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CO-COMPOSTING OF FAECAL SLUDGE WITH SOLID WASTE TO IMPROVE FSM PRACTICE

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ABSTRACT

Mymensingh city with 83,682 inhabitants mostly comprises onsite systems i.e septic tanks and pits. When the pit or septic tank is full, the usual practice is to engage professional sweepers are employed to manually empty them and deposit the wastes in mostly the nearby water bodies and open environment which creates environmental degradation. 77% of the excreta is not contained and therefore unsafely managed (in figure-01). Off-site sanitation and open defecation are not existing in Mymensingh city area. A co-compost plant was designed and established by the Mymensingh City Corporation and NGO Forum for Public Health, OXFAM Bangladesh and it has been in operation since 2019 to tackle faecal sludge generated from pit toilets and septic tanks, and solid waste from households exploring sanitation service chain. The co-compost plant has also created an opportunity to gain scientific and hands-on knowledge on the technical and operational aspects of co-composting of FS and SW in small towns/cities in Bangladesh. This study provides a description of an innovative co-composting system which improves current FSM practice in city regimes and toward building a resilient city. The generated lessons against tackling the operational challenges of the sanitation service chain will provide good learnings for replicating similar practices in another city.

Keywords: FSM, Co-compost, Safely Managed Sanitation

FSM SERVICES IN BANGLADESH

FSM is a pressing matter in rural and urban areas of Bangladesh. 61% of the population use improves toilets but the sludge and waste from these toilets are polluting the environment as they not properly treated and disposed of. There are no sewerage systems in the towns and municipalities other than in the capital of Dhaka which covers only about 22 per cent of the total population. In the areas where there is no sewerage network, about 55 per cent of the buildings do not have any septic tanks and these buildings directly discharge the sewage into the open drain, storm drainage and/or the environment resulting pollution of surface water bodies (Jahan and Al-Muyeed, 2015). There is also a lack of treatment facilities for FS and the emptying of on-site sanitation systems mostly dependent upon an unhygienic manual emptying process. Manual emptying and transportation process includes emptying with buckets and using vans and carts for transport and discharging the faecal waste into the open environment or canals. In some other municipalities, vacutug is used, but numbers and services are inadequate compared to the actual demand.

SANITATION AND FSM IN MYMENSINGH CITY CORPORATION

The Shit-Flow-Diagram shows that, 77% of the excreta is not contained and therefore unsafely managed (in figure-01). Off-site sanitation and open defecation are not existing in Mymensingh city area. However, a small portion of floating population living in slums and on-street are still practicing open defecation. We did not consider this proportion as it is negligible. There is no central sewerage system in the project area therefore, excreta are either discharged to open drain and water bodies mainly. All onsite sanitation system in Mymensingh require emptying services. However, only 8% of total population utilizes emptying services in case of sludge contained in the onsite technology. On the other hand, 17% of total population utilizes emptying service in case of sludge not contained in the onsite technology. 23% of the population has not received the emptying services and their sludge are contained in the technology. Which results the 23% safely managed of faecal sludge. The diagram was developed using this link https://sfd.susana.org/data-to-graphic. Following the analysis of the SFD it was decided through a participatory process to involving the city authority and other stakeholders to construct a co-composting of FS and organic SW system to address the situation. Vacutug services were also introduced for collection and transportation of FS as an initiative towards modernized transportation and recycling of FS at Mymensingh City Corporation.

