Assessment of Operational Status of Fecal Sludge Treatment Plants

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Abstract

The demand for safely managed sanitation services is increasing with the rise of the global population. The declaration of open defecation-free (ODF) in 2019 has ensured access to toilets to all in Nepal but increased the challenge of safe management of generated sludge from these toilets. Ten Faecal sludge treatment plants (FSTP) have been established by 2022 but studies on their operational status are limited. This paper aims to present the operational status and implication of social, financial, technical and managerial aspects on the operational good/poor status of seven FSTPs in Nepal. The study was conducted through literature review, deskwork, key informant interview (KII), multi-stakeholder consultation meeting (MSCM), field observation and data analysis. The study was conducted in 6 operational FSTPs; Lubhu, Gulariya, Charali, Kakarbhitta, Waling and Birendranagar, and one established but not operational FSTP; Madhuwan. The FSTPs were accessed on 7 indicators in total considering social, managerial, technical and financial aspects. None of these FSTPS was in good operation in all aspects. However, Gulariya and Waling FSTP were in the satisfactory condition given the treatment quality meets the standards protecting the public health of locals. To conclude, FSTPs in Nepal are still facing challenges in operating in good condition.

Keywords: Faecal sludge, FSTP, Nepal, operational status, sanitation

1. Introduction

The demand for safely managed sanitation services is increasing with the rise of the global population. Most developing countries are facing sanitation challenges. About 4.5 billion people in the world still do not have access to safely managed sanitation practising either open defecation or using unsafe sanitation practices posing public health risks mostly in developing countries [1]. Although most people have access to on-site toilets, faecal sludge sludge generated from these toilets is not effectively treated or disposed of creating environmental and public health concerns. Faecal sludge treatment plants have been established in many developing countries to address this issue. However, many of them could not operate for the long term. More than 123 FSTPs were established in South Asia and sub- saharan countries but only 68 of them were operational by 2017 [2]. The studies have found that most of these treatment plants fail in a lack of ongoing finances during the operation [3].

Nepal was declared Open defecation free in 2019 through the nationwide campaign to provide access to the toilet to all. The aftermath of this successful campaign was the challenge of safely managing the sludge generated from these toilets. At present, 89% of households have on-site sanitation; pit latrines or septic tanks [4]. This has increased the demand for emptying services, transportation, treatment and safe disposal of the generated sludge. At present, the daily sludge generation in the country is 2,925 m^3 per day. However, most of this sludge is disposed of in nearby water bodies or open lands [5]. By 2022, there

were 10 FSTPs established in Nepal but only 6 were operational. This shows the need of establishing more FSTPs in the country to treat the generated sludge. In addition, the study of issues behind these FSTPS stopping to operate is limited and the factors affecting the sustainable operation of FSTPS need to be studied.

This paper aims to present the operational status and implication of social, financial, technical and managerial aspects on the operational good/poor of FSTPs in Nepal.

2. Materials and Methods

The study was completed in three distinct phases. The preparatory work was conducted followed by the assessment of FSTPs and then data analysis and interpretation (see Figure 1).

