THE SAKHIPUR FAECAL SLUDGE TREATMENT PLANT (CO-COMPOST PLANT): A MODEL FOR SUSTAINABLE FAECAL SLUDGE MANAGEMENT IN BANGLADESH

Md. Ashiquzzaman Pavel[1], Asma Ul Hosna[2], Saima Alam Trisha*[3], Harun Or Rashid[4], Sharmin Upama [5], Md Mehadi Hasan

[1]Undergraduate Student, Sonargaon University, Dhaka-1215, Bangladesh, e-mail: pavelashiquzzaman@gmail.com
[2]Lecturer, Sonargaon University, Dhaka-1215, Bangladesh e-mail: sumona.ce13@gmail.com
[3]Undergraduate Student, Sonargaon University, Dhaka-1215, Bangladesh, e-mail: saimatrisha73@gmail.com
[4]Undergraduate Student, Sonargaon University, Dhaka-1215, Bangladesh, e-mail: harun.bce9104.su@gmail.com
[5]Undergraduate Student, Sonargaon University, Dhaka-1215, Bangladesh, e-mail: sharminupama121@gmail.com
[6]Undergraduate Student, Sonargaon University, Dhaka-1215, Bangladesh, e-mail: mehadihasan0032@gmail.com

***Corresponding Author**

ABSTRACT

Faecal sludge treatment plants are facilities designed to treat human waste and other organic matter collected from pit latrines, septic tanks, and similar sources. In densely populated countries like Bangladesh, where access to proper sanitation facilities can be challenging for a significant portion of the population, faecal sludge management becomes a critical issue. To address these challenges, WaterAid Bangladesh (WAB) and the Bangladesh Association for Social Advancement (BASA) have supported Sakhipur Municipality in establishing a co-composting plant on April 11, 2015. In this present study, a field survey was made in Sakhipur Municipality to know the situation of FSM. According to the 2018 Safely Managed Sanitation Service Delivery (SFD) assessment, 43% of the town's sludge is now handled through safe management practices. Excreta flow diagrams (EFDs) were developed to assess the municipality's sanitation status and achieve the goal of 100% safely managed sanitation. Ten drying beds are used for dewatering and drying the faecal sludge. The dried faecal sludge is mixed with organic waste to create a uniform mixture, which takes eight weeks to complete. The wastewater from dewatered faecal sludge is disinfected with *Canna indica* and reused to clean the treatment plant. In the treated wastewater, the average values of Biochemical Oxygen Demands (BOD_5) were found to be 5.71 mg/l, and the value of Total Suspended Solids (TSS) was less than 10.0 mg/l, within the Bangladesh Standards for Effluents from Sewage Treatment Plants (BSS 1630:2009). The amount of Nitrate (NO_3) and Phosphate / Orthophosphate (PO_4^{3-}) in the final effluent was respectively 9.87 mg/l and 2.12 mg/l which are within standard limits. An average of 24 metric tons of compost is produced annually. The municipal authority sells the compost to local farmers for BDT 15.00 (USD 0.14)/kg. This co-composting plant offers a unique example of covering the whole cycle of the sanitation value chain and has created opportunities.

Keywords: *Faecal sludge, safely managed sanitation, waste management, Composting, treatment plant.*