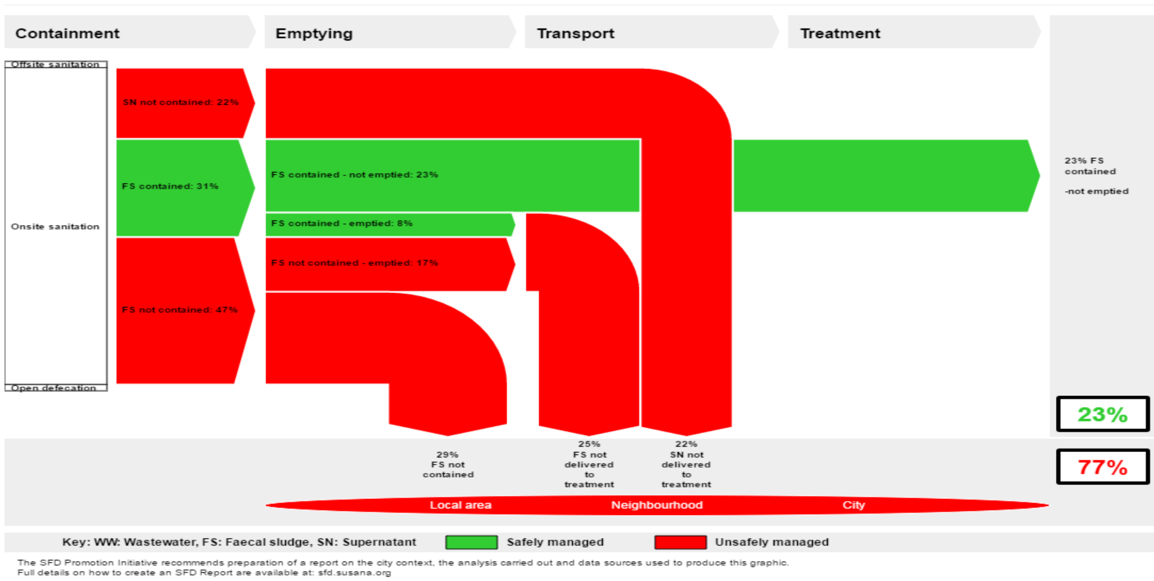

Figure 1 Shit flow diagram of faecal sludge in Mymensingh City Corporation

TECHNICAL ASPECTS OF FSM INTERVENTIONS

The co-compost plant has also created an opportunity to gain scientific and hands-on knowledge on the technical and operational aspects of co-composting of FS and SW in cities in Bangladesh. On the other hand, good decomposition of organic constituents of FS and SW confirms good quality of soil conditioner or compost. But enduring to safe reuse of developed compost is also a technical challenge. The city authority played the central role realizing their need of FSM and donated 43 decimal lands at the outskirt of the city area for the co-compost plant. The project has been implemented jointly OXFAM Bangladesh, NGO Forum for Public Health, and Mymensingh City Corporation. Occupational health & safety measures are taken care in all technical operations following the organisational guideline prepared for local government of GoB and FSM sector actors (OS&H guideline, 2015).

Transportation of faecal sludge

Transportation is a crucial part of a sanitation system to reduce risks of contamination and proper recycling of sludge. Liquid FS is collected from septic tanks and pit toilets by a vacutug owned by the City Corporation. The capacity of the truck is 2000 litres (L). The FS is collected from within the city corporation areas and transported to the co compost plant. The vacutug charges USD 6.5 for each trip irrespective of pit or septic tank within the city corporation. Depending on size of the pit and tank, necessary numbers of trips are made. Weekly 20,000-25,000L of FS is collected and discharged on the unplanted drying beds from around sixteen to twenty tanker trips.

Pre-treatment at drying beds

There are 09 beds (5 Planted and 4 Unplanted drying beds), each of $9m^2$ with a loading capacity of maximum 5000L of sludge per bed at a loading depth of about 20cm. They consist of different layers of a gravel-sand filter media of different thickness and gavel sizes (1.25 cm, 2.0 cm and 2.5 cm). The benefits of these beds include no requirement of electrical power and the being built with minimal construction skills and from local materials. The drying process is enhanced by evaporation and solid-liquid separation by gravity percolation of leachate. All ten drying beds are protected by a heavy transparent celluloid sheet covered roof as it is found effective in drying operation (Buro Happold, 2013). The sheet traps heat and aids the drying process. Also, during the rainy season, it provides cover from the rain. It is identified that about two weeks is required to separate liquid and solid part of the raw sludge with significant reductions in indicator pathogens. The dried sludge (e,g dry sludge cake) is removed from the bed and left in a maturation bed for one week. The separated liquid part (leachate) of raw FS pre-treated on drying beds further undergone with planted constructed wetland and followed by a polishing pond. The effluent is then discharged into the environment within the Bangladesh effluent discharge standards. *Canna indica*, a perennial is planted out in the constructed wetland to aid further leachate treatment at the constructed wetland.