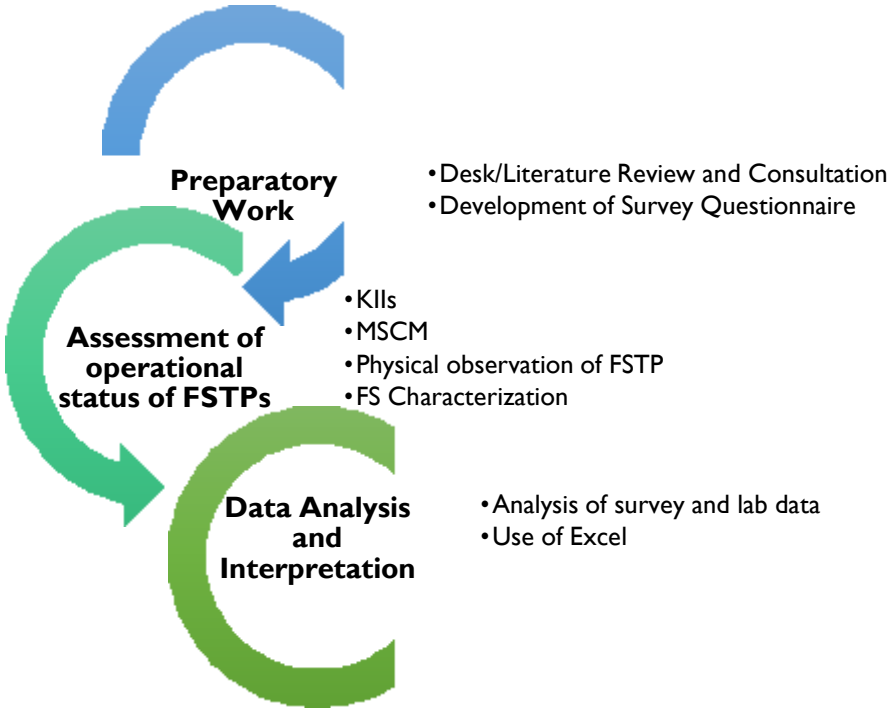

Figure 1: Methodology

2.1 Preparatory work

A literature review on existing FSTPs in Nepal was conducted to gather preliminary information on their location, establishment, and existing situation. Meanwhile, the desk study on the methodology, research techniques, and survey procedures was started. The indicators for good operation of FSTPS in the study were decided by the pool of experts in ECO-CONCERN and survey questionnaires for the study were prepared. After the desk study, the municipalities of the selected FSTPs were contacted and a consultation meeting was conducted for the effective coordination of the study.

2.2 Assessment of FSTPs

After preparatory work, the assessment was started for each criterion. In coordination with stakeholders, Key Informant Interviews (KII), and Multi-Stakeholder Consultation Meetings (MSCM) were carried out in all selected municipalities. The operational status was observed through a field visit by the technical team of ECO-CONCERN. MSCM included a Ward

Chairperson, ward member representatives, HHs representatives, a ward secretariat, FSTP Operator, a private desludger, a municipality representative, and a school representative. The stakeholders in the MSCM validated the responses of KIIs. Grab sampling on untreated and treated faecal sludge in the treatment plants was done to further study on the efficiency of the technology used. The operators were interviewed to understand the existing operation and maintenance in the plants.

2.3 Data Analysis and Interpretation

The collected data from the assessment were further analyzed to study the operational status and to identify the key factors affecting the effective operation of these FSTPs. In addition, the fundamental gaps and need for other interventions were studied.

3. Study Area

By 2022, ten FSTPs have been established in Nepal out of which 6 are in operation, 1 has completed construction, and the remaining two only have sludge drying beds. The two FSTPs with only a sludge drying bed and no other component of treatment have been excluded from this study. Seven FSTPS; Lubhu, Gulariya, Charali, Kakarbhitta, Waling, Birendranagar and Madhuwan were selected for this study. These FSTPs are spread across Nepal (see Figure 2)

