Faecal sludge treatment and reuse system in Mahalaxmi Municipality, Nepal

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Abstract

Faecal Sludge Management is growing issue in cities in Nepal. Due to lack of faecal sludge treatment plant, the unsafe disposal of faecal sludge very common in Kathmandu Valley. After the devastating earthquake on April, 2015, many agencies constructed temporary latrines in the campsites and open spaces. As a result, the pits get filled up quickly requiring immediate desludging services. With an aim to treat the faecal sludge generated from the emergency latrines, a faecal sludge treatment plant was established in Lubhu which is first of its kind in Nepal. This article presents the current situation of treatment plant, its performance and scope of replication as being the proven example with successful operation for a year and aided sector learning in context of Nepal. The data were collected from the field visits, interviews, results from laboratory analysis. The efficiency of FSTP in removing organic matters and nutrients was found good. Some operation and maintenance problems were identified and fixed during the monitoring period. Such kind of FSTP can be replicated in other communities in the urban areas in Nepal.

Key words: biogas, compost, desludging, FSM in emergencies, pre-fabricated system

Introduction

In many emergency situations, providing better access to adequate sanitation facilities is important to minimize the risk of widespread of water borne diseases. Besides the provision of good sanitation, faecal sludge management and logistics in emergency settings are always a major challenge for the humanitarian organizations. The development of suitable treatment and disposal methods of large quantities of human excreta in (post) emergency settings has been often neglected due to other priorities. Inappropriate disposal of FS generated from the emergency latrines often result in public health risks and environmental pollution. Thus the proper FSM should be planned while providing emergency sanitation facilities during the emergency settings.

In the aftermath of the devastating earthquakes in 2015, people started residing in number of relief camps in the open spaces for several months. The

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temporary emergency latrines were established to improve the sanitation and safeguard the health conditions of people residing in the relief camps. Lubhu situated in recently Open Defecation Free (ODF) declared Mahalaxmi Municipality of Kathmandu Valley where 10 small relief camps were set for 500 occupants. The intensive use of emergency latrines in the camp setup and settlements resulted the problem of overflowing black water from the pits. The unsafe disposal of faecal sludge (FS) after the desludging, due to lack of appropriate FS treatment system in Kathmandu Valley, was preeminent problem during the emergency situation.

Environment and Public Health Organization (ENPHO) with support from the Municipality, Bremen Overseas Research and Development Association Organization (BORDA) and The Consortium for DEWATS Dissemination (CDD) Society established the Faecal Sludge Treatment Plant (FSTP) in March 2016, primarily to treat FS generated from the camp sites and earthquake affected households. The pre-fabricated treatment plant was constructed within 45 days in 300 m^2 land area provided by the local NGO, Saligram Orphanage. FSTP with design capacity of 6 m^3 per week is based on gravity flow system and have reuse potential in the existing vegetable farmland. Besides FS from emergency latrines, the treatment plant also received FS from the households. The research team have performed regular monitoring, performance evaluation, sampling and laboratory analysis to understand the one-year of performance and efficiency of FSTP. The objective of this paper is to present the status of treatment plant in terms of performance, acceptability and sustainability and to discuss possibility of replication in the context of Nepal.

Methods

Questionnaire Survey

A structured questionnaire for the caretaker of the treatment plant was designed to understand the major O&M requirements and overall perception of caretaker towards FSTP. A questionnaire was also prepared for private tanker collecting sludge to understand the emptying practices, frequency of pit emptying, difficulties during haulage and desludging and protective measures used during emptying of the tank.

Sampling and Analysis of FS

With an aim to understand the performance of treatment plant samples were collected by following grab methodology from different treatment units. Table 1 shows sampling location and volume of sample collected.

Each sample was collected in a sterilized 1L and 250 ml plastic bottle and 500 ml acidified bottle (for sample preservation) provided by the ENPHO laboratory using personal protecting equipment. Bottles were properly labeled in the site to prevent any kind of errors and brought on the same day to ENPHO laboratory for analysis. pH, electrical conductivity, total solids, total volatile solids, total alkalinity as $CaCO_3$, ammonia-nitrogen, nitrate, total phosphorus, total nitrogen, total kjeldahl nitrogen (TKN), chemical oxygen demand (COD), potassium, helminths, total coliform and E. Coli were analyzed following prescribed Standard

Table 1: Sampling Location and Amount of Sample Collected

Treatment units	Exact point of sample collection
Feeding tank (FT)	Inlet of Feeding Tank
Biogas digester (BGD) 1	Expansion chamber of BGD1
Biogas digester (BGD) 2	Expansion chamber of BGD2
Stabilization tank (ST)	Final chamber of ST
Anaerobic baffle reactor (ABR)	Final chamber of ABR
Anaerobic filter (AF)	Final chamber of AF
Planted gravel filter (PGF)	Outlet of PGF

Operating Procedures defined in APHA, AWWA, WEF (2012) in ENPHO laboratory. The sampling for the selected parameters were done and analyzed to know the efficiency of FSTP during pre-monsoon, monsoon and post-monsoon seasons.

