RESEARCH PROPOSAL FOR DEVELOPMENT OF ON-SITE TREATMENT OF FAECAL SLUDGE

FAECAL SLUDGE AND ITS MANAGEMENT

Faecal sludge comprises partially stabilized excreta and slurry from improved single pit latrines, septic tanks as well as latrines based on other improved and unimproved technologies and which is recognized as a risk to the environment and public health. Besides the usual contaminants characterized by 'biological oxygen demand' and 'chemical oxygen demand', faecal sludge contains ammonia/ nitrogen and phosphorus which can adversely affect surface and groundwater quality (though, under the impression of availability of N & P one school of thought perceives this as a resource for agriculture). However, of more serious and immediate concern is the health risk posed by pathogens, viruses and parasites that it harbours. The exact composition of contaminant biosolids can change from time to time and place to place (Jenkins-et-al, 2007) Typically it is characterized by Total Coliform count of 10^6–10^8/100 ml, Faecal Coliform count of 10^5–10^7/100 ml (Polprasert, 1996), (USEPA, 1994), and (USEPA, Decentralised Systems Technology Fact Sheet -Septage Treatment/Disposal, 1996), Bacteriophages count of 10^3–10^4/100 ml (Polprasert, 1996), and Helminths eggs around 4000/litre (MoUD, 2013) . Evidently indiscriminate handling and disposal of such material in to the environment – either in water bodies, on land or farms can lead to contamination of sources of drinking water, piped supplies, hand pumps, agriculture crops, vegetables, etc., it can infect people, farm workers, etc. upon exposure, and can severely undermine public health. In this respect it is pertinent to highlight an aspect which is of serious concern and which pertains to occupational health and safety of manual scavengers involved in removal of the faecal sludge. In most small towns where mechanized desludging devices are not available (and for that matter even in large and medium towns as well) it is removed manually which causes serious exposure of workers and leads to, among others, skin and respiratory infections and reduces life span. In India although manual scavenging has been banned through the recent legislation entitled 'Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013', it is estimated that there are lakhs of manual scavengers across the country who are still engaged in this dehumanizing work.

The extent of the challenge

Of the 247 million households in India, about 123 million have sanitation services. Out of these about 55 million have installed septic tanks and 19 million have leach pit

latrines(Govt-India-Census, 2011). The data on the number of septic tanks and leach pit latrines across the country and specifically in the two states where interventions are planned is presented in Table 1. Based on this data a conservative estimate is that across the country about 64 million household toilets require servicing for faecal sludge removal while in the states of Bihar and West Bengal it is around 6 and 8.5 million respectively.

Table 1.Estimates of potential users of FSM services (Govt-India-Census, 2011)

Country/ State	**Total number (million)**						**Estimated households needing FSM, (million)**
	Septic tank			**Pit latrines#**			
	Total	**Urban**	**Rural**	**Total**	**Urban**	**Rural**	
India	55.0	30.3	24.7	19.0	5.2	13.8	64.0
Bihar	3.0	1.0	2.0	3.2	2.9	0.3	6.2
West Bengal	4.1	2.8	1.3	4.5	1.3	3.2	8.5

#: The original text defines these as 'ventilated pit latrines', however that is not technically correct designation as VIPs are very rare in the Indian context.

The need for faecal sludge removal

For reasons of economy, the substructures of household/institutional/ community/ public toilets/ latrines are not made very large. Their capacity is designed considering, among others, a certain rate of contribution of organic solids by individual users, the expected number of users, and the rate of degradation of the organic matter – the latter being dependent on local geo-climatic factors. For instance in the case of a pour flush leach pit latrine, typically for a family of 5-7 persons, the size of the perforated substructure (which comprises depth of 1 to 1.5 m and 1.25 m diameter) is determined considering sludge accumulation rate of 40 and 60 litres/person/year for shallow and deep ground water table conditions respectively (Franceys-et-al, 1992) and pit emptying rate of once every year (however, depending on intensity of use and geo-climatic factors, households have reported uninterrupted usage over extended periods, ranging from 2-5 years).

