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STUDY ON EMPTYING OF FAECAL SLUDGE AT SELECTED AREAS IN KHULNA CITY

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ABSTRACT

Faecal sludge (FS) is the human excreta both in liquid and semi-liquid forms accumulated in pits and septic tanks. Emptying and disposal of FS is usually not managed properly in the developing countries. The aim of this study was to evaluate emptying techniques of FS and to categorize the emptying techniques as safe, partially safe and unsafe at three different types of settlements in Ward No. 9 of Khulna City Corporation (KCC). The three types of settlements included a residential area, a mixed-use area, and a slum area. The study involved a series of questionnaire survey and analysis of the collected data by Standard Package for Social Science (SPSS) and Microsoft Excel software. The study reveals that manual emptying accounts for majority of emptying, while mechanical emptying accounts for only a small fraction of emptying. The emptying of on-site facilities in the residential area is found to be safe" for 56%, "partially safe" for 12.8% and unsafe" for 31.2%. For the mixed-use area, the emptying of on-site facilities in the residential area is found to be safe" for 56%, "partially safe" for 14.2% and unsafe" for 44.5%. And for the slum area, safe emptying is found as 24.7%, partially safe emptying as 13.7%, and unsafe emptying as 61.5%. The study also reveals that the overall quality of emptying techniques is found as 42.1 for the residential and 35.6 for the mixed-use area which represents partially safe emptying techniques exists both two areas. The score for the same is also found as 17.4 at the slum which indicates emptying is unsafe.

Keywords: *Faecal Sludge, Faecal Sludge Management, Emptying, Quality of Emptying Techniques.*

1. INTRODUCTION

Historical records show that sanitation has been a matter of concern to the human race for a very long time. According to WHO (2008), the importance of sanitation is indisputable. It is a crucial stepping stone to better health that sanitation offers us the opportunity to save the lives of 1.5 million (Agyei, 2009) children a year who would otherwise succumb to diarrheal diseases, and to protect the health of much more. It is also key to economic development such as education and health, and bring measurable economic returns (Nkansah, 2009). Bangladesh is lagging behind in the provision of improved sanitation, while making excellent progress in eliminating open defecation and mostly completed the Millennium Development Goal (MDG)-7 by 2015.

According to JMP (2015), Open defection has reduced from 19% in 2000 to 1% in 2017, though 53% of households still do not use improved sanitation. Bangladesh has shown remarkable progress in liminating open defecation, but there is urgent need for Faecal Sludge Management (FSM) in Bangladesh mainly in urban areas (Islam, 2016), where most human waste is dumped untreated into waterways or onto marginal land, harming the environment and health, especialy of the country's poorest (Opel, 2011). There are also instances where faecal sludge are disposed of into the environment untreated (Murungi and Peter, 2014). Most city residents connect their septic tanks directly to drains and local water bodies which is risky for the environment. The city authority have been unable to regulate pollution effectively despite the detrimental effects on the environment or the public health threat (Opel, 2011).

Faecal sludge comprises all liquid and semi-liquid contents of pits and septic tanks of on-site sanitation system, (Strande *et al.,* 2014). The solid part that has been the partially digested and settled at bottom of the onsite sanitation systems. FSM includes the storage, collection, transport, treatment and safe enduse or disposal of FS (Singh *et al.,* 2017). FSM is important because although over a billion people in urban and peri-urban areas of Africa, Asia, and Latin-America are served by on-site sanitation technologies, FS is not well managed in many cities (Murungi and Peter, 2014).

Most of the cities in Bangladesh, including the third largest city Khulna and one of the most climate vulnerable cities in the world (Haque, 2013) having a population around 1.5 Million (KCC, 2017) has no sewer network. In this city, the inadequate containment and emptying option is found for FS (Kabir and Salauddin, 2015). In this city, about 628,070 m^3 (Islam, 2016) of FS is produced every year. Unfortunately, in Khulna City Corporation (KCC) the entire FSM process is unsystematic and mainly maintained by informal private service providers (Islam, 2016). Hence the households are connecting the toilet to a drain. In Khulna city, about 84% of the total households have a septic tank (Kabir and Salauddin, 2015) are connected to a drain or surface water. The practice of safe septic tank emptying is almost absent in Khulna city. More than half of the total households, irrespective of wealth situation,

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either use unsafe emptying or do not at all practice fecal sludge emptying. Safe disposal and treatment of fecal sludge are mostly absent in Khulna (Kabir and Salauddin, 2015) and construction of a Faecal Sludge Treatment Plant (FTP) has been completed in 2017 at Rajhbondh site in Khulna with the initiative of KCC and SNV Netherlands Development Organizations and sludge is being dumped here.