Collection of household solid waste

Each household pays USD 0.4/month as collection fee. SW is collected and separated for co-composting. The composting plant handles 125 ton of SW a year, and organic components are segregated during the separation process and the inorganic part is recycled and used by different industries which require it. However, the project has tied with the concept of source separation of SW from households but still it requires manual separation at the plant. This is one of the key challenges of collection of household SW.

Co-composting process

The treatment process follows the batch system where a batch of mixed organic waste (mix of FS and SW) is prepared and aerobically composted separately with intense biological activity from other batches to a final product. The overall performance of the composting process is therefore the combined effect of the activity of individual microorganisms in each batch. Since aerobic metabolism renders more energy for the microorganisms, they grow faster when oxygen is present (Wéry et al. 2008). Heat is produced in aerobic decomposition of waste, which is a highly exothermic process. Therefore, mixing ratio is an important factor for co-composting. In each batch process, the organic SW and dried FS are mixed with a volume ratio of 3:1 to get efficient aerobic bacterial activity. It also increases the carbon to nitrogen (C: N) ratio of the matrix. There are number of sawmills (woodcutting industry) at the nearby locality where sawdust is readily available at cheaper rate. If the C: N ratio is high beyond 30, aerobic decomposition slows down. If the C: N ratio is low (less than 5), organic decomposition rate becomes slow due to inhibition of bacterial activity resulting possible anaerobic mining or inhibition inside the compost matrix (Onwosi et al. 2017).

SW has higher C:N ratio (15:1- 25:1) and FS has lower C: N ratio (about 3:1-5:1). By mixing the organic contents (FS and SW) with saw dust (C:N ratio>60) improve the proportion of the initial compost matrix is at about 15:1. The mixture is then composted aerobically for eight weeks. Turning, watering, temperature measurement, weighing, sampling and laboratory analysis are carried out during a composting cycle. Turning of compost mass during decomposition process has many important functions, e.g. supplying oxygen, redistributing the waste products generated by degradation reaction, redistributing some anaerobic zone, releasing excess water content, etc. A customized locally made mechanical turner is used to confirm uniform mixing during starting of the operation and then turning of the mixture regularly at three days' interval to release inhibition effect during decomposition. During the eight weeks of composting, moisture content reduces to about 25% from 60%. It further reduces to less than 15% while maturation process (under natural air) takes place for one week.