Likewise in the case of septic tanks, household installations are sized from 1 to 4 cum considering still lower sludge accumulation rate of 25 litres/persons/year (which is attributed to intensive biological degradation under optimal conditions) and desludging frequency of once in 1 to 3 years. However, depending on affordability some house owners generally construct larger septic tanks to minimize or altogether avoid emptying requirement; secondly given the lack of regulation and technical supervision, often the walls and floor of such 'septic tanks' are made porous to leach out wastewater. Both these practices represent irrational measures at the grassroots which undermine potential benefits from improved sanitation. As regards frequency of desludging of septic tanks under Indian setting, according to one study about 16% households report twice a year, 23% do it once a year, another 23% once every 2 years and 17% carry out once every 3-5 years. Balance 20% report emptying once in 6-10 years or more than 10 years.(Sangeeta Chowdhry - Doulaye Kone, 2012). In the case of larger installations at public and community toilets evidently emptying frequency can be much higher - ranging from once a quarter to twice a year. On an average, a household empties a septic tank at an interval of 3 to 3.5 years in Kathmandu Velly (HPCIDBC, 2011).

Timely removal of sludge is imperative if system efficiency in retaining solids and attenuating effluent quality has to be maintained. It is also necessary to avoid system malfunction and ensure uninterrupted service. Furthermore, areas characterized by high water table (including alluvial riverine belts, delta areas and coastal regions) and low permeability soil warrant higher maintenance. In this respect it is also noteworthy that in the case of septic tanks there is another essential maintenance requirement which pertains to replacement/ regeneration of the filter media in the 'soak away'/'drainage field' typically once every few years to avoid chocking and malfunctioning.

FAECAL SLUDGE MANAGEMENT (FSM)

Characteristics of faecal sludge

Faecal sludge characteristics differ from the sewage. table 2 shows the average and range of major parameters in faecal sludge. solid content in faecal sludge is higher than in sewage.

Table 2. Characteristics of faecal sludge

Constituent (All units are in mg/l except pH)	Average	Range
Biochemical Oxygen Demand	6480	440-78600
Chemical Oxygen Demand	31900	1500- 703000

Total solids	34106	1132- 130745
Total Volatile Solids	23100	353- 71402
Total Suspended Solids	12862	310-93978
Volatile Suspended Solids	9027	95-51500
Total Kjeldahal Nitrogen	588	66-1060
Ammonia-Nitrogen	97	3-116
Total Phosphorus	210	20-760
Alkalinity	970	522-4190
Grease	5600	208-23368
pH		1.5-12.6

Components of FSM

Faecal sludge management accommodates source, collection and transport with treatment and disposal as shown in figure 1. Septic tank/leach pit is the source. Collection is also termed as emptying.

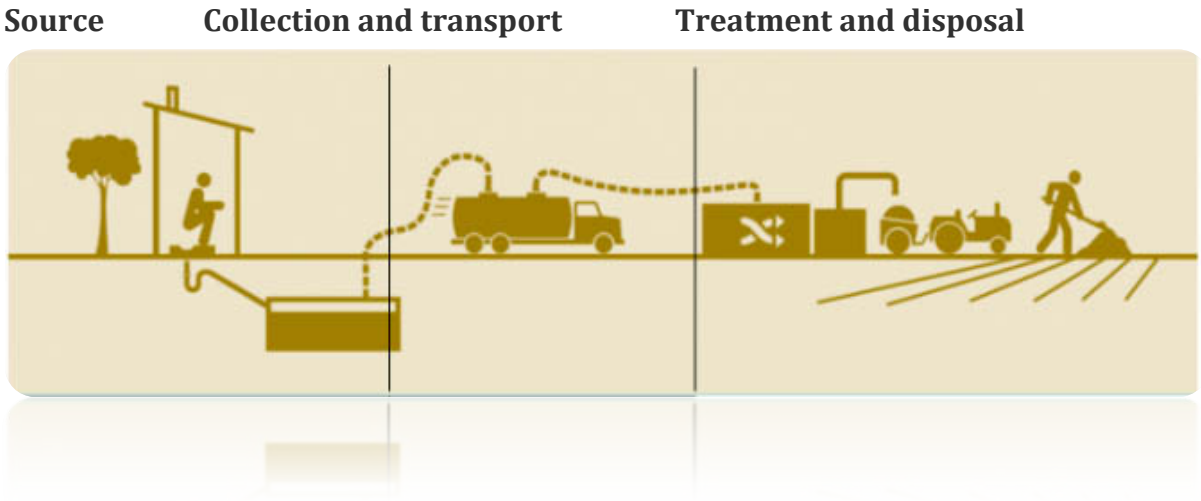


Figure 1. Schematic representation of RSM

Collection

The following are the techniques and technologies employed for collection of sludge from the septic tank / leach pit in India and other countries :

- **VacuumTanker** : Pit emptying by using Vacuum tanker is a conventional method. 1 to 10 Cubic metre. capacity tank is mounted on a truck with vacuum pumping arrangement to suck out the sludge from the septic tank.