The specific objective of this study is to identify the on-site containment emptying techniques a categorized by safe, partially safe and unsafe emptying at three different types of settlements in Ward No. 9 of Khulna City Corporation (KCC).

2. FAECAL SLUDGE EMPTYING

The initial part of FSM is the containment and it means the storing of human sludge or excreta. Generally, pit and septic tank is regarded as the containment. After a certain times containment needs to be cleaned, that is termed as the emptying of faecal sludge. There are considerable knowledge gaps about fecal sludge emptying as a service, and its effectiveness as a component or an integrated part of city's sanitation service provision. It has been clearly stated in BNBC that the septic tanks should be emptied between six months to one year (BNBC, 2014).

2.1 Quality of emptying techniques

Quality of emptying techniques means the quality of the combination of containment condition and other infrastructures regulations, quality of emptying, always safely for both of workers and environment. Kabir and Salauddin (2015), classified the quality of emptying techniques into five parts. These are environmentally safe emptying, safe emptying, partially safe emptying, and unsafe emptying and not ever emptied.

2.1.1 Safe Emptying

Safe emptying is that which does not cause environmental pollution, safe for emptiers etc. Safe emptying, transportation, and disposal of sludge are extremely important for public health as well as for the social and environmental benefits it brings (Franceys *et al.,* 1992). The next level, mostly safe, indicates that sludge is not discharged directly into the environment; the containment has been emptied within the last three years (Islam, 2016). Selection criteria for safe emptying is shown in Figure 1.

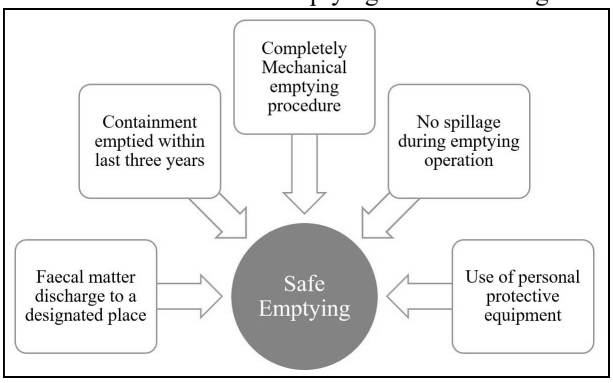

Figure 1: Selection criteria for safe emptying (Source: Islam, 2016)

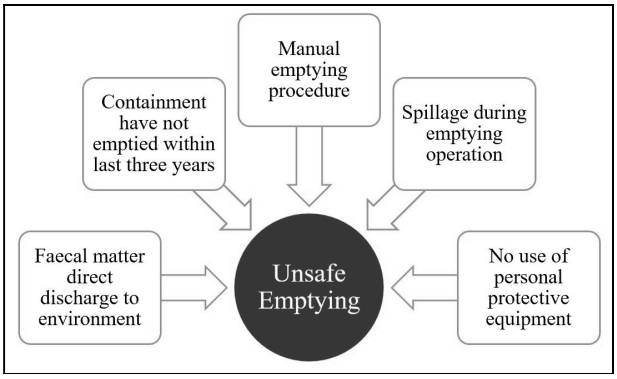

Figure 2: Selection criteria for unsafe emptying (Source: Islam, 2016)

2.1.2 Unsafe Emptying

When the environmental pollution and a certain health hazard has come to account due to the bad emptying of pit and septic tanks, then it can be said unsafe emptying (Franceys *et al*., 1992). In Bangladesh faecal sludge management is generally provided by individuals or informal private sector operators in an unplanned, unsystematic, unhygienic and poorly regulated way (Repon *et al.,* 2015). The level of unsafe emptying is recorded when the sludge is directly discharged into the environment (Islam, 2016); pits have not been emptied within the last three years, or emptying is done with someone entering the containment without protective gear. In Khulna, more than 85% of households practice unsafe faecal sludge emptying and conveyance (Kabir and Salauddin, 2014). Selection criteria for unsafe emptying are shown in Figure 2.

