the results show that 16.7% and 11.9% of the systems receive emptying services once every two and three years, respectively, while 6.8% of the systems get emptied 2-3 times a year. However, due to the relatively low number of samples compared to SNV (2014) and less information on statistical representativeness of the sample distribution, figures presented in Table 7 were regarded as more reliable.

Table 8: Emptying frequency of onsite sanitation technologies in Khulna, assessed by (Opel et al., 2012)

Emptying frequency	% of respondents (n = 348)
2-3 times a year	6.8
Once per year	0
Once every 2 years	16.7
Once every 3 years	11.9
Once every 4 years	11.6
Between 5 – 10 years	35.0
Over 10 years	18.0

For the final estimations for the SFD matrix on emptying frequency, the data sources presented above were combined to make a final estimation, as shown in Table 9. Only systems having received emptying within the last three years are considered to contain faecal sludge due to the significant risk of groundwater contamination. As mentioned above, data collected by SNV (2014) is regarded as the most representative, but to account for the significantly higher percentage of systems having received emptying within the past three years assessed by (Opel et al., 2012), it was decided to use 5% as the final percentage for the SFD calculations. This furthermore results in 95% of the population using systems without emptying services. Due to the significant risk of groundwater pollution, this percentage will fully contribute to excreta not being contained.

Table 9: Estimations on emptying frequency in Khulna.

Emptying frequency	SNV (2014)	(Opel et al., 2012)	SFD Khulna
< = 3 years	3%	35%	5%
> 3 years < 5 years	97%	12 %	20%
> = 5 years		53 %	75%

To verify the information presented in section 3.1.4, Table 3, which shows that on average 69 m^3 faecal sludge per day are being collected, a theoretical calculation based on information in Table 10 was performed.

In Khulna, a total of 1,350,612 people are using onsite sanitation technologies that require emptying services. 5% or 67,530 people received this service within the past three years, or on average 22,510 per year. In Khulna, the average household size is five people per household (compare Table 10) and 68% of all households are using septic tanks, while pit latrines are used by 32%. This results in an average of 3,061 households with septic tanks and 1,440 households with pit latrines serviced per year. The total theoretical amount of faecal sludge being collected from these systems is 49,516 m^3/yr using 2.5 m^3 and 15 m^3 as the average size for pit latrines and septic tanks, respectively. On average per day, this results in 135 m^3 of faecal sludge being collected, which is about twice as high as the amount that was based on field surveys conducted under this study (68.6%). The result is supported by the fact that about 98% of the population of Khulna use manual emptying services to empty their system (compare

Table 11). This study revealed that on average less than one trip per day is performed by motorized emptying service provider, while 200 manual emptying service providers are active in Khulna. As a result, the amount of faecal sludge that is collected is more likely around 100 m^3/d. AIT (2014) and Opel et al. (2012) performed a theoretical calculation of the produced faecal sludge in Khulna of 1,975 and 864 m^3/d, respectively (see Table 10). Using 100 m^3/d as the amount that is being collected, this means that either 95% or 88% remains uncollected. This result supports the assumption of this study, which shows that 5% of the total population use onsite sanitation technologies with emptying services. It is furthermore supported by the fact that systems in Khulna generally do not contain faecal sludge at the step of containment, which was concluded in section 3.2.1.

Table 10: Parameters to for the calculation of collected faecal sludge volumes

Parameter	(AIT, 2015)	(SNV, 2014)	(Opel et al., 2012)	SFD study
No. of ppl per HH	4.2	5.32	4.5	5
Volume septic tank in m^3	16.64	-	14.4	15
Volume pit latrines	1.96	-	3.13	2.5
Production of FS in m^3/day	1,975 [13]	-	864 [14]	-
Theoretical FS collection in m^3/day	NA	NA	NA	135
FS collection in m^3/day, based on field survey	NA	NA	NA	66

Table 11: Percentage of households using motorized and manual emptying services in Khulna.

