

STUDY OF CHARACTERISTICS OF RAW FAECAL SLUDGE (RFS), SUPERNATANT, THICKEND FAECAL SLUDGE (TFS) AND EFFLUENT FROM SLUDGE DRYING BED

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BACKGROUND

Faecal sludge management (FSM) has become a global problem due to rapid urbanization and population growth with unplanned settlements. Majority of the population rely on onsite sanitation in these urbanized area in developing nation. Improper disposal of FS is causing environmental degradation and contamination of water bodies, hence threatening public health. The proper disposal of FS can only be done when it is treated effectively. Design parameters are crucial for the good design of any technology. The objective of this research is to characterize the FS at various stages like raw faecal sludge emptied and transported by a desludging tanker, thickened faecal sludge upon settlement, supernatant after settling tank and effluent of faecal sludge from sludge drying bed.

OBJECTIVES

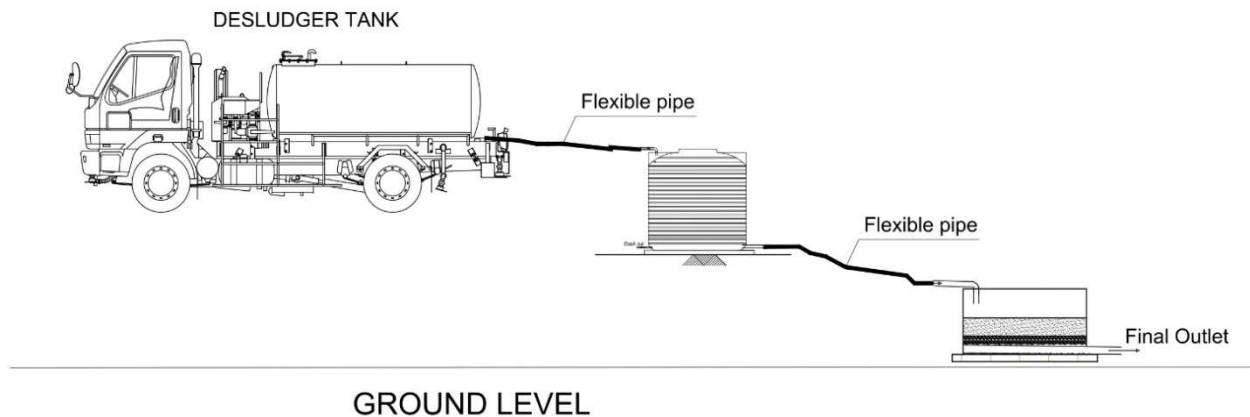
The major objective of the study was to characterize faecal sludge for assisting the design parameters of faecal sludge treatment plant. The specific objectives are:

- i. To characterize the raw faecal sludge (RWS) emptied and transported by desludging vehicles.
- ii. To document the change in characteristic of thickened faecal sludge (TFS) upon thickening in the thickened tank for four hours.
- iii. To study the characteristics of supernatant upon separation of solid and liquid in thickened tank.
- iv. To study the characteristics of effluent from the sludge drying bed.

METHODOLOGY

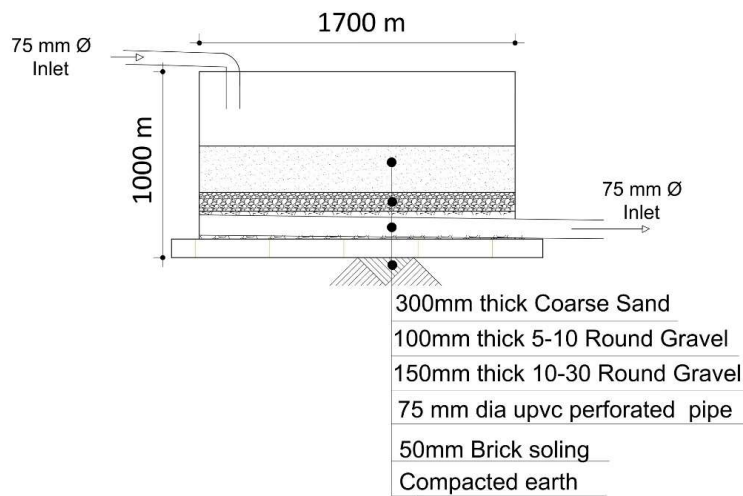
ESTABLISHING EXPERIMENTAL FIELD SETUP

An experimental field setup was established. The setup consists of thickening tank and sludge drying beds. The schematic diagram of the setup is as shown in the figure.



A conceptual diagram of an experimental setup

All together 15 experimental sludge drying beds (SDB) were constructed, the capacity of each SDB was 1 cubic meter. Coarse sand and gravel were used as filter media. The size and layer of the filter media was as shown in the figure below.