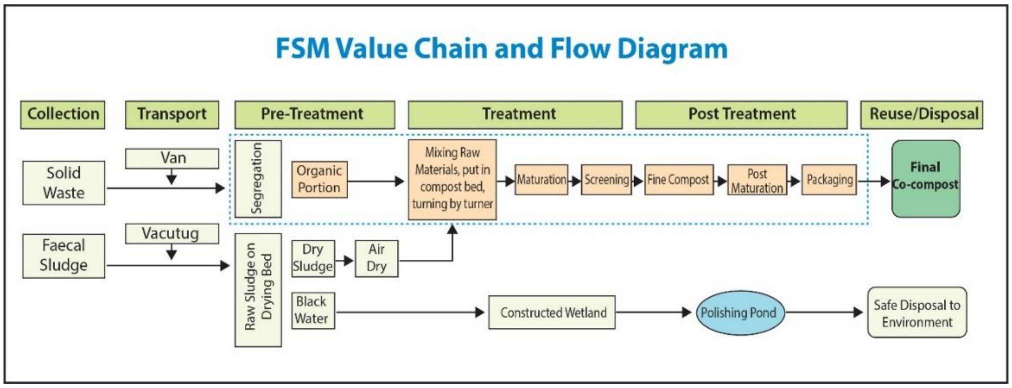

Figure 2 Faecal sludge service chain in Mymensingh City Corporation

CO-COMPOST QUALITY FOR CROPS PRODUCTIVITY

The treated FS and solid waste collected from households are mixed to produce co-compost. This CC is being manufactured with the objective that it will be put to further use of different agricultural field. To ensure the proper use, it is needed to assess the quality of the CC and is to be carried out its potential on crop productivity, profitability, and soil health. This research was carried out in collaboration with Bangladesh Agriculture University. The experiment was done in a randomized complete block design with three replications consisting of 2 *Boro* rice varieties and 10 chemical fertilizer and CC combinations and the result was that highest grain yield was obtained by application of 100% RDF (Recommended Dose of Fertilizers) + high dose of CC in both varieties. Thus, reaching a conclusion that CC could be a potential soil conditioner and an alternative source of plant nutrients to reduce chemical fertilizer dependence in rice cultivation. This could lead to a decrease in environmental pollution, improve soil health and ensure sustainable rice production.

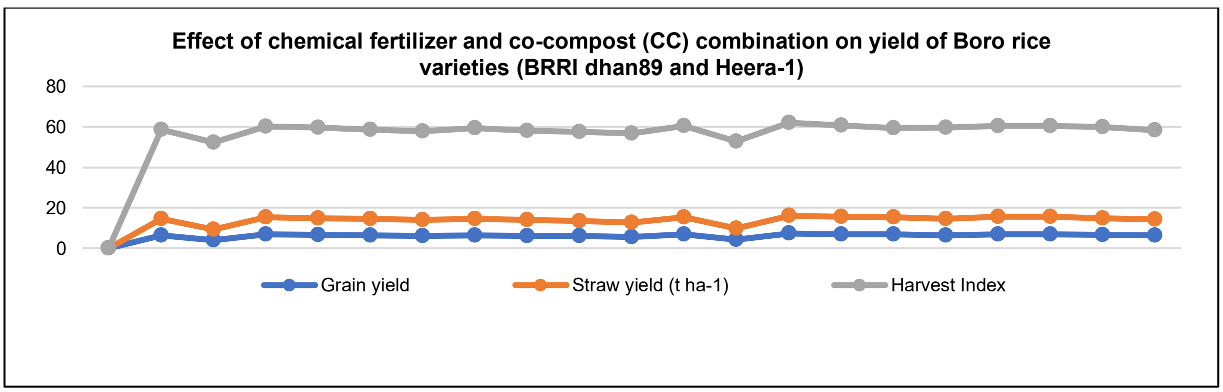

Figure 3 Effect of chemical fertilizer and co-compost

REUSE OF COMPOST PRODUCT

The laboratory tests report at the Soil Resource Development Institute of Bangladesh shows the end-product is reusable as soil conditioner and is free from hazard of heavy metals (Table 1). About 10 ton/year of compost is produced by treating 2.5-ton FS and 7.5 ton of SW. The departments of Bangladesh of Agricultural University have been providing technical guidance for proper reusing and distributing the compost among the local farmers for USD 0.18 per kilogram. The farmers use the compost as soil conditioner and their feedback is encouraging. The compost is in high demand in and around the town.

CONTRIBUTION TO CLIMATE CHANGE

The city has no sewerage system, onsite sanitation system of this city corporation (CC) mostly comprises of septic tank and pit latrines and usual practice of managing faecal sludge (FS) of this CC involves manual emptying and discharging FS into the open environment and water bodies when pits and septic tanks become full. However, a FS treatment plant has been in operation at MCC to tackle both the generated FS and organic waste with a due attention to exploring co-treatment option. The motivation behind the employment of such a project is that it has been mitigating climate change and its adverse impacts and ensuring availability and sustainable management of water and sanitation for all, and it would also promote an inclusive and sustainable economic growth including productive and decent effort for all.