Emptying service	(SNV, 2014)	(Opel et al., 2012)
HHs using manual emptying	98%	96.3%
HHs using motorized emptying	1%	2%
HHs using other methods	1%	1.7%

3.2.4 Transport

As outlined in section 3.1.5, there is only one legal discharge location existing in Khulna. At this location, only two vehicles discharge faecal sludge per month. Based on findings by (Opel et al., 2012), collected faecal sludge is discharged into open drains (30%) or transported to a designated location for solid waste (25%). Another common practice in Khulna is to dig a hole, discharge the sludge and cover the hole with mud afterwards (40%). This information was confirmed by manual emptying service provider, who reported the discharge of faecal sludge into a nearby drain, if available, or into a hole close to the point of collection, which is covered afterwards. None of these practices can be considered as faecal sludge being delivered to treatment. Therefore, it was decided to use 100% as the figure for sludge being collected but not delivered to treatment.

[13] Details on calculation in (AIT 2015. Draft Feasibility Report, Support to the Selection, Design, Construction and Operation of Short Time Treatment Options for Feacal Sludge. p.35
[14] Calculated by using 0.5 liter per person and day

Table 12: Destination of collected faecal sludge. Adapted from (Opel et al., 2012)

Dumped here and there	2%
Dumped into open drain	30%
Dumped in a particular place (undesignated)	25%
Put into a hole and covered with mud	40%
Open water body	3%

3.2.5 Treatment

As outlined in section 3.1.5, around 200 households in Khulna are connected to a DEWATS plant, but not included into the overall SFD matrix, due to the low percentage of 0.07% of the total population using this system.

However. During field observations guided by the PEHUP project officer, performance data for the existing DEWATS could be collected and is presented in appendix 7.3. The characteristics of the effluent comply with the local limits for disposal in water bodies (ECR, 1997) for the parameters of Biochemical Oxygen Demand (BOD), Total Suspended Solids and Nitrate. However, effluent values are above the limits for Faecal Coliform and Phosphate. The effluent is discharged into an open drain, which flows through the nearby neighbourhood.

Comparing influent and effluent values of nine sampling events between June 2012 and September 2014 shows an average reduction of 86% for BOD, while the reduction for COD is only at 60%. Discharge limits for COD concentrations do not exist, however effluent concentrations range from 320 to 4,800 mg/L (average 2,261 mg/L). This indicates a high concentration of non-biodegradable organic material in the wastewater. During field observations it was noted that the influent of the DEWATS not only constitutes of blackwater but also greywater from showers and washing of laundry. A possible explanation could be the extensive use of detergents, which may include a high concentration of non-biodegradable organic material. An in depth assessment is required to verify this information.

3.2.6 Enduse/Disposal

SNV (2014) found that some households practise the use of faecal sludge endproducts on a very small scale. The study found 99 cases out of a total survey size of 4,367 households, practising resource recovery activities. These activities are presented in Table 13 and include the production of biogas, use in agriculture, poultry and fish feed.

Extrapolation of these numbers for the whole of Khulna, results in 2% of the population using faecal sludge, which would be included as end-use or disposal of excreta in the SFD tool. However, this percentage was not included in the SFD matrix, because faecal sludge from these system is not being collected and transported to designated treatment plants, but rather used directly, untreated, at the household level. Future adaptations of the SFD methodology could consider including these activities as a stream for contained excreta.

Table 13: Activities for resource recovery and end-use of faecal sludge in Khulna. Adapted from (SNV, 2014).

Enduse activity	No. of respondents (n = 4,367)
Biogas	26
Agriculture	68
Poultry feed	1
Fish feed	4

3.2.7 Uncertainty of Data

A variety of data sources were used to derive the best possible estimate of percentages for the SFD matrix. SNV (2014) was regarded as a reliable source of information and representative for the whole city, due to the high number of survey participants, recent completion, and statistical distribution of samples. Methods used for the survey are clearly described. Other publications were also used for validation of data. If there were significant differences between data sources, the authors used this information to formulate questions for KIIs or FGDs. Field observations were also conducted to obtain and evaluate data. For example, in Khulna, literature and interviews suggested that faecal sludge is discharged at the trenching ground located at the sanitary landfill. However, physical observations in combination with a review of discharge records at the site revealed contradictory information.