- **Manual emptying :**Emptying of septic tank / leach pit through manual process is very common in many developing countries. In India though manual scavenging is banned, it is estimated that around 9 lakhs manual scavengers are engaged in the work illegally. The manual emptying involves digging out the sludge by using hand tools such as spades, shovels and buckets. Often manual emptying done by group of people / team of people. The duck out sludge is used as manure in the agriculture field or buried.

- **Mini Vacuum Tankers :** These are the scale down version of vacuum tanker often called as Vacutug.

- **MAPET :**Manual Pit EmptyingTechnology was piloted in Tanzania during 1980s by WASTE. The two key element of MAPET are piston pump with flywheel and 200 litres vacuum tank.

- **MDHP :**Manual Desludging Hand Pump was developed by the London School of Hygiene and Tropical Medicine together with Oxfam. MDHP includes one bucket, fibre bags, a hoe, shovel and protective equipment.

Transportation

The sludge from the toilet, septic tank and leach pit is transported to the treatment site by the following way.

- **UGD**: Under Ground Drainage line is used to transport the black water from the toilet to the treatment site in Metropolitan and other class one cities across the country. The UGD coverage in India is very meagre percentage.

- **Mechanized Truck** : The sludge and scum from the septic tanks are transported to the treatment site mainly through trucks.

- **Manual operated vehicles** : A small tank is mounted on a tricycle or cart operated by manually. Sludge from the septic tank is transferred to the tank and transported to the treatment plant. Since the capacity of the tank is small the

multiple number of trips are made to empty a tank. Also it is operated manually often the sludge is indiscriminately.

Treatment

Commonly, faecal sludge is treated in sewage treatment plant and Independent Septage Treatment Plants are also employed to treat the faecal sludge.

Challenges in FSM business

Faecal sludge management faces lot of challenges starting from the source to the treatment and disposal and FSM business becomes successful. At the source, say in leach pit/septic tank , pit filling rate and emptying interval are yet to be studied under various hydro-geological conditions. In the part of transport, the travel distance determines the operative cost and profit of the tanker operators. Loss in profit has been reported at many places. Establishing a proper treatment and disposal of faecal sludge requires a huge amount of money.

DEMAND FOR ON-SITE FAECAL SLUDGE TREATMENT

Leach pit/septic tank form the major component in the on-site sanitation. Solid retention is done in the said structure allowing the liquid portion to disperse. General liquid dispersion system for septic tank is shown in figure 2. Hydro-geological parameters like, high water table/ water logging, low permeable soil, etc , render the filing up of leach pit/septic tank.