1. INTRODUCTION

Access to proper sanitation and wastewater management is a fundamental human right and a critical aspect of public health. In many parts of the world, including Bangladesh, inadequate sanitation facilities and the improper disposal of faecal sludge pose significant challenges, leading to numerous health and environmental problems. From 34% in 1990 to 0% in 2017, there has been a notable decline in open defecation in Bangladesh *(The Crisis | WaterAid Banglade*sh, n.d.), primarily because of a confluence of favorable situations, such as political will, development partners' efforts, and the community's and local government institutions' active participation. Although the decrease in open defecation represents a significant accomplishment, it has also led to the proliferation of thousands of pit latrines that fail to guarantee the appropriate and hygienic separation of human waste from human contact (Hanchett & Akhter, 2015). Thus, faecal sludge management (FSM) has become a subsequent sanitation issue in Bangladesh, where only two percent of urban faecal sludge gets adequately processed and handled through sewage systems *(The Crisis | WaterAid Banglade*sh, n.d.). In response to these challenges, the collaboration between WaterAid Bangladesh (WAB) and the Bangladesh Association for Social Advancement (BASA) led to the establishment of a co-composting plant in Sakhipur Municipality on April 11, 2015 *(Co-Composting Plant in Sakhipur, Bangladesh – Planning for Climate Change and Rapid Urbanisati*on, n.d.). The facility processes both faecal sludge and organic waste, producing high-quality compost (Cofie et al., 2009). This brief emphasizes non-technical factors, particularly how this facility leads the path toward comprehensive and secure sanitation in the town, the key factors contributing to this achievement, and the potential for its successful replication. Table 1 briefly explains Sakhipur Municipality and some of the treatment plant's amenities.

Table 1: General Information about SakhipurMuncipality

Facts	Information
Year of Establishment	October, 2000
Area in square kilometers	13.77
Population	30,028
No of Wards	9
No of Households (HH)	7,473
Number of FSTP	1
Estimated population covered by FSTP	33,940

Sakhipur, formally recognized as a municipality, is a town in Sakhipur Upazila situated 39 kilometers by road from Tangail and 77 kilometers northwest of Bangladesh's capital, Dhaka. The Sakhipur municipality spans 13.77 square kilometers and comprises nine wards and 18 mahallas *(Sakhip*ur, n.d.). Sakhipur municipality had 7,473 households and 30,028 people overall in 2011, according to the Bangladesh Bureau of Statistics (BBS) Census (Sfd & Report, 2020). While there is no dedicated sewerage system in the city, every resident can access a toilet, eliminating open defecation. The predominant sanitation infrastructure in the city consists of on-site systems, such as pit latrines and septic tanks. This city grapples with the issue of an inadequate and ineffective waste disposal system. Forty-three percent (43%) of the excreta flow is classified as safely managed *(Small Town Sanitation Learning Se... Preview & Related Info | Mendel*ey, n.d.), and the remaining fifty-seven (57%) percent is classified as unsafely managed (Sfd & Report, 2020). To deal with this obstacle, Sakhipur Municipality received technical and financial support from WaterAid Bangladesh (WAB) and the Bangladesh Association for Social Advancement (BASA). The Municipality established a co-composting plant in 2015, which started activities and evaluated potential options. This facility collects and treats approximately 60,000 and 70,000 liters of feces monthly (Sfd & Report, 2020). Every single unit of incoming faecal sludge undergoes treatment at the plant. However, Bangladesh does not currently have a widespread system in place for treating faecal sludge or composting waste *(Urban Sanitation in Bangladesh - Component 4: Treatment, Disposal and Reuse | S*NV, n.d.). This research evaluates the Sakhipur FSTP's whole faecal sludge treatment procedure as

well as any potential benefits. The aim of this research is to assess Sakhipur FSTP's present state in terms of treatment effectiveness, sustainability, and faecal sludge management. It also looks ahead to produce more compost and other environmentally friendly products.

2. MATERIALS & METHODS

2.1 Study Area: Sakhipur Co-Compost Plant is located at 8553+QMH, Unnamed Road, Sakhipur Municipality area of Tangail District, Bangladesh. The plant is located on a 1.5-acre site at the end of the Sakhipur-Dhaka highway. Figure 1 indicates that, the FSTP is approximately 3.5 kilometres from the Sakhipur zero point and 2.9 kilometres from the Sakhipur Bazar. The exact coordinates of the plant are 24.319205° N, 90.172466° E. The municipality has acquired a 0.3-acre piece of land on the city centre's outskirts to establish a co-composting plant. It has implemented a constructed wetlands system and drying beds. Sakhipur Municipality is estimated to provide services for 33,940 people.