Another complication is that surveys of access to onsite sanitation facilities frequently use different terminology than what is commonly in use in the local context. These surveys also typically focus on hygienic standards regarding human health and user interface, whereas the SFD methodology focus starts with the onsite containment. Field observations are necessary to evaluate and crosscheck this information, and thereby increase the credibility of the SFD.

Assumptions regarding the amount of faecal sludge being emptied vs. faecal sludge being produced have a high impact on the overall SFD. Reliable methods for estimating quantities of faecal sludge produced on a citywide scale do not yet exist, and it is complicated by the informal nature of the sector. However, data on quantities of total faecal sludge is still frequently reported, even if not reliable. The possibilities for error are clear when comparing these numbers to the numbers for faecal sludge that is being collected. It is clear that this is one benefit of conducting a field-based, versus desk-based study.

4 Stakeholder Engagement

4.1 Key Informant Interviews

SNV Bangladesh was very involved in the preparation of the field study, the identification of key informants, and the verification of results produced during this study. As SNV Bangladesh is actively engaged with local stakeholders, such as the KCC, universities, NGOs, and other cities in Bangladesh, they were able to select key informant interviews that provided reliable and quality information.

In total, eight KIIs were conducted during the field study with representatives from local government and NGOs. Five interviews were within government offices: a KCC engineer, the KDA city planning officer, the managing director of KWASA, a Conservancy Department officer and a Conservancy Department assistant officer. Two interviews were with NGOs: the Nabolok program officer, and the UPPR officer. One interview was with CDC officers.

The advantage of being in the field was that information from existing reports could be crosschecked, and the state of faecal sludge management was readily observable. In addition, most interviewees also provided additional data to complement existing data.

4.2 Focus Group Discussions

Local government officers readily shared their experiences with sanitation service provision in Khulna. Local government officers were interested in the results of the SFD project, and thought they would be useful for illustrating sanitation service provision issues in Khulna.

In total, six focus group discussion (FGD) sessions were conducted. They consisted of users of community toilets, users of private toilets, manual emptiers and employees of the mechanized service provider. The FGD sessions for the users of community toilets and of private toilets were held separately for men and women.

Table 14: List of FGD sessions

Date	FGD session	Number of participants
May 19th 2015	User of community toilet woman session	6
May 19th 2015	User of community toilet man session	6
May 21st 2015	User of private toilet woman session	7
May 21st 2015	User of private toilet man session	5
May 20th 2015	Manual emptier	6
May 26th 2015	Driver and helper of Vacutug	4

The findings from the FGD sessions revealed information that increased the understanding of the sanitation and faecal sludge management sector in Khulna. For example, during the FGD with manual emptying service providers an informal contractual agreement was identified, which allows manual emptying service providers to empty larger containment systems collectively, and consequently generate higher revenue. This highlights potential future roles for the private sector and the potential future role in sanitation service provision in Khulna. Additionally, the FGDs provided a unique atmosphere for discussion in which the participants could freely express their opinions and relate relevant first hand experiences.

4.3 Observation of service providers

Observing the complete process of a manual emptying event provided great insight into the nature of manual emptying service provision in Khulna. The acquired information ranged from: the type of tools used for emptying, the amount of time needed to empty one containment system, the amount of revenue one can earn to the acceptance of manual emptying service provision in local communities. Data collected through direct observations corroborate with the data gathered from FGDs. People using the manual emptying services mentioned that, compared to motorized emptying, the benefit of manual emptying is that the system gets completely emptied.

The biggest advantage of direct observation is that it provides unbiased data and the observer has the opportunity to evaluate the situation from their own perspective. Observation of the official location for faecal sludge discharge provided good insight into the conditions and the surroundings of the place and also generated understanding of the record keeping of daily sludge disposal. It was reported that faecal sludge is generally discharged at this location but it could be observed that sludge had not been discharged for several days, as it was already dry. However, due to a lack of accurate recording, it could not be verified how much sludge is discharged at this location on a daily basis.