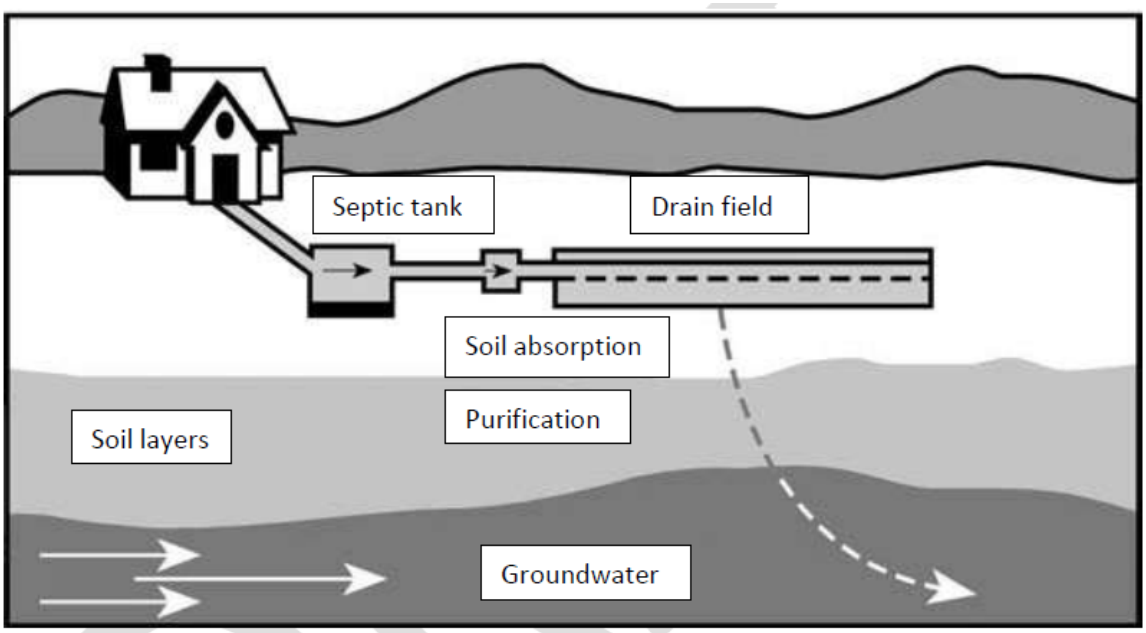


Figure 2. A schematic diagram of a septic tank

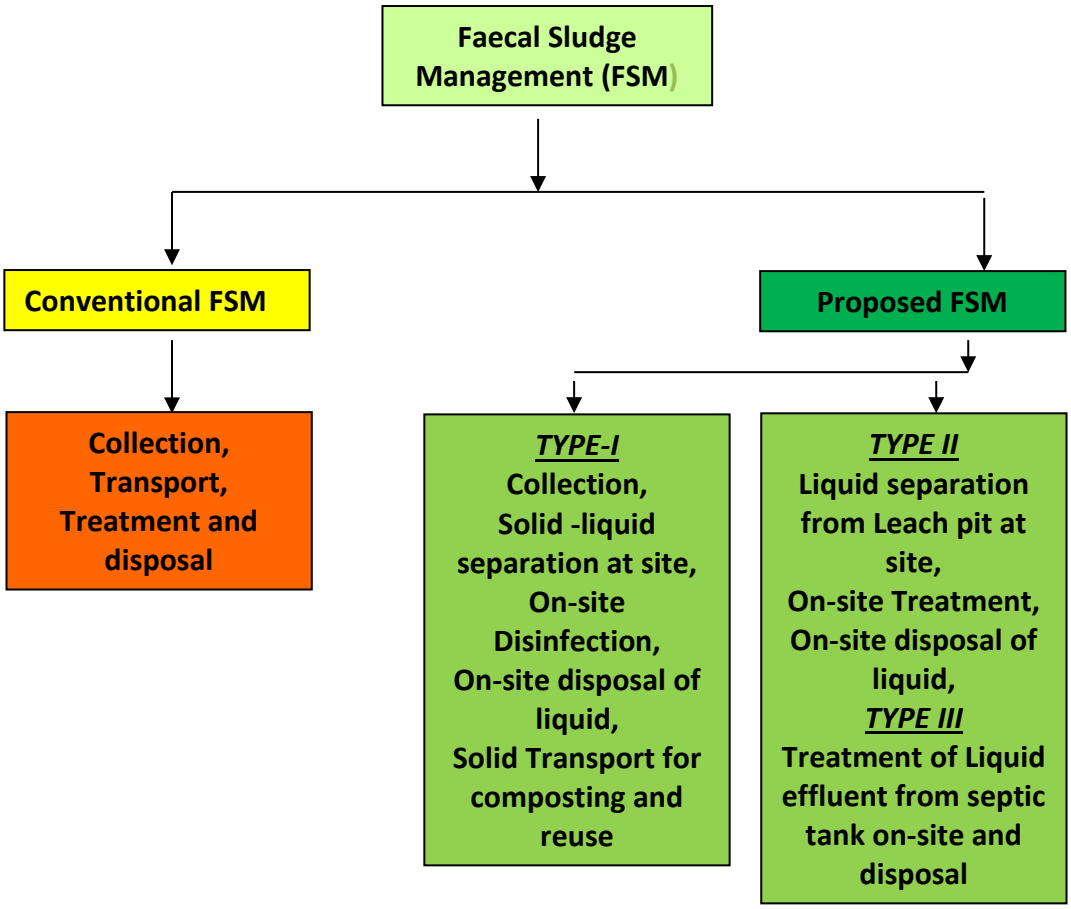
Cleaning (emptying) of leach pit/septic tank is required to keep it in hygienic condition.Faecal sludge, the content in the leach pit/septic tank, needs to handled scientifically to environmental safety. Septic tank effluent contains BOD in the range, 140 to 200 mg/l and the faecal coli form in the order of 1000 to 1000000 MPN/100 ml.