2.1.3 Partially Safe Emptying

Partially safe emptying is considered as a modified quality of emptying techniques between the safe emptying and unsafe emptying. It is an assumption quality of emptying techniques. Sometimes it has been regarded as the

moderate emptying which represents that mostly safe emptying is occurring but a certain percentage of unsafe emptying is occurring besides. Table 1 shows the selection criteria of three types of quality of emptying techniques.

Table 1: Description of the categorized sections for quality of emptying techniques

Categorized Sections	Description
Safe Emptying	➢ Containment is older than three years have been emptied within the last three years ➢ Totally mechanical emptying procedure and no one entered the containment at any time during emptying ➢ Emptiers used safe emptying devices ➢ Emptiers wore protective gear during emptying ➢ FS is discharged in a designated place
Partially Safe Emptying	➢ Households are aware of the need and frequency (standard) of periodic emptying of FS from the containment ➢ Containment has not emptied within last three years but emptied less than five years ➢ Combination use of mechanical and manual procedure to empty the thicken sludge ➢ Containment is accessible by mechanical emptying but lack of willingness to pay for mechanical device ➢ Faecal matter does not directly discharge into environment
Unsafe Emptying	➢ Households are not aware of the need and frequency (standard) of periodic emptying of FS from the containment ➢ No containment and faecal matter directly discharges into environment ➢ Containment is older and have not ever emptied or emptied 5 years ago ➢ Totally manual emptying procedure without use of PPE ➢ No accessibility of mechanical emptying provision ➢ Spillage during emptying operation ➢ Manual emptying requires someone to enter the containment ➢ No protective gear is worn

(Source: Kabir and Salauddin, 2015)

3. METHODOLOGY

In this section, the methodology to conduct the study has been described and also represents the steps of the research work process. The methodology also includes study area selection, sampling method, extensive data collection and analysis procedure.

3.1 Study Area Selection and Description

Khulna is the third largest metropolitan city and situated in the south-western part of Bangladesh. The area of the total city corporation is 45.65 km^2. The population in this city is about 1.5 million and has in total 31 wards (KCC, 2017). This study mainly focuses on the emptying of three types of settlements for assessment. The first type of settlement is a planned residential area, the second one is a mixed-use area and the last one is a slum area. This three types of settlements have been found in Ward No. 09 in Khulna City Corporation. For this reason, Ward No. 09 is selected as the study area. Figure 3 shows the specific study area.

3.2 Selection of Indicators

The research focus is mainly on the assessment of quality of emptying techniques determination. But emptying of FS has been linked with containment management practices and knowledge and perception of the users. In baseline survey by Kabir and Salauddin, 2015 divided the emptying provision into five criteria. Applying some modification here the quality of emptying techniques has been divided into three categories namely unsafe emptying, safe emptying and moderate emptying that means partially safe emptying as shown in Table 2.

3.3 Sample Size Determination and Questionnaire Administration

The questionnaire has been prepared in such a way that there were three portions *i.e.* unsafe emptying, partially safe emptying and safe emptying for each parameter under each indicator. That's why the questionnaire has been prepared into three sections for each question. The first portion of the question is for totally unsafe emptying and will get score 0, then the middle part of the answer is moderate which means partially safe emptying and will get

score 0.5. And the last one is for safe emptying which gets score 1. The questionnaire target is the house owner who can give the extensive information about the containment. The questions have repeated sometimes to check the consistency of the answers.