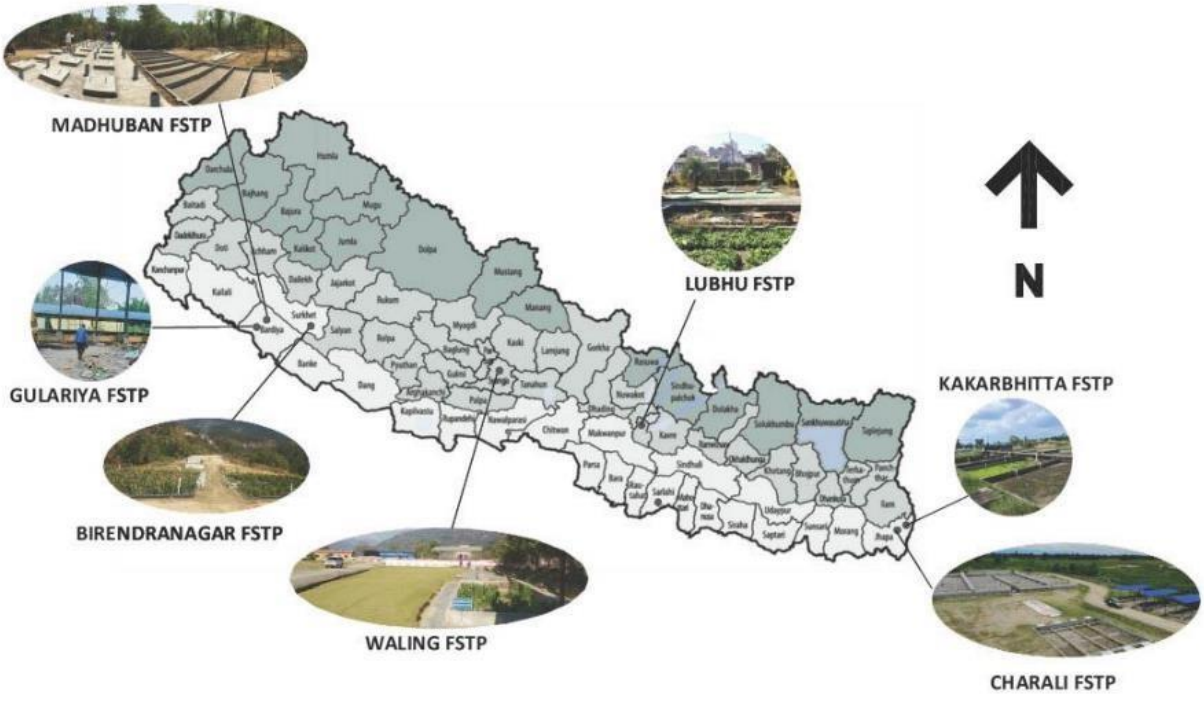

Figure 2: Location of the selected FSTPs (source: ECO-CONCERN)

The Lubhu FSTP with a design capacity of 6 m^3/week is located in Mahalaxmi municipality. It started operating in March 2016 covering a plant area of 300 m^2[6]. Gulariya FSTP is of a design capacity of 3 m^3/day and situated in Gulariya municipality. Its operation started in July 2016[7]. Charali FSTP covers 9,632 m^2 of land provided by Mechinagar municipality and can treat 27 m^3/day of faecal sludge since 2020. Kakarbhitta FSTP started operation on July

2019 covering a footprint of 4,600 m^2 and a design capacity of 12 m^3/day [8]. Waling FSTP has a design capacity of 6 m^3/day, covers 338 m^2 and started operating at the beginning of 2022 [9]. Birendranagar FSTP was designed for 50 m^3/day but the present operational capacity is 16 m^3/day and covers 1380 m^2 [10]. Madhuwan FSTP was established with a capacity of 3 m^3/day in 2018 covering foot print of 506 m^2 but has not come into operation[11].

4. Results and Discussion

4.1 Indicators for FSTP operation

The pool of sanitation experts in ECO-CONCERN discussed the possible indicators for good operation of FSTP based on their years of experience working in the sanitation sector. The indicators were identified based on 4 aspects; social, managerial, technical and financial. In total 9 indicators were identified upon which the FSTPs will be assessed for their operational performance and the criteria for their good or poor is decided as shown in Table 1.

Table 1: Indicators for the operational status of FSTP

Aspect	SN	Indicators	Good	Poor
Social	1	Awareness	The majority of the households nearby the FSTP are aware of the existence of the FSTP and its purpose	The majority of households nearby FSTP are not aware of the existence of the FSTP
	2	Acceptance	General acceptance towards the FSTP and the majority are not offended by the stigma of a waste treatment plant laying around.	The majority of households are against the existence of FSTP in their locality
	3	Demand for FSM	The demand for FS emptying/ desludging is close to the design capacity of the FSTP	The demand for FS emptying is less than the design capacity of the FSTP
Managerial	4	Dedicated Team	An exclusive and adequate team assigned solely for the complete responsibility and management of the FSTP by the municipality	No dedicated team
	5	Policy formulation	Availability of FSM policy (acts, bylaws, directives)	No policies