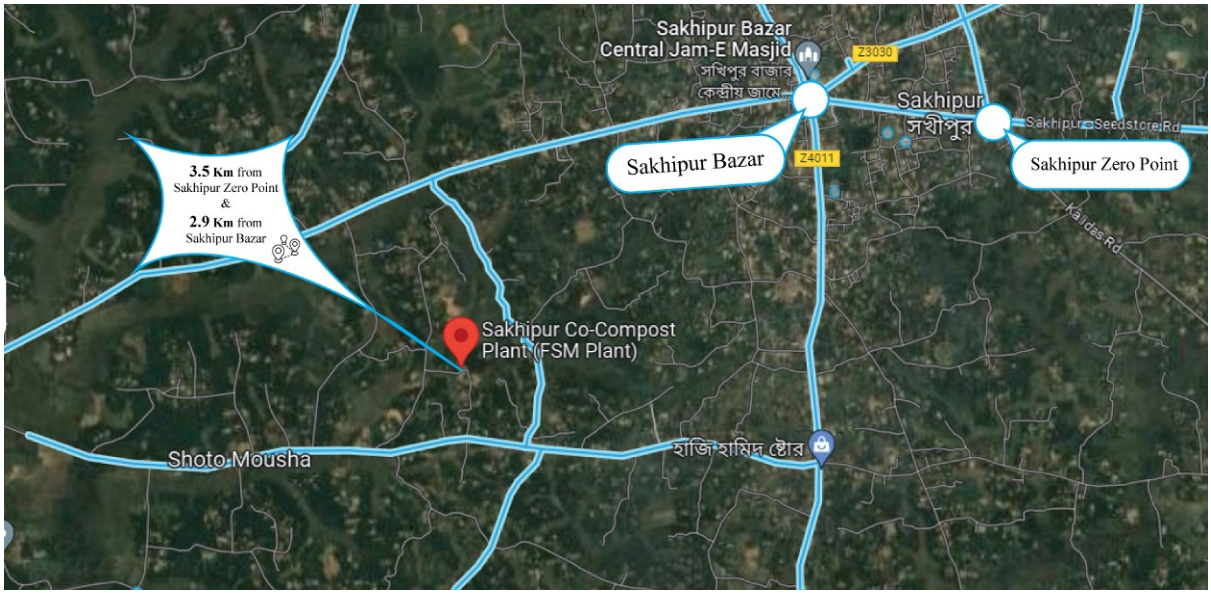

Figure 1: Location of Sakhipur Faecal Sludge Treatment Plant (Co-compost plant), Sakhipur, Tangail.

2.2 Sample Collection and Laboratory test: Samples were gathered from the Sakhipur Faecal Sludge Treatment Plant (FSTP) to evaluate the facility's operational efficiency. Plastic water bottles free from contamination were employed to gather percolate effluent from the receiving tank after both primary and final treatment processes. Samples were conveyed to the laboratory using established procedures for assessing various parameters related to water quality. Comprehensive laboratory tests were conducted to assess the efficacy of the treatment unit. The treatment unit's effectiveness was assessed by examining multiple water quality parameters, including Biochemical Oxygen Demand (BOD_5 ;20^0C), Nitrate (NO_3), Phosphate/ Orthophosphate (PO_4^{-3}), Total Suspended Solids (TSS), and Faecal coliforms (FC), using established standard procedures and also conducted a comparison of the compost data with the established benchmarks provided by the Soil Resource Development Institute, a division of the Bangladesh Ministry of Agriculture (MOA). All the test parameters have been determined as per the standard method (APHA, 2019) and HACH recommended method of wastewater analysis as there is no standard method for faecal sludge analysis. The tested water quality parameters included various types of physical, chemical, and bacteriological characteristics.

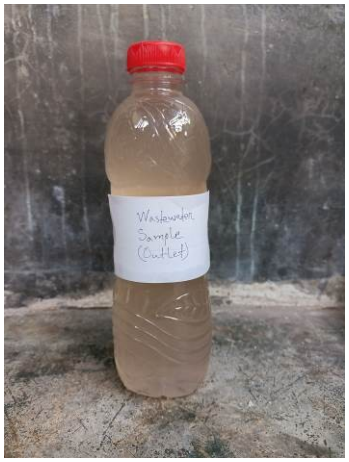

Figure 2: Collected sample of Inlet & Outlet Wastewater

Figure 3: Sakhi Compost

3. RESULTS AND DISCUSSION

The plant can produce 24 tonnes of compost annually by processing 1,200 tonnes of faecal sludge and 125 tonnes of solid waste. According to an SFD completed in 2018, 43% of the town's sludge is managed safely.