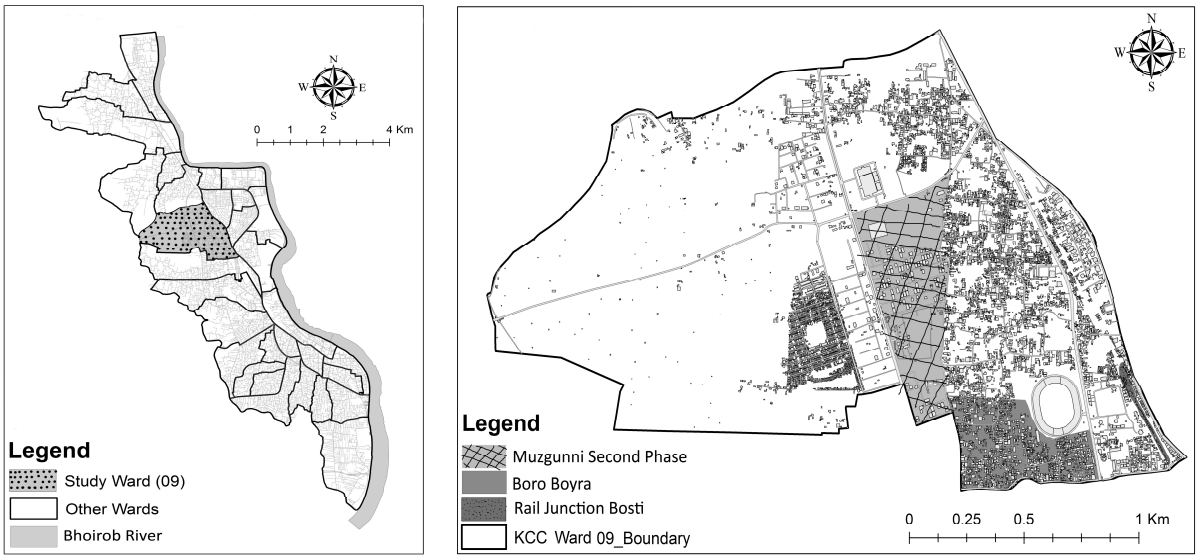

Figure 3: Study area location of Ward No. 09 in Khulna City Corporation (KCC)

Table 2: Indicators of quality of emptying techniques determination

Criteria	Indicators
Containment	Containment size
	Containment condition
	Containment location & accessibility
	Containment outlet connection
Emptying	Emptying type
	Emptying service providers
	Emptying frequency
	Safety issues
	Emptying cost
	Vacutug efficiency
	Disposal of FS
Users Knowledge & Perception	Containment infrastructure
	Policy and regulations
	Mechanical emptying provision

The sample size has been calculated based on the total number of containment of the study area. A stratified random sampling method has been adopted for this study and sample size has determined to assume 95% confidence level and 5% confidence interval. According to Sudman *et al*. (1982) and www.researchadvisors. com, the sample size has been calculated by Equation 1.

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

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

The sample size is adjusted for three types of settlements and distributed according to the total number of containment of each area as shown in Table 3.

3.4 Data Entry and Analysis

After collection of total 234 household information, the data has firstly entered and processed in Standard Package for Social Science (SPSS) software. The variables have selected and identified for the preparation of data input. After completing data input, the data have converted to a Microsoft Excel spreadsheet for further analysis.

Table 3: Distributed sample size for each selected area

Ward No.	Area Name	Number of Containment	Calculated Sample Size	Distributed Sample Size
09	Muzgunni Second Phase	156	234	62
	Boro Boyra	330		131
	Rail Junction Bosti	105		41

Quality of emptying techniques has been determined by two way based on indicators of containment, emptying and knowledge and perception of the users. Firstly, safe emptying, partially safe emptying and unsafe emptying have been identified specifically. This specific quality of emptying techniques for each area has been calculated by summing all the safe responses, partially safe responses and unsafe responses. Again, an overall quality of emptying techniques score has been derived by some several steps and by applying priority to each indicators and based on this score according to the priority index Table 5. And also from Table 5, the overall quality of emptying techniques has been identified based on this score obtained. Islam (2017) uses the score 1 for low risk, 0.5 for medium risk and 0 for high risk and based on the score, the score of quality of emptying techniques has been selected as shown in Table 4.

Table 4: Score for quality of emptying techniques

Quality of emptying techniques	Score
Safe emptying	1
Partially safe Emptying	0.5
Unsafe emptying	0

The scores quality of emptying techniques determination have given accordingly within value 0-1. There are three numbers of equations has been developed based on the equation used in the research of Islam (2017). Mainly eauation no. 2 & 3 directly comes from the research of Islam (2017) but equation 4 has been developed based on the eauation no. 2 & 3. Now, the weighted value has been calculated for each parameter by Equation 2.

$$\text{Weighted Value (WV) (n)} = \frac{Res\ (Unsafe)\times 0 \mid Res\ (Partially\ Safe)\times 0.5 \mid Res\ (Safe)\times 1}{Nj} \quad (2)$$

Where,
$WV_{(n)}$ = Score of N parameter,
Res = Number of responses and
N_j = Total number of responses under that parameter 'j'

After determining the weighted value for each parameter, then quality of emptying techniques score for each indicator has been found using the following Equation 3 according to Islam (2017).