Conventionally, faecal sludge is collected , transported to the disposal point . Distance of travel crucially determines viability of the FSM business. As such, development of an alternate method of handling the faecal sludge management, to overcome the present challenges, is needed.

EXPERIMENTAL STUDY OF ON-SITE FAECAL SLUDGE TREATMENT METHODS

Proposed Concept

The proposed idea of on-site faecal sludge management is given below with the conventional practice in FSM.

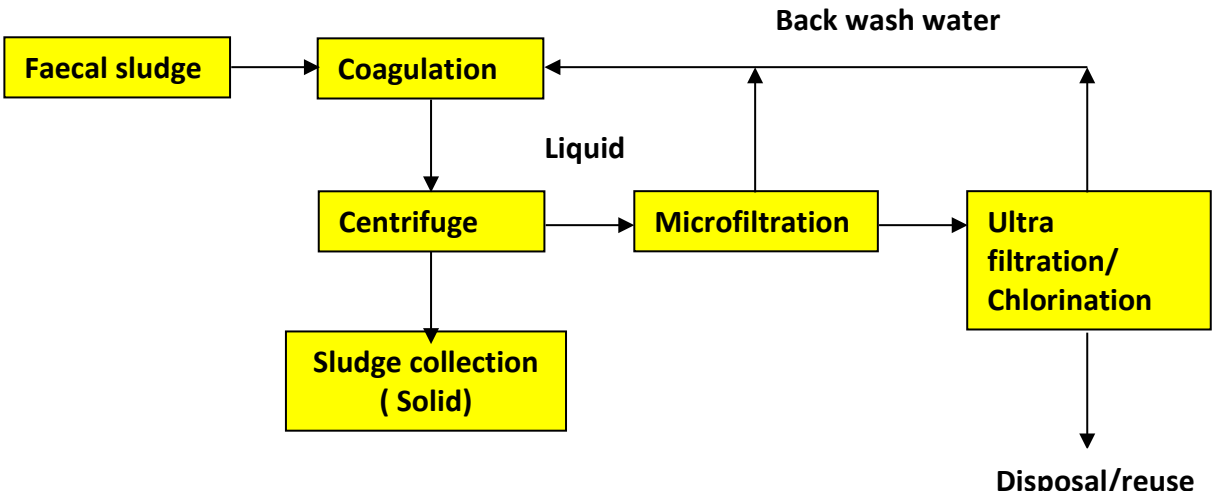


Solid-Liquid separation and Treatment (TYPE I)

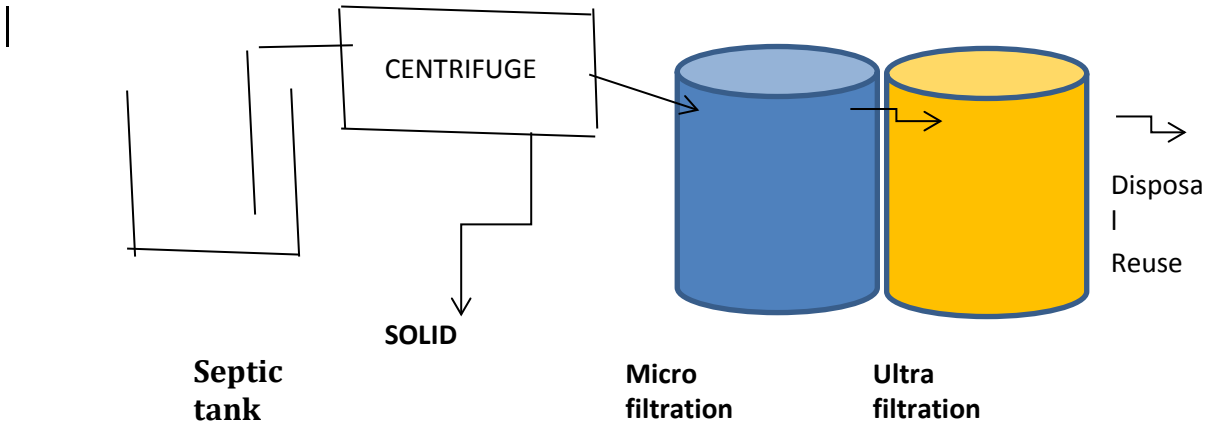
As long as faecal sludge and water mixed, management of the same is cumbersome. It will be easier if sludge and liquid is separated. Solid separation shall be done by a combination of coagulation, sedimentation and filtration (membrane process). Chemical disinfection or membrane treatment shall be done for pathogenic organisms removal. Necessary back wash arrangement shall also be incorporated and coupled. All the units shall be mounted on truck with compressor and will be as mobile unit. The following Two models shall be field tested (Model I with Centrifuge and Model II with reciprocating pump and membrane).

