Planning And Operational Analysis of Faecal Sludge Treatment

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Abstract- *Faecal sludge is the faecal waste stored within onsite sanitation technologies. In addition to faeces it includes everything that goes into the toilet, for example, urine, flush water, greywater, anal cleaning materials and municipal solid waste (Strande et al., 2014). Faecal sludge differs significantly from fresh faeces alone; it is typically much more dilute due to the addition of liquids. Additionally, its characteristics are highly variable due to differences in storage duration, storage temperature and storage technology, and can range from fresh, to partially degraded, to completely stabilized.*

Fecal sludge and septage are more concentrated than domestic wastewater which makes it difficult to treat and requires immediate attention otherwise, it leads towards serious environmental problems. In this review, an attempt has been made to highlight and discuss the various aspects of fecal sludge and septage management (FSSM) like its generation, characterization, containment, transportation, treatment, reuse and disposal.

I. INTRODUCTION

Fresh feces contains around 75% water and the remaining solid fraction is 84–93% organic solids. These organic solids consist of: 25–54% bacterial biomass, 2–25% protein or nitrogenous matter, 25% carbohydrate or undigested plant matter and 2–15% fat. Household hazardous waste(HHW).