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

Where,
$_n AWV\ ^i_{ind}$ = Quality of emptying techniques score of N^{th} indicator and
Np = Total number of indicators

After determining the average weighted value for each indicator, the value is multiplied by prioritizing value 0, 0.5 and 1 according to the Table 5 depending on which average weighted value obtained for each indicator. Then further averaging the value of indicators the final quality of emptying techniques score is found. Since the quality of emptying techniques score is being determined using average score of the responses and points, the total quality of emptying techniques score is thus interpreted as an average quality of emptying techniques score as shown in Table 5.

Applying priority to each indicator average weighted value, the obtained termed named as prioritized weighted value (PWV). Then from here, the overall quality of emptying techniques score for each area has been derived by the Equation 4.

$$QE_{(i)} = \frac{\sum PWV_{ind}}{N} * 100 \quad (4)$$

Where,
$QE_{(i)}$ = Quality of emptying techniques score of 'i' variable
PWV_{ind} = Prioritized weighted value of 'i' indicator and
N = Total number of indicator

Table 5: Indicators prioritizing indexing value

Quality of emptying techniques	Average Weighted Value	Prioritizing Value
Safe Emptying	0 - ≤ 33	0
Partially Safe Emptying	> 33 - ≤ 67	0.5
Unsafe Emptying	> 67 - 100	1

4. RESULTS AND ILLUSTRATIONS

This sections describes the output and findings of the study and reveals elaborately the existing containment emptying process investigation and quality of emptying techniques determination.

4.1 Existing Containment Emptying Process at the Study Area

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

4.1.1 Manual Emptying Process

Manual emptying is provided by the sweepers traditionally. The sweepers live at ward no 21 and 17 named sweeper colony in Khulna city. The sweepers are easily available only by a phone call. For this reason, people want to get service by sweepers instead of mechanical emptying service providers. While emptying, they dig a ditch nearby the containment where land is available; otherwise, they dispose it to the drains or water bodies.

The sweepers also doing the emptying job the suburbs along with the city corporation area. Sometimes, they use drum carrying the van. KCC also provides manual emptying against a fixed charge. KCC manual emptiers emptied the containment manually but transport this manually emptied sludge to the disposal place by boggy (700L circular tanks like boggy of the train which is hauled by a tractor). This is actually manual emptying. The sweepers empty the pit/septic tank with a bucket and the tank of the boggy or trailer is filled-in. Then the boggies are carried with the engine and dumped elsewhere. The capacity of one boggy is 300 litters only and the charge for one boggy is BDT 300. Sometimes they get into the septic tank or pit to empty the solid part of the sludge which very risky for them. Again most of the cases, they neglect the safety issues.

4.1.2 Mechanical Emptying Process

Vacuum tankers or vacutugs are being used as a mechanical device in the city. Khulna is largely dependent on the services of individual sweepers even though KCC provides service. Most of the people think that the sweepers are the only professionals who can empty the containment as they are not aware regarding the mechanical service. Awareness gap and cost of mechanical emptying are the main issues for lower percent of mechanical emptying. Mechanical service is provided in this area by both KCC and a local authority Community Development Committee (CDC).

The percentage of mechanical emptying is relatively very low comparing manual emptying in this city. There are two 4000 liters capacity vacutugs in KCC. Which one is functioning, a tanker is carried by a tractor. The vacutug is large and needs a wide road to access. One has to apply and then pay a bank fee and deposit to KCC to get vacutug services from KCC conservancy department. Mechanical service is also provided by a local authority CDC. CDC has three vacutags. The operator of these vacutugs is the cluster CDCs based at Ward No. 03, 17 and 22 respectively. They are providing service in the entire city also outside of the city. They do service on-call basis and quickly. A fecal sludge treatment plant (FTP) has been constructed in 2016 at Rajhbadh-2 beside the solid waste dumping site. This FTP is 10 kilometers away from city center.

4.2 Quality of emptying techniques at the Study Area

The main aim of this research was to identify the quality of emptying techniques of the three types of settlements. It has been mentioned previously that, quality of emptying techniques has been categorized by unsafe emptying,

partially safe emptying and safe emptying. Quality of emptying techniques is determined by quantitative analysis in this study based on the questionnaire survey.