Field Observation

Technical team from ENPHO visited the treatment plant for regular supervision of operation and maintenance of the plant and record books. The team performed the maintenance work in the site due to overflowing wastewater in Integrated Settler with ABR and AF and ponding PGF during post-monsoon.

Description of modules of Treatment Plant

The treatment plant has two different treatment systems integrated into one: Liquid Treatment Plant and Solid Treatment Plant. After the desludging truck empties faecal sludge from its tank into the feeding tank through hose pipe, supernatant is conveyed to liquid treatment system and thick sludge is conveyed to solid treatment system, after retention for 3 to 4 hours. Following are the components of two different treatment system with their respective size and functions;

Table 2: Function and Size of Treatment Modules

	Name of Module	Size	Function
	Feeding Tank (FT) (common for both treatment plant)	4 cum	Bar-screen provided within feeding tank separates solid waste; Incoming faecal sludge (FS) is retained for 3-4 hours for solid-liquid separation; After retention, supernatant is discharged to settler with anaerobic baffle reactor (ABR) and anaerobic filter (AF) and sludge into biogas digester.
Sludge Treatment Units	Biogas Digester (BGD) (in series)	6 cum each (2 numbers)	Anaerobic treatment of highly concentrated organic sludge; Produces biogas as the by-product.
	Stabilization Tank (ST)	10 cum	Allow the sludge to get further stabilized, which leads to settlement of solids at the bottom and supernatant to flow into the settler with integrated ABR and AF.
	Planted Sludge Drying Beds (PSDB)	20 sq. m each (3 numbers)	Digest the sludge to reduce the organic activity, thereby reducing the pathogen content. Dehydrates the sludge to produce bio-solids that can be easily transported or handled for reuse applications.
Wastewater Treatment Units	Integrated Settler Anaerobic Baffle Reactor (ABR) with Anaerobic Filters (AF)	10 cum	Wastewater undergoes sludge stabilization with biological treatment in settler (settler); Anaerobic degradation of suspended and dissolved solids while flowing through sludge blanket making use of the pollutants for metabolism by anaerobic bacteria (ABR); Allows the growth of microorganisms to make use of the pollutants for metabolism, degrading the organic material present in the wastewater (AF).
	Planted Gravel Filter (PGF)	15 sq. m	Aerobic tertiary treatment unit where the pollutants (mostly nutrients) present in the wastewater are degraded aerobically.
	Collection Tank	4 cum	Collects treated water.

Results and Discussion

The efficiency of FSTP in removing various parameters is presented in Table 3.

With Solid Loading Rate (SLR) of 210 kg TS/ m^2.year, this FSTP showed similar efficiency as observed in the planted sludge draying bed study by Koottatep *et al.* (2004). The efficiency of FSTP in removing the physico-chemical parameters has increased in monsoon but again decreased in post-monsoon. The overflowing of wastewater treatment system was observed during monsoon. Some key technical problems such as leakages in control valve of feeding tank and backflow of faecal sludge from the clearing pipe into the control valve

Table 3: Removal Efficiency of Treatment Plant During Pre-monsoon, Monsoon and Post-monsoon

Parameters	Unit	After 76 days of operation	After 152 days of operation	After 271 days of operation
		Pre-monsoon (June)	Monsoon (August)	Post- monsoon (December)
		Removal Efficiency (%)	Removal Efficiency (%)	Removal Efficiency (%)
pH	-	NA	NA	NA
Electrical Conductivity	µS/cm	55.41%	69%	22%
Total Solids	mg/L	71.37%	78%	50%
Volatile Solid	mg/L	75.70%	85%	70%
Total Alkalinity as $CaCO_3$	mg/L	40.43%	91%	26%
Nitrogen-Ammonia	mg/L	53.87%	71%	42%
Nitrate	mg/L	NA	90%	96%
Total Phosphorus	mg/L	72.90%	80%	71%
Total Nitrogen	mg/L	55.78%	73%	56%
Total Kjeldahl Nitrogen (TKN)	mg/L	55.78%	73%	56%
Organic Dry Matter	mg/L	75.70%	85%	70%
Chemical Oxygen Demand (COD)	mg/L	90.62%	91%	86%
Potassium (K)	mg/L	33.11%	65%	-68%
Helminths	Present/ Absent	Absent	Absent	Absent
E. coli	CFU/mL	TNTC	TNTC	TNTC

TNTC: Too Numerous To Count

units increased undesired volume of sludge in each unit of wastewater treatment system. As a result, the efficiency of FSTP in removing nutrient, solid and organic matters slightly decreased during post-monsoon season (Figure 1).