Model I (With Centrifuge)

The various processes contemplated using centrifuge for solid – liquid separation are shown as flow diagram below.



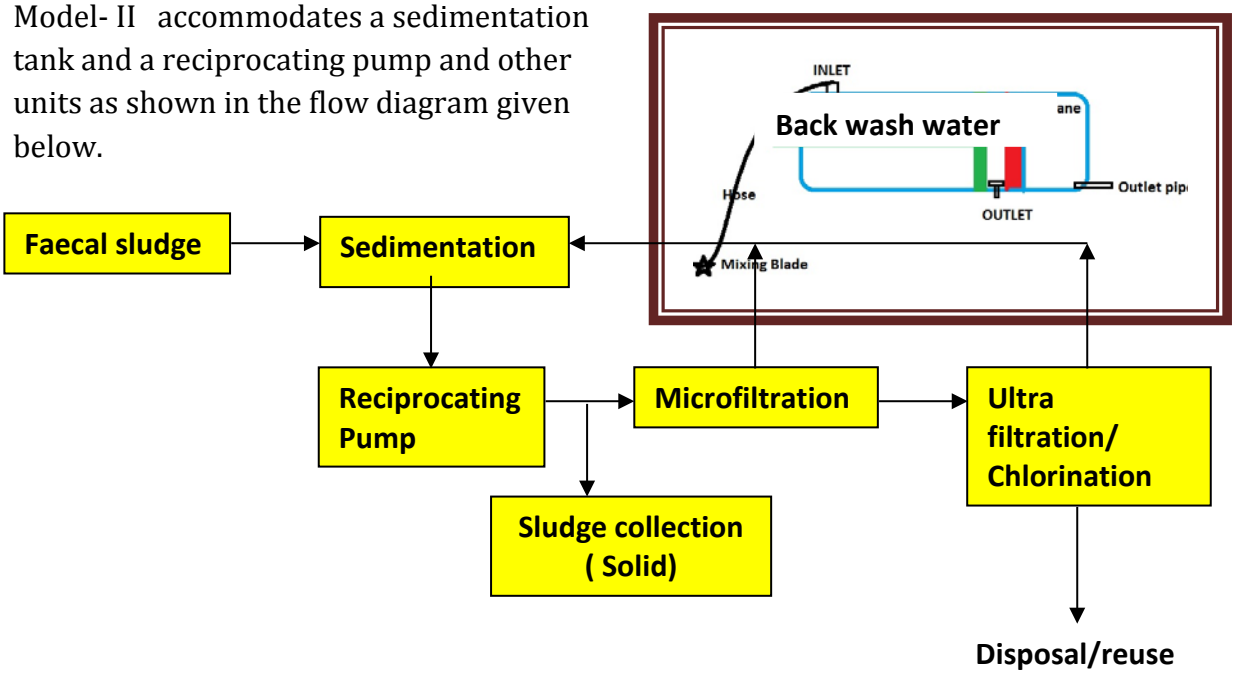
Flow diagram showing various process units in Model I