	6	Database management	Proven by the existence of a database (E.g.: logbook/ recordkeeping of every truck visit	No database
Technical	7	Technology	The FSTP technology should be compatible with the local context (easy to operate, not too complex).	Complex technology and external support for the O&M
	8	Treatment Efficiency	Effluent quality should meet the referred standards.	Effluent quality does not meet the referred standards
Financial	9	Financial sustainability	The revenue generated from the FSTP (tipping fee, visitors' fee, compost cost) should be enough to sustain the O&M costs at the least, to ensure financial self-sustainability. These include utility costs for routine cleaning and fuel, and the salary of the staff designated exclusively for the plant	The cost is higher than the revenue

4.2 FSTP assessment

Awareness

The awareness survey was conducted in households near the FSTPs. It was found that in all 7 FSTPs, the majority of households are aware of the presence of the treatment plant. In Lubhu FSTP, the nearby people do not know much about the actual purpose of the treatment plant.

Acceptance

The house survey, KIIs and MSCMs were conducted in all 7 municipalities to study social acceptance. People accepted and regarded it beneficial in the case of Gulariaya, Kakarvitta, Birendranagar and Madhuwan FSTP. Most nearby households have no issues in Waling FSTP. However, people complained about the foul smell and leachate spillover in Lubhu FSTP, additionally the unavailability of benefits in Charali FSTP.

Demand for FSTP

The incoming faecal sludge load were studied to access the demand for the FSTP. The actual average load incoming in each FSTP is shown in Table 2. There is high demand for Lubhu FSTP. The sludge comes not only from the residing municipality but also from nearby cities. However, the incoming sludge is not meeting the design

capacity in Gulariya, Kakarvitta and Waling FSTPs. In Charali, although there is a high demand for desludging, the incoming load in FSTP is less due to private dumping in the tea farm upon the owner's request. In the case of Madhuwan, there is high desludging demand but the FSTP is not in operation.

Table 2: Actual average FS load incoming in FSTPs

FSTP	Design capacity	Actual average FS load*	Overload (%)	Underload (%)
Lubhu	6 m^3/week	12 m^3/week	100	-
Charali	27 m^3/day	2.4 m^3/day	-	91.1
Kakarbhitta	12 m^3/day	8.1 m^3/day	-	32.5
Gulariya	3 m^3/day	2.1 m^3/day	-	30
Birendranagar	16 m^3/day	12 m^3/day	-	25
Waling	6 m^3/day	1.6 m^3/day	-	73.3

** source: Technical field assessment and MSCM conducted by ECO-CONCERN in 2022*

Dedicated team

The study found a lack of a definite department in the municipality and FSTP to look after overall management in Gulariya, Charali, Waling, Birendranagar and Madhuwan FSTPs. In Lubhu FSTP, there is an operator assigned by Saligram Balgriha to take care of the O&M of the system and sanitation department in the municipality, but no dedicated team to monitor the operation. While the Kakarbhitta Water Users and Sanitation Committee (WUSC) is authorised for the operation of the FSTP since 2021. The WUSC has been overseeing the FSTP's maintenance, selection and recruitment, and all of its financial management along with the operation of the ISO-standard desludging vehicle.

Policy formulation

Nepal government has published the institutional framework for faecal sludge management but there are no policies and standards specific to faecal sludge management[12] . Although there are no policies for faecal sludge management at a national level, some municipalities have formulated bylaws. Mahalaxmi municipality and Birendranagar metropolitan city have formulated the FSM bylaws or policies for effective management of faecal sludge that has a positive impact in Lubhu and Birendranagar FSTP, respectively[13][14]. No such policies were seen in Gulariya, Charali, Waling, Mechinagar and Madhuwan municipalities.

Database management

During the study, it was observed that the log book for the incoming sludge loads and tipping fee payments is being maintained in Lubhu, Gularia, Charali, Waling and Birendranagar FSTP. The kakarbhitta FSTP, despite being operational, does not have any record keeping. Madhuwan has not started operation so no databases were found.