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7 Appendix

7.1 Appendix 1: Stakeholder identification (Tab 2: Stakeholder Tracking Tool)

	Stakeholder Group	Name of organisation
Stakeholder 1	City council / Municipal authority / Utility	Khulna Development Authority (KDA)
Stakeholder 2		KDA
Stakeholder 3		Khulna City Corporation (KCC)
Stakeholder 4		KDA
Stakeholder 5		KDA
Stakeholder 6		Khulna Water Supply and Sewerage Authority (KWASA)
Stakeholder 7		Khulna City Corporation (KCC)
Stakeholder 8	Service provider for emptying and transport of faecal sludge	Khulna City Corporation (KCC)
Stakeholder 9		CDC Vacutug
Stakeholder 10		CDC Vacutug
Stakeholder 11		CDC Vacutug
Stakeholder 12		CDC Vacutug
Stakeholder 13		CDC Vacutug
Stakeholder 14		CDC Vacutug
Stakeholder 15		Private Emptier
Stakeholder 16		Private Emptier
Stakeholder 17		Private Emptier
Stakeholder 18		Private Emptier
Stakeholder 19		Private Emptier
Stakeholder 20		Private Emptier
Stakeholder 21	External agencies associated with FSM services: e.g. NGOs,	KUET
Stakeholder 22		Khulna University
Stakeholder 23		Khulna University

Stakeholder 24	academic institutions, donors, private investors, consultants	Nabolok
Stakeholder 25		Nabolok
Stakeholder 26		Nabolok
Stakeholder 27		Nabolok
Stakeholder 28		UPPRP
Stakeholder 29		Nabolok
Stakeholder 30		Mahidol University (Thailand)
Stakeholder 31		AIT

7.2 Appendix 2: Tracking of Engagement (Tab 3: Stakeholder Tracking Tool)

Stakeholder	Date of Engagement	Purpose of Engagement	Maximum 100 word summary of outcomes
City council / Municipal authority / Utility	04-May-15	Meeting	Introducing SFD Project
	06-May-15	Interview	Role of KDA in FSM
	05-May-15	Interview	Explaining in general the FSM in Khulna. No treatment plant and no sewerage system yet. Mostly depends on external support.
	06-May-15	Interview	Role of KDA in FSM
	06-May-15	Interview	Role of KDA in FSM
	07-May-15	Interview	KWASA is responsible for the off-site sanitation system in Khulna but, until today, there is no sewerage system yet. KWASA will conduct a feasibility study later this year.
	26-May-15	Interview	The Conservancy Unit is responsible for FSM in Khulna and for providing emptying and transporting services for FS.
	27-May-15	Interview	Public service provider for emptying and transporting FS. Only one big lorry FS sucker is active right now. KCC provides transportation means for manual emptiers.
Service provider for emptying and	26-May-15	FGD	Information regarding vacutug fleet in Khulna. How the

transport of faecal sludge	26-May-15	FGD	vacutug is operated, who is the costumer, how many trips per month on average, location of the dumpsite, etc.
	26-May-15	FGD	
	26-May-15	FGD	
	20-May-15	FGD	Information regarding manual emptier in Khulna. How the manual emptier community is organized themselves, who is the costumer, how much is cost for the service, What tools they are using, etc.
	20-May-15	FGD	
	20-May-15	FGD	
	20-May-15	FGD	
	20-May-15	FGD	
	20-May-15	FGD	
External agencies associated with FSM services: e.g. NGOs, academic institutions, donors, private investors, consultants	13-Apr-15	Meeting	To organise support from the local university in regards to knowledge and providing FGD assistance.
	16-Apr-15	Meeting	To organise support from the local university in regards to knowledge and providing FGD assistance.
	16-Apr-15	Meeting	To organise support from the local university in regards to knowledge and providing FGD assistance.
	16-Apr-15	Site Visit	Exploring DEWATS in low-income housing. The only decentralised wastewater system in Khulna.
	15-Apr-15	Site Visit	Inspecting the condition of railway low-income area. A local NGO provided a community toilet, but some of the dwellers still do not have access to the sanitary latrine.
	29-Apr-15	Site Visit	Inspecting the condition of railway low-income area. A local NGO provided a community toilet, but some of the dwellers still do not have access to the sanitary latrine.