QUALITY ANALYSIS OF CO-COMPOST

Taking the above results under consideration, it is quite evident that the co-compost which is produced from dried and treated FS mixed with organic SW is within the parameters which are set by the Government of Bangladesh. From following all the physical parameters of colour, odour, and physical state to ensuring that the compost has effective levels of other chemical elements. Even though the regularity bodies of Bangladesh allow the presence of inert materials till a certain level, but the co-compost doesn't have any presence of this which means that none of the materials of the co-compost is non-biodegradable. While there is presence of heavy metals in the co-compost, but it is in very low levels compared to the allowable standards.

Table 1. Chemical analysis of the sample co-compost

Parameter	Colour	Physical conditions	Odour	pH	Moisture	Organic Carbon	Total Nitrogen (N)	C: N
Bangladesh Standard	Dark grey to black	Non-granular form	Absence of foul odour	6.0-8.5	15-20%	10-25%	0.5-4%	20:01
Test Result	Dark grey	Non-granular form	Absence of foul odour	7.90	16.90%	11.70%	0.61%	19.18:1

Parameter	Sulphur (K)	Phosphorous (P)	Chromium (Cr)	Cadmium (Cd)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)	Inert material	Copper (Cu)
Bangladesh Standard	0.1-5%	0.5-3%	50 ppm	5 ppm	30 ppm	30 ppm	0.1% (max)	0.5-4%	0.05% (max)
Test Result	0.38%	0.64%	35.16 ppm	0.78 ppm	23.92 ppm	21.34 ppm	0.04 %		0.01%

Chemical fertilizers are commonly and popularly used because of its ability of enhance the crop yield but we fail to understand the implications of employing chemical fertilizers long-term. Chemical fertilizers leach the soil overtime, and this is where co-compost comes in. One of the important attributes of the co-compost is that it actively acts as a soil conditioner and in the long run it will reinstate the nitrogen and carbon levels in the leached soil. Not only as a soil conditioner but the co-compost when used in combination with chemical fertilizer, it increases the rice productivity by quite a margin. This attribute is also very important because Bangladesh is a densely populated country with a 1.0% increase every year and this puts Bangladesh at risk of not producing enough food for all but with wide use of co-compost in cultivation, this crisis can be averted. The other attribute is that the co-compost is being produced from recycling waste, this takes care of the accumulation waste, and this manufacturing process addresses the 3Rs (reduce, recycle and reuse) quite effectively.

LESSONS LEARNED

The co-compost plant has experienced few lessons learnt during operation:

- Microbiological activity that renders co-composting process depends upon a number of controlling factors like mixing ratio, moisture content, aerobes bacteria and uniform turning.
- Due to seasonal variations, more liquid sludge is collected in the wet season. The highest demand on collection and transport services occurs during the rainy season, as heavy rainfalls result in overflowing and flooding of onsite systems. Consequently, the volume of dry sludge is reduced which has an effect in compost operation.
- Building resilient cities through contributing the Climate Change by safely managed waste management service.

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- An important issue is whether subsidy is needed for such treatment system by City led approach. The lessons learnt from a year of O&M prompts to get a sustainable context specific business approach through a full life cycle analysis.

CONCLUSION

The co-compost plant exemplifies how to effectively deal with SW and FS induced environmental pollution with context specific innovation of FSM technologies and sustainable services. The innovative solution and municipal led approach already get the attention of the government and sector actors to tackle the pressing second generation sanitation problems in Bangladesh. Therefore, a sustainable business approach to operate such treatment plant needs to associate full life cycle analysis. The recent political will of the government to develop institutional and regulatory framework of FSM is a much inspiring one, which could help turn such technological innovations into widespread practice. Further extended research is required to validate such engineering conceptual design. Sharing the lesson learnt and knowledge on the technical and operational aspects of co-composting of FS and SW in Cities in Bangladesh. Detail description of an innovative co-composting system which improves current FSM practice in city regimes and toward building a resilient city.

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