Technology

The field visit team observed that the FSTPS were constructed using locally available materials in Gulariya, Charali, Kakarbhitta, Waling, Birendranagar and Madhuwan FSTP, and parts were locally available for O&M. However, the Lubhu FSTP has prefabricated modular units imported from India which makes it challenging for maintenance in the units. The treatment units and their capacity are shown in Table 3.

Table 3: Treatment units in FSTPs

	Lubhu[6]	Charali [8]	Kakarbhitta [8]	Gulariya [7]	Madhuwan [11]	Birendra Nagar [10]	Waling [9]
Design capacity	6 m^3/week	27 m^3/day	12 m^3/day	3 m^3/day	3 m^3/day	50 m^3/day (operational 16 m^3/day)	6 m^3/day
Feeding tank	1 unit (4 m^3)	-	-	-	-	-	1 unit (6.35 m^3)
Anaerobic digester	-	-	-	-	30 units	-	-
Biogas digester	2 units (6 m^3 each)	-	1 unit (88 m^3)	2 units (not in use)	-	-	-
Stabilization tank	1 unit (10 m^3)	-	1 unit (2 chambers; 12 m^3 each)	-	-	-	-
SDB	Planted; 3 units (20 m^2 each)	Planted; 28 units (60 m^2 each)	16 units (60 m^2; 0.2 m depth)	7 units (21 m^2; depth 0.5 m)	10 units	Planted; 2 units (102.5 m^2 and 94.46 m^2)	15 units (14 m^3 each)
Settler	1 unit (10 m^3)	1 unit	-	1 unit (3.7 m^3)	-	-	1 unit (8.1 m^3)
ABR		1 unit (3 chambers)	1 unit (3 chambers)	1 unit (4.6 m^3)	1 unit	-	1 unit (2.16 m^3 each chamber)
HFCW with PGF	1 unit (15 m^2)	4 units (30 m^2; depth 0.6 m)	1 unit	1 unit (28 m^2; depth 0.5 m)	1 unit	-	1 unit (15 m^3)
Collection well	-	-	1 unit	-	-	2 units	-
Polishing pond	-	1 unit	1 unit	-	1 unit	1 unit	-
Collection tank	1 unit (4 m^3)	-	-	-	-	1 unit (11.264 m^3)	-

Treatment Efficiency

The grab samples were collected in the inlet and outlet of treatment plants. Lab analyses were conducted for BOD, COD, pH, TS, TSS and helminths. It was observed that the treated effluent doesn't meet the standards for BOD, COD, TSS and Helminths in Lubhu FSTP. Charali FSTP complies with all parameters except TSS. Kabarbhitta FSTP does not comply with the standards for COD and TSS, and birendranagar FSTP does not meet the standard for BOD, COD and TSS. Only Gulariya and Waling FSTP comply with all parameters tested. (see table 4)

Table 4:Treated effluent quality in FSTPs

Parameter	FSTP							Nepal Standard **
	Lubhu*	Gulaiya*	Charali*	Kakarbhitta*	Waling*	Birendranagar*	Madhuwan	
BOD5 (mg/l)	*106*	*50*	*28*	*36*	*30*	*160*	*N/A*	*50*
COD (mg/l)	*1600*	*155.7*	*75*	*330*	*125*	*275*		*250*
pH	*5.33*	*7.68*	*7.55*	*8.41*	*8.52*	*8.2*		*5.5-9*
TS (mg/l)	*2034*	*2665*	*1438*	*593*	*251*	*1159*		-
TSS (mg/l)	*348*	*13*	*53*	*454*	*11*	*78*		*50*
Helminths (count/ml)***	*presence*	*absence*	*absence*	*absence*	*absence*	*absence*		*<1*

* source: Lab test results from 2022 [15](Annual revenue should be revisited, because most of the treatment plant they are not recovering the O&M cost)
** Source: Government of Nepal, Ministry of Population and Environment: Generic Standard Part III: Tolerance limits for wastewater to be discharged into inland surface waters from combined wastewater treatment plant[16]
*** Source: WHO guidelines for the use of wastewater in agriculture and aquaculture [17]

Financial sustainability

In all operational FSTPs, the main source of income is tipping fee from desludging trucks. The average tipping fee is NPR 500 per trip for private desludgers. There are log books for tipping fee but no clear record of cost incurring operation and maintenance. The operator's salary comes from Saligram Balgriha in Lubhu FSTP, and from municipalities in other FSTPs. In Gulariya and Charali FSTP, there is no tipping fee for desludging truck run by municipality. There are potential of sale of end products in Lubhu and Kakarbhitta FSTPs, but not much action is taken. In Birendranagar FSTP, the tipping fee has been increased to NPR 800 and may generate better revenue in future. However, none of the municipalities are financially self sustained.