SECTION AT Y-Y

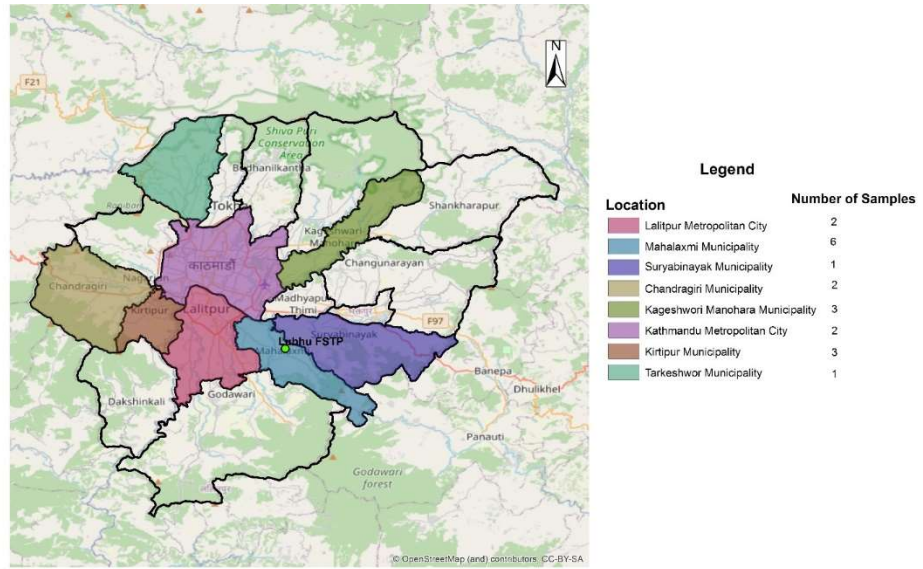
COLLECTING SAMPLES

RAW FAECAL SLUDGE SAMPLES

The raw faecal sludge (RFS) samples were collected from the desludging vehicles. The homogenous samples were collected from the faecal sludge emptied from the onsite sanitation systems in Kathmandu Valley and transported to experimental field setup. The map shows the location and number of samples collected.

THICKENED FAECAL SLUDGE (TFS) AND SUPERNATANT OF FAECAL SLUDGE (SFS) SAMPLES

The raw faecal sludge is fed to the experimental thickening tank with the capacity of 500 liters from the desludging vehicles. The vehicle was herked and moved front and backward prior to feeding in the experimental tank. The raw faecal sludge thickened by gravitational settling for four hours. The supernatant samples were collected from the cleared liquid portion of the experimental tank. The thickened faecal sludge (TFS) samples were collected by opening the valve connected at the bottom of the experimental tank.



EFFLUENT OF FAECAL SLUDGE (EFS) SAMPLES FROM SDB

The thickened faecal sludge was fed to the experimental sludge drying bed. A collection tank was connected at the bottom of the SDB to collect the effluent sample.

PARAMETERS ANALYZED

Physical, chemical, and microbial parameters were analyzed to characterize the faecal sludge. Physical parameters such as solid contents were analyzed following gravimetric methods. Chemical parameters such as BOD and COD were analyzed following Winkler's iodometric method and open reflux method, respectively. The BOD was analyzed within the six hours of collection of the sample. Similarly, TKN and TP were analyzed following the Kjeldahl method and ascorbic acid reduction (spectrophotometric) method, respectively. Helminths were analyzed following the floatation method (microscopy). The table below shows the analyzed parameters and reference methodologies.

S.N.	Parameters	Sample	Reference
1.	pH	RFS, SFS, TFS, EFS	APHA, AWWA, WEF (2017), 4500-H B
2.	Biochemical Oxygen Demand (BOD)	RFS, SFS, TFS, EFS	APHA, AWWA, WEF (2017), 5210 B
3.	Chemical Oxygen Demand (COD)	RFS, SFS, TFS, EFS	APHA, AWWA, WEF (2017), 5220 B
4.	Total Solid (TS)	RFS	APHA, AWWA, WEF (2017), 2540 B
5.	Volatile Solid (VS)	RFS	APHA, AWWA, WEF (2017), 2540 E
6.	Total Suspended Solid (TSS)	RFS, SFS, TFS, EFS	APHA, AWWA, WEF (2017), 2540 D
7.	Total Kjeldhal Nitrogen (TKN)	RFS	APHA, AWWA, WEF (2017), 4500-Norg B
8.	Total Phosphorous (TP)	RFS	APHA, AWWA, WEF (2017), 4500 P E
9.	Helminthes	RFS, SFS, TFS, EFS	Priya, M. et al, (2008)