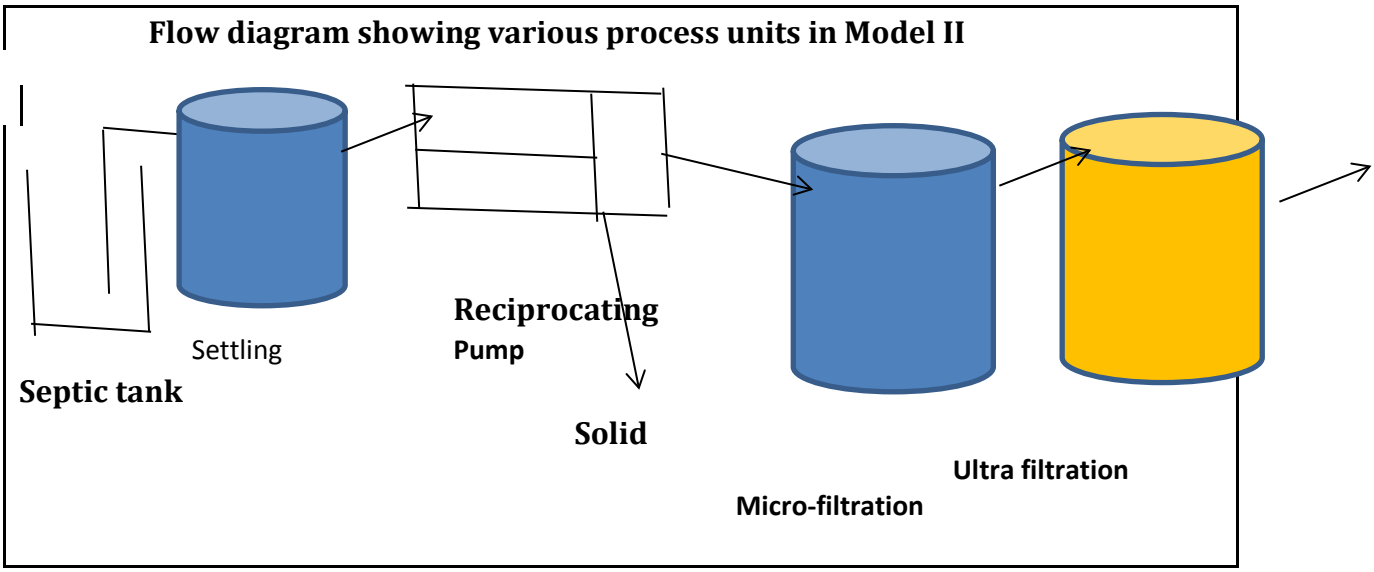


In model I, the faecal sludge from the septic tank/leach pit shall be pumped and after coagulation it will be passed through a centrifuge wherein the sludge is separated and collected in a container for further composting and reuse. Usually the solid content will be much less comparing the liquid part in faecal sludge. The liquid part received from the centrifuge is passed through micro-filtration and ultra-filtration successively to remove any fine solid particles and micro-organisms removal respectively. BOD and COD besides other parameters shall be analysed before and after to assess the efficiency of the model.

Model II (With Reciprocating Pump)

Model- II accommodates a sedimentation tank and a reciprocating pump and other units as shown in the flow diagram given below.





In the Model -II design, it is proposed to construct an air tight cylindrical tank with an inlet and out arrangements. A piston is placed in such a way that it moves up and down in the cylindrical tank. At the down end of the cylinder a membrane filter will be placed and a liquid storage cum disinfection unit is attached to the filter bed to collect liquid which pass through the membrane. The inlet is connected to a long hose with a mixing blade arrangements – this would help to mix the sludge with supernatant water to lift to the cylindrical tank. The cylindrical tank is operated similar to 2 stroke engine that inlet