Operational status

The overall operational status of the FSTPs is shown in table 6. It was observed that nearby households were aware of the treatment plant in all FSTPs. But they were socially accepted only in 5 FSTPs; kakarbhitta, Waling, Birendranagar and Madhuwan. the . There is a high demand for FS treatment only in Lubhu FSTP. No dedicated team in all FSTPs. The policies were formulated only in 2 FSTPs; Lubhu and Birendranagar. The record-keeping was maintained in all FSTPs except Madhuwan. The technology was nature-based and construction materials are locally available in all FSTPs except Lubhu. The treatment efficiency was good in two FSTPS, Gulariya and Waling others are facing challenges in meeting the set standards. All FSTPs are struggling to meet all O&M costs with the income from the tipping fee.

Table 5: Operational status of FSTPs for each indicator

Indicator	**FSTP**						
	Lubhu	**Gulaiya**	**Charali**	**Kakarbhitta**	**Waling**	**Birendranagar**	**Madhuwan**
Awareness	*Good*	*Good*	*Good*	*Good*	*Good*	*Good*	*Good*
Acceptance	*Poor*	*Good*	*Poor*	*Good*	*Good*	*Good*	*Good*
Demand for FSM	*Good*	*Poor*	*Poor*	*Poor*	*Poor*	*Poor*	*Poor*
Dedicated Team	*Poor*	*Poor*	*Poor*	*Poor*	*Poor*	*Poor*	*Poor*
Policy formulation	*Good*	*Poor*	*Poor*	*Poor*	*Poor*	*Good*	*Poor*
Database management	*Good*	*Good*	*Good*	*Good*	*Good*	*Good*	*N/A*
Technology	*Poor*	*Good*	*Good*	*Good*	*Good*	*Good*	*Good*
Treatment Efficiency	*Poor*	*Good*	*Poor*	*Poor*	*Good*	*Poor*	*N/A*
Financial sustainability	*Poor*	*Poor*	*Poor*	*Poor*	*Poor*	*Poor*	*N/A*

None of the FSTPs showed good performance in all aspects. The major setback was faced by Madhuwan FSTP which could not operate in a lack of a dedicated team and interest of the municipality despite having good social acceptance. The treatment efficiency in Lubhu FSTP is impacted by the overloading due to high demand and no other treatment in nearby municipalities. However, in other FSTPs the incoming load is less than the design capacity suggesting either low emptying practices or in some instances such as Charali and kakarbhitta, disposing of them in farmland instead of bringing them to the treatment plant. The major challenge observed was the managing team in all FSTPs. In lack of a dedicated, consistent team comprising FSM and FSTP experts and managers who can be made responsible to oversee the FSTP's operation, repair and maintenance routine, analyzing the financial flow and strategic planning, and cater to the needs and health of the FSTP operators. The FSTPs can be operated in good condition only when all the aspects can be met but no FSTP met all these conditions. However, Gulariya and Waling FSTP were in the satisfactory condition given the treatment quality meets the standards protecting the public health of locals.

5. Conclusion

To conclude, none of the operating FSTPs studied was good in all operational aspects considered. Overall, Gulariya and Waling FSTP can be considered to be in satisfactory operation in terms of treatment quality that meets standards and protects the environment and public health. In other FSTPs, there are multiple setbacks in fulfilling the treatment standards in the lack of a dedicated team to overlook the overall operation of the FSTPs.

Acknowledgement: This study would not have been complete if not for the kind cooperation of the survey participants and the involved officials of the seven municipalities. We also thank the research team for their relentless efforts in the field visits.

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