	29-Apr-15	Site Visit	Inspecting the condition of railway low-income area. A local NGO provided a community toilet, but some of the dwellers still do not have access to the sanitary latrine.
	06-May-15	Interview	International donor backed-project in Bangladesh applied in Khulna. Supporting poor people with various activities in FSM, including providing hardware for urban sanitation, especially low-income dwellers and vacutugs for CDC.
	07-May-15	Interview	Local NGO that contributed to helping poor people to meet their urban sanitation needs. The local NGO received funds from international donors to develop their program.
	11-May-15	Meeting	The consultant team proposed three types of treatment plants for Khulna. The decision making will involve Mayor, counsellors and engineering team of KCC.
	11-May-15	Meeting	The consultant team proposed three types of treatment plants for Khulna. The decision making will involve Mayor, counsellors and engineering team of KCC.
	29-Jun-15	Interview	How CDC vacutug is managed and operated.
	29-Jun-15	Interview	How CDC vacutug is managed and operated.

7.3 Appendix 3: Wastewater characteristics of DEWATS in Khulna.

Wastewater Quality at Different Stages of Treatment Process

Year of Project	Sl No.	Date of Test	Units	Limits dor Disposal in Water Bodies (Bangladesh Gadget,1997)	Inlet of Settler	Outlet of Settler	Middle of ABR (anaerobic filter Bed)	Outlet of anaerobic baffled reactorfilter Bed)	Outlet of Planted filter	Outlet of Polishing pond	Remarks
PH											
1st	T-1	10.06.2012	--	--	6.99	6.66	6.69	6.74	6.72	6.77	--
	T-2	29.07.2012	--	--	7.27	6.89	6.91	6.98	7.08	7.01	--
	T-3	29.08.2012	--	--	7.22	6.77	6.79	6.85	6.93	7.08	--
	T-4	28.11.2012	--	--	6.7	6.56	6.57	6.58	6.58	6.62	--
	T-5	20.02.2013	--	--	7.04	6.98	7.06	7.06	7.11	6.91	--
2nd	T-6	27.05.2013	--	--	6.94	6.52	6.55	6.59	6.59	6.9	--
	T-7	27.01.2014	--	--	6.96	6.93	6.92	6.88	7.01	7	--
	T-8	18.03.2014	--	--	6.88	6.82	6.7	6.84	6.79	6.9	--
3rd	T-9	16.09.2014	--	--	6.93	6.93	6.95	6.98	7.01	7.07	--
BODs											
1st	T-1	10.06.2012	mg/l	40	558	279	84.6	54.6	26	28.2	--
	T-2	29.07.2012	mg/l	40	138	162.9	107.1	92.4	46.8	54.3	--
	T-3	29.08.2012	mg/l	40	590	195	67.3	56.8	41.6	36.2	--
	T-4	28.11.2012	mg/l	40	510	126	81.9	67.2	44.3	33.2	--
	T-5	20.02.2013	mg/l	40	530	138	133	113	63	38	--
2nd	T-6	27.05.2013	mg/l	40	224	195	130	91	76	31	--
	T-7	27.01.2014	mg/l	40	312	180	151	135	106	98	--
	T-8	18.03.2014	mg/l	40	397	116	89	58	33	34	--
3rd	T-9	16.09.2014	mg/l	40	290	104	68	57	31	28	--
COD											
1st	T-1	10.06.2012	mg/l	--	3840	2880	1920	1920	1920	1920	--
	T-2	29.07.2012	mg/l	--	8000	4800	6400	3200	3200	4800	--
	T-3	29.08.2012	mg/l	--	1920	1280	960	880	848	832	--
	T-4	28.11.2012	mg/l	--	1920	928	768	672	640	320	--
	T-5	20.02.2013	mg/l	--	7680	4480	3840	2560	1920	1280	--
2nd	T-6	27.05.2013	mg/l	--	4800	3200	2400	2400	1600	1600	--
	T-7	27.01.2014	mg/l	--	8000	5920	4800	4800	3200	3200	--
	T-8	18.03.2014	mg/l	--	6400	5600	4800	4800	4640	4720	--
3rd	T-9	16.09.2014	mg/l	--	5840	3200	2880	2560	2160	1680	--