FINDINGS

The mean value of total solid (TS) in the RFS samples was 19,281 mg/l with a standard deviation of 22,597. A correlation coefficient of 0.48 was found when total solid was analysed against storage time. The average TS in the effluent of FS from Sludge Drying Bed (SDB) was 3,869 mg/l with 617 mg/l and 15,599 mg/l minimum and maximum average TS. The average BOD in raw FS was 1478 mg/l and it has reduced to an average of 231 mg/l in the effluent from SDB. The reduction of BOD through gravitational settling was 54%. The average removal efficiency of BOD by SDB was 84%. The average COD in raw faecal sludge is 23,031 mg/l. The gravitational settling reduced COD by 47.5% in the supernatant. The removal efficiency from the SDB is 93% but the average COD is 1593 mg/l which is unsafe for discharging into environment. The mean value of TKN in raw faecal sludge was 937 mg/l with a standard error of a mean of 127 mg/l. It was reduced to 301 mg/l in the effluent. The mean value of TP in raw faecal sludge samples was 156 mg/l with a standard error of mean 34 mg/l. The major helminths detected were Ascaris and Toxocara eggs. Similarly, the helminths eggs were observed in 95% of the thickened faecal sludge.

CHARACTERISTICS OF RAW FAECAL SLUDGE (RFS)

RAW FAECAL SLUDGE				
Parameters	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Std. Deviation
Total Solids (TS)	2,352	79,751	19,281	22,597
Total Suspended Solids (TSS)	284	73,180	11,947	16,647
Volatile Solids (VS)	1,370	41,814	10,551	12,245
BOD ₅	190	3,350	1,478	1,053
COD	1,419	77,200	23,031	20,979
TKN	103	2,414	937	570
Total Phosphorous	12	637	156	152
Potassium	46	247	137	61

CHARACTERISTICS OF THICKENED FAECAL SLUDGE (TFS)

RAW FAECAL SLUDGE				
Parameters	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Std. Deviation
Total Solids (TS)	2,352	79,751	19,281	22,597
Total Suspended Solids (TSS)	1340	80,780	26,531	22,071
Volatile Solids (VS)	1,344	347,240	47,711	925
BOD ₅	160	7,400	2,312	1,780
COD	3,272	82,489	38,041	30,196
TKN	96	3,388	1,597	925
Total Phosphorous	17	1,602	435	445
Potassium	40	235	131	65

CHARACTERISTICS OF SUPERNATANT OF FAECAL SLUDGE (SFS)

RAW FAECAL SLUDGE				
Parameters	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Std. Deviation
Total Solids (TS)	1,051	54,410	8,695	11,591
Total Suspended Solids (TSS)	312	20,700	3,735	5,634
Volatile Solids (VS)	210	25,172	5,008	5,911
BOD ₅	105	1,550	678	485
COD	664	83,600	12,088	19,754
TKN	150	1,909	753	440
Total Phosphorous	5	413	90	92
Potassium	16	247	127	59

CHARACTERISTICS OF EFFLUENT OF FAECAL SLUDGE (EFS) FROM SDB

RAW FAECAL SLUDGE				
Parameters	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)	Std. Deviation
Total Solids (TS)	617	15,599	3,869	3,777
Total Suspended Solids (TSS)	76	4,070	705	1,085
Volatile Solids (VS)	98	14,496	2,457	3,766
BOD ₅	10	1,075	231	269
COD	204	7,321	1,593	2,060
TKN	8	692	301	194
Total Phosphorous	0	1,602	435	445
Potassium	18	568	122	117

MICROBIOLOGICAL CHARACTERISTICS

Helminthes were observed in 75% of the raw faecal sludge samples. The major helminths detected were Ascaris and Toxocara eggs. Similarly, the helminths eggs were observed in 95% of the thickened faecal sludge. While it was observed in only 40% and 25% of the supernatant and effluent samples. The data showed the helminths eggs are settled during gravitational settling and the sludge drying bed efficiently filtered it.

CONCLUSION

The major conclusions from the study were as listed:

- Reduction of suspended solids through gravitational settling process is depends upon the TS content in the raw faecal sludge.
- The removal efficiency of TSS through sludge drying bed was 94% with respect to raw faecal sludge.
- The concentration of VS in the raw faecal sludge ranges between 15% and 88%.
- The average BOD of faecal sludge was 1,478 mg/l. Upon removing the BOD of diluted FS, the average BOD is 1893 mg/l. While the BOD of thickened faecal sludge is 2,800 mg/l removing value of diluted sludge samples.
- The average reduction of BOD through gravitational settling was 54%.
- The average removal efficiency of BOD by SDB was 84%.
- The average COD in raw faecal sludge is 23,031 mg/l. The gravitational settling reduced COD by 47.5% in the supernatant. The removal efficiency from the SDB is 93% but the average COD is 1593 mg/l which is unsafe for discharging into the environment.