After these results and field observations, the problems observed in FSTP have been fixed. The next round of sampling and analysis will confirm if the efficiency of FSTP improved after fixing the problems. No helminths were found in the effluent. The majority of houses are served by on-site sanitation systems such as septic tanks and unsewered toilets. The faecal sludges (FS) revealed that the bulk of helminths eggs contained in wastewater or in faecal sludge end up in the bio solids generated in treatment schemes (Ingallinella *et al.,* 2002). Thus, bio-

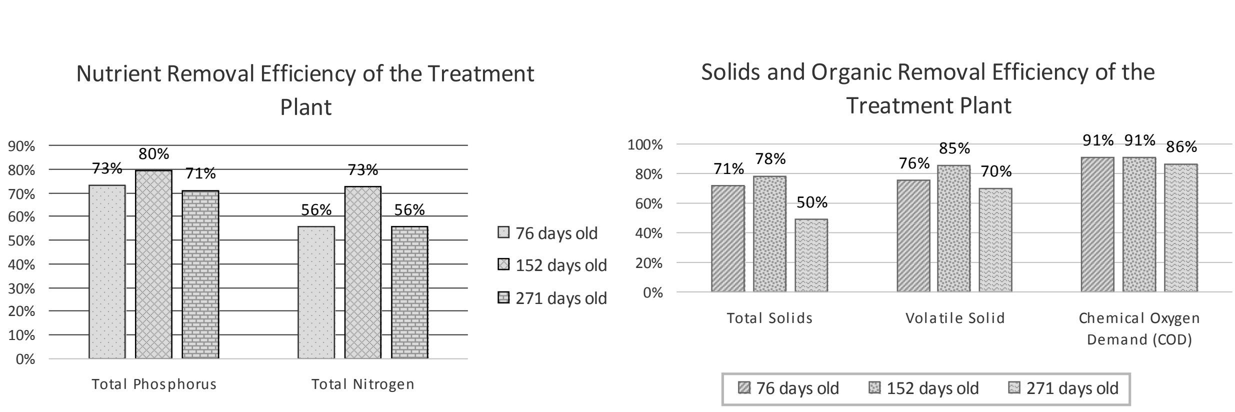

Figure 1: Season-wise nutrient, solids and organic removal efficiency of FSTP

solids that would be obtained from the treatment plant needs to be examined and verified with the proposed guideline value (3-8 eggs/g TS) for bio-solids by Xanthoulis and Strauss (1991). *E. coli* count was found very high in all the time. It indicates the need of hygienic reuse of treated wastewater and sludge. The instructions on hygienic use of treated wastewater and sludge was provided to the caretaker.

Altogether 91 trips of FS, about 320 m^3 of FS have been fed into FSTP, producing around 180 m3 of treated wastewater, which is being used by Saligram orphanage in the farm land. Following the theoretical calculation method used by Lier *et al.* (2011), nearly 507 m^3 biogas has been produced from the system. Nevertheless, the actual recorded data showed that 254 m^3 of biogas have been used for cooking by the caretaker's family.

The calculation showed that use of biogas from the system has saved money for buying about 7 cylinder of LPG gas which accounts for saving of USD 95. In addition, the amount saved due to use of treated wastewater is around USD 200 per year. Besides, financial benefits, the caretaker deemed that the productivity has been increased after the use of treated wastewater in the farm land. This is further supported by the results of treated effluent with high NPK value. It is expected that the used of treated sludge will further increase the financial benefits and productivity.

The private FS tanker operators deemed the safe disposal of FS into FSTP is very good practice and showed willingness to pay for the safe disposal. The demand for the desludging services is around 4-5 times per day. They feel bad disposing FS haphazardly but they don't have any options. Thus, the operators suggested to establish additional FSTP in different locations for easy disposal. It will also minimize transport mileage as suggested by Ingallinella *et al.* (2002). Agyei *et al.* (2011) indicated the need of strong political will for effective and sustained FSM services at local level. The local stakeholders at Lubhu provided their support in identifying the land to establish FSTP and the municipality office has been providing salary to the caretaker of this system. These commitments showed by the local stakeholders is promising for sustainability of this FSTP. In addition, the local stakeholders are proud to showcase this demonstration project which is a good platform for sector learning.

According to Niwagaba and Mbéguéré (2014), the rate of biological degradation increase with warmer temperatures. Thus FSTP can be largely replicated in the Hilly and Terai regions of Nepal, where temperature is relatively high and the practices of onsite sanitation systems is growing. The targeted populations at those regions can be benefitted by the productive use of biogas, treated wastewater and sludge.

Conclusion

Contrary to wastewater management, the development and implementation of strategies and options to cope with faecal sludge (FS) adapted to the conditions prevailing in developing countries has long been neglected. In such situation, the promising results of the treatment efficiency, the emerging demand and the self-sustaining potential of this type of proven treatment plant indicates the relevance and hence the importance of scaling up of these types of systems in the rapid and haphazard urbanization context like of Nepal. Continued research and monitoring in terms of financial, institutional, environmental, technical and social aspects of such treatment plant is essential to scale-up replication in other communities. The findings and evidences from this study can be useful for the policy makers in developing and implementing standards and policies on FS handling, disposal and treatment. The FS desludging and transportation services should be regulated and recognized that will significantly contribute in effective FSM in Nepal.

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