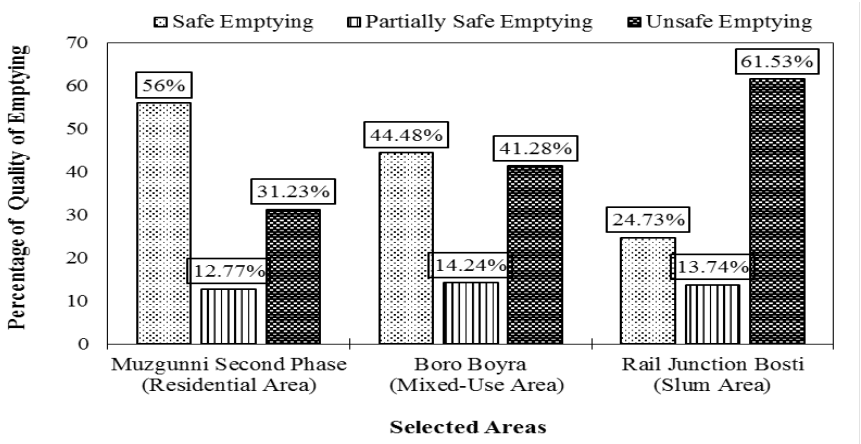

Figure 4: Specific quality of emptying techniques of selected areas

Figure 4 shows the specific quality of emptying techniques namely unsafe emptying, partially safe emptying and safe emptying. For Muzgunni Second phase area as a residential area, quality of emptying techniques is found unsafe emptying as 31.23%, partially safe emptying as 12.77%, and safe emptying as 56%. Most of the containment type in a residential area is a septic tank, most are suitable in case of size. For this reason, the percentage for safe emptying is found more than the others two.

For Boro Boyra as a mixed-use area, quality of emptying techniques is found unsafe emptying as 41.28%, partially safe emptying as 14.24%, and safe emptying as 44.48%. Finally, for Rail Junction Bosti as a slum area, quality of emptying techniques is found unsafe emptying as 61.53%, partially safe emptying as 13.74%, and safe emptying as 24.73%. Besides, the percentage of unsafe emptying is also higher for this area among three. It is due to some of the factors such as high emptying frequency, lack of knowledge about mechanical service etc. Most of the containment type in slum area is an ordinary pit; most of them were not suitable in case of size according to users. Again, there is no such containment that is accessible for mechanical emptying. The slum situates beside Dhaka-Khulna rail line and long distance from the roadside. For this reason, the percentage for unsafe emptying is found more than the others two. However, in all three area, the respondent who knows for mechanical emptying but goes for manual emptying due to emptying cost, availability.

The overall quality of emptying techniques has been evaluated for each type of settlements, which shows present practice of emptying in that area as shown in Table 6. The overall quality of emptying techniques score is calculated by prioritizing of each indicator under containment, emptying and knowledge, and perception of the users according to the Table 5. The overall quality of emptying techniques score for Muzgunni Second phase, Boro Boyra, and Rail Junction Bosti is found 42.1, 35.6, and 17.4 respectively.

According to this score and from Table 6, partially safe emptying exists currently both Muzgunni Second Phase and Boro Boyra and totally unsafe emptying for Rail Junction Slum. In this slum, most of the containment inaccessible, containment are in worst condition. For that reason, quality of emptying techniques score comes to very low and that results unsafe emptying.

Table 6: The overall quality of emptying techniques score

Area Name	Quality of Emptying Tchniques Score	Quality of Emptying
Muzgunni Second Phase	42.1	Partially Safe Emptying
Boro Boyra	35.6	Partially Safe Emptying
Rail Junction Bosti	17.4	Unsafe Emptying

5 CONCLUSIONS

The major findings of the study are concluded below.

Most of the containment emptied by manually where the percentage of mechanical emptying is very low and private sweepers are dominantly doing the emptying job. All the emptiers both manual and mechanical ignore the safety

issues during emptying operations. KCC and CDC provide the mechanical vacutug service at the study area. The quality of emptying techniques for Muzgunni Second phase area as a residential area is found unsafe emptying as 31.23%, partially safe emptying as 12.77%, and safe emptying as 56%. Again for Boro Boyra as a mixed-use area, quality of emptying techniques is found unsafe as 41.28%, partially safe as 14.24%, and safe as 44.48%. And for Rail Junction Bosti as a slum area, unsafe emptying is found as 61.53%, partially safe emptying as 13.74%, and safe emptying as 24.73%.

Finally, the overall quality of emptying techniques score for Muzgunni Second phase, Boro Boyra, and rail Junction Bosti is found as 42.1, 35.6, and 17.4 respectively. This score indicates that partially safe emptying exists currently both Muzgunni Second phase and Boro Boyra but unsafe emptying for Rail Junction slum.

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