Inside view of the plant

Vacutug

Leachate Tank/ Polishing Pond

Constructed wetland (*Canna indica*)

Solar Greenhouse Dryer

Figure 4: Present view of Sakhipur Faecal Sludge Treatment Plant (Co-compost plant)

Two notable waste streams are in focus:

a) Faecal sludge, found in pits and septic tanks, is gathered by municipal workers using a Vacutug, a truck-mounted tank with a 1 m3 capacity and a mechanical pump. Typically, the workers complete 4 to 7 trips daily for this task.

b) Municipal workers frequently gather organic waste from homes, generally kitchen waste. By improving awareness among the public, the municipality actively works to encourage the separation of the two types of waste (organic and inorganic) at its place of source.

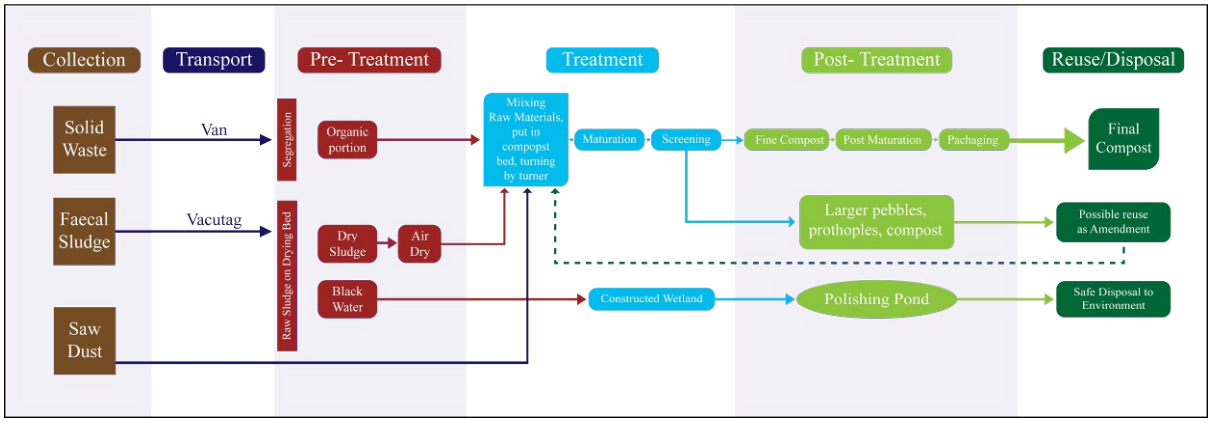

Figure 5: Operational models of Sakhipur Faecal Sludge Treatment Plant (Co-compost plant)

They have ten beds (drying) in the plant. Each bed covers an area of 9 square meters and 5000 liters of sludge per bed (maximum), and the loading depth is 20 centimeters (approximately). These beds are made of gravel and sand; gravel sizes are around 1.25cm, 2.0cm, and 2.5cm.

Figure 6: Drying Bed

These drying beds are dedicated to dehydrating and desiccating faecal sludge. After this phase, the dried fecal sludge and organic waste are meticulously blended to achieve a uniform mixture. Regular turning or aeration of the cross is carried out to facilitate the introduction of oxygen to transform it into compost within an eight-week timeframe. The efficient aerobic bacterial activity in composting relies on carefully considering the mixing ratio. In each batch, the ratio of organic solid wastes, dried faecal, and sawdust is 3:1:1, facilitating the highly exothermic aerobic decomposition process, which generates heat. To maintain the optimal porosity of the compost matrix, which is approximately 70 to 80 percent (volume/volume), and to keep the combined materials' moisture content at about 60% by weight, sawdust is added as a supplement. After an additional two-week maturation and safety period, the compost is prepared for retail under the name "Shakhi Compost". This procedure capitalizes on the elevated nitrogen content in fecal sludge and organic waste's substantial organic carbon content. The entire process spans approximately twelve weeks, from the delivery of the sludge to the production of the final compost intended for reuse. The Soil Resource Development Institute of Bangladesh's laboratory test report confirms that the final product can be effectively reused as a soil conditioner without any heavy metal hazards.