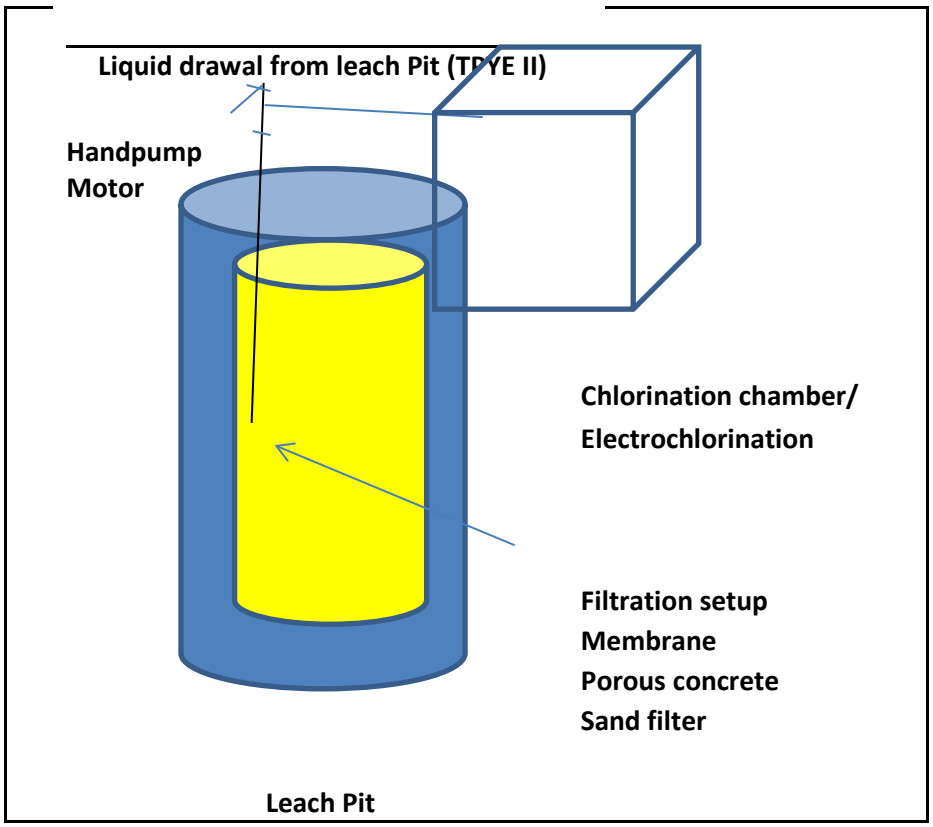
open, the sludge pumped into the chamber. Once sludge reaches to the maximum permissible level, the inlet valve closes, the piston start its move from top to bottom end and it compress the sludge, which forces the liquid in the sludge to separate from the sludge and pass through the membrane. The solid sludge accumulate at the end of the chamber will be removed through the outlet. COD and BOD level of the liquid which passes through the membrane will be tested before disposal. The main purpose of the whole cylindrical is getting rid of liquid from the sludge, which would reduce the transport cost of the sludge to the STPs.

Liquid separation from leach pit (TYPE II)

In order to increase the longevity of the leach pit and to have longer emptying interval, it is proposed to erect a filter unit inside the leach pit to get the liquid filtered for pumping out. Disinfection system is also provided for killing the pathogenic micro organisms.

The filter may be of following three forms:

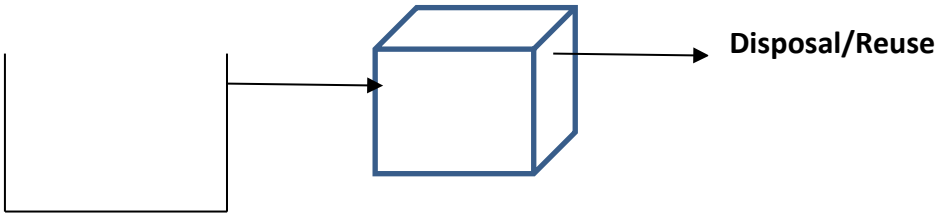
- **Micro filtration membrane:** Micro-filtration membrane shall be wound cylindrically in diameter lesser the diameter of the leach pit so as to erect the same inside the pit as shown in figure below. So fabricated filtration unit shall be lowered inside the leach pit. As the micro-filtration membrane permits only liquid to pass through, liquid gets collected. Thus collected liquid part will be pumped out either by hand pump or electrically operated pump to a collection chamber for chlorination by either chlorination or electro-chlorination. Disinfected effluent is suggested for irrigation.
- **Porous concrete :** In order to filter the liquid part and increase the longevity of the leach pit, a permeable cylinder is cast using porous concrete (Cement and 20 mm hard broken stone). The Porous concrete shall be kept inside the leach pit. The liquid which gets collected shall be pumped out either by hand pump or electrically operated pump. The liquid (effluent) shall be reused after disinfection by any one of the methods described above.
- **Sand filter**: As the sand is the universally available natural material for filtration, a filter unit with sand as media shall be made and erected into the leach pit for liquid separation. The liquid portion shall be pumped by above method. Disinfection will be done as above and sent for reuse.



The analysis of chemical and bacteriological quality of the treated (disinfected) shall be done as per the standard testing procedure stipulated by the American Public Health Association. .

Treatment of liquid effluent from septic tank (TYPE III)

In the case of septic tank, the liquid effluent shall have pathogenic organisms. Improper disposal leads to environmental pollution. In order to kill the pathogenic organisms, the Overflow from the septic tank shall be collected in a tank having one day holding capacity in a chamber and disinfected before discharge either by chlorination or electro-chlorination as shown in the process flow diagram. Treated effluent shall be reused for cultivating vegetables etc. Both type of disinfection shall be tried for evaluation. Total coliform and faecal coliform counts will be analysed


Disposal/Reuse
Septic tank
Chlorination chamber