Table 2: Chemical analysis results of organic manure samples (from Sakhipur FSTP)

Serial No.	Results obtained	Government Disruption
1	Color: Dark Grey	Color: Dark Grey to Black
2	Physical Condition: Non granular form	Physical Condition: Non granular form
3	Odor: Absence of foul odor	Odor: Absence of foul odor
4	Moisture: 16.16%	Maximum: 15.0% – 20.0%
5	pH: 7.6	pH: 6.0 – 8.5
6	Organic Carbon: 16.18%	Organic Carbon: 10.0% -25.0%
7	Total Nitrogen (N): 1.32%	Total Nitrogen (N): 0.5% - 4.0%
8	C: N: 12.26: 1	C: N - Maximum: 20:1

9	Phosphorus (P): 0.99%	Phosphorus (P): 0.5% - 3.0%
10	Potassium (K): 1.04%	Potassium (K): 0.5% - 3.0%
11	Sulphur (SO_4-S): 0.40%	Sulphur (SO_4-S): 0.1% - 0.5%
12	Zinc (Zn): 0.053%	Zinc (Zn) - Maximum : 0.10%
13	Copper (Cu): 0.005%	Copper (Cu) - Maximum: 0.05%
14	Lead (Pb): 19.47 ppm	Lead (Pb) - Maximum: 30.00 ppm
15	Cadmium (Cd): 0.005 ppm	Cadmium (Cd) - Maximum: 5.00 ppm
16	Chromium (Cr): 2.35 ppm	Chromium (Cr) - Maximum: 50.00 ppm
17	Nickel (Ni): 0.750 ppm	Nickel (Ni) - Maximum: 30.00 ppm

The wastewater generated during the dewatering of fecal sludge is treated with *Canna indica* for disinfection and repurposed for washing purposes within the treatment facility. The laboratory test results provide an overview of the current status of the fecal sludge treatment plant and its treatment efficiency level.

Table 3: Laboratory Test Results of Inlet Wastewater Sample

Serial No.	**Water Quality Parameters**	**Results**	**Bangladesh Standard for Sewage Discharge (ECR'97)**	**DOE Guidelines update 2019, Schedule 7- Standards for Sewage Discharge**
1	Biochemical Oxygen Demand (BOD_5)	46.5 mg/L	40	30
2	Fecal Coliform (FC)	24500 CFU/ 100mL	1000	1000
3	Total Suspended Solids (TSS)	55.57 mg/L	100	100
4	Nitrate (NO_3)	130.12 mg/L	250	250
5	Phosphate (PO_4^{3-})	27.86 mg/L	35	35

The faecal coliforms and BOD levels in the inlet sample exceed the permissible limits of the Bangladesh Standard and the DOE Guideline for sewage discharge. This indicates that the faecal sludge entering the FSTP is highly contaminated. The amount of Nitrate (NO_3) and Phosphate / Orthophosphate (PO_4^{3-}) in inlet samples are within the Bangladesh Standard and the DOE Guideline for sewage discharge.

Table 4: Laboratory Test Results of Outlet Wastewater Sample

Serial No.	Water Quality Parameters	Results	Bangladesh Standard for Sewage Discharge (ECR'97)	DOE Guidelines update 2019, Schedule 7- Standards for Sewage Discharge
1	Biochemical Oxygen Demand (BOD_5)	5.71 mg/L	40	30
2	Fecal Coliform (FC)	580.00 CFU/ 100mL	1000	1000
3	Total Suspended Solids (TSS)	<10.0 mg/L	100	100
4	Nitrate (NO_3)	9.87 mg/L	250	250
5	Phosphate (PO_4^{3-})	2.12 mg/L	35	35

The faecal coliforms, BOD_5, NO_3, and PO_4^{-3} levels in the outlet sample are within limits set by the Bangladesh Standard and the DOE Guideline for sewage discharge. This is a positive outcome, indicating the efficacy of the Sakhipur FSTP in eliminating these contaminants from the faecal sludge. The 2018 Safely Managed Sanitation Service Delivery (SFD) assessment in Sakhipur revealed significant progress in the town's efforts to manage its sludge safely and sustainably. Shit Flow Diagrams (SFD) were created to assess the initial and subsequent conditions of the municipality. The municipality faced a concerning situation before the intervention in 2015, with 0% of faecal sludge being managed safely. However, this figure significantly improved to 43% following the implementation of a co-composting facility. Reaching 100% safely managed sanitation, the municipality plans future actions to achieve the goal. The treatment plant handles around 18 percent of the municipality's annual generated sludge.

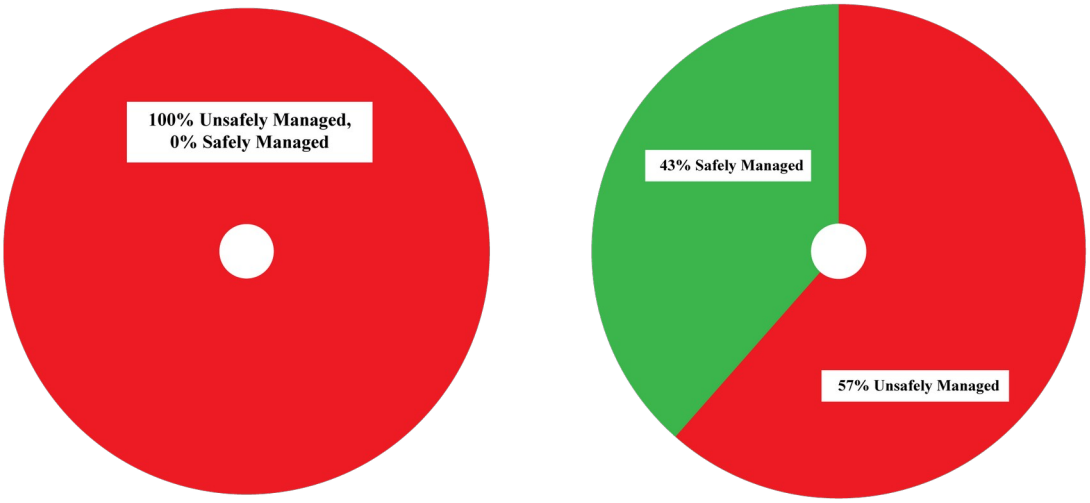

Figure 7: The situation before the intervention in 2015 (Left)
The situation after the intervention during 2015 -SFD done in 2018 (Right) -by WaterAid

4. CONCLUSION

The study above indicates that the Sakhipur FSTP excels in its treatment capabilities and effectively carries out comprehensive treatment procedures. The co-composting facility is a prime example of addressing environmental pollution caused by solid waste (SW) and faecal sludge (FS) by applying tailored innovations in FSM technologies and providing sustainable services. The goal is to ensure that all faecal is collected, treated, and disposed of safely not to make people sick or pollute the environment. The Sakhipur FSTP is a model for sustainable faecal sludge management in Bangladesh. Using compost from a co-composting plant, such as the one in Sakhipur, Tangail, for agriculture can be a sustainable and environmentally friendly practice. There will be many challenges and a huge opportunity to develop more by properly using and maintaining the FSTM, Sakhipur. The Bangladeshi government and sector stakeholders recognize the creative and locally-inspired solutions to the pressing challenges posed by second-generation sanitation problems. Our Government is also taking initiatives and technical frameworks for the development of the management of faecal sludge. Maybe these could lead us to a new door of opportunity and help us to achieve the 6th goal of SDG 2030 of ensuring access to water and sanitation for all. The research should be continued to get more practical designs and engineering procedures for the sustainable development of this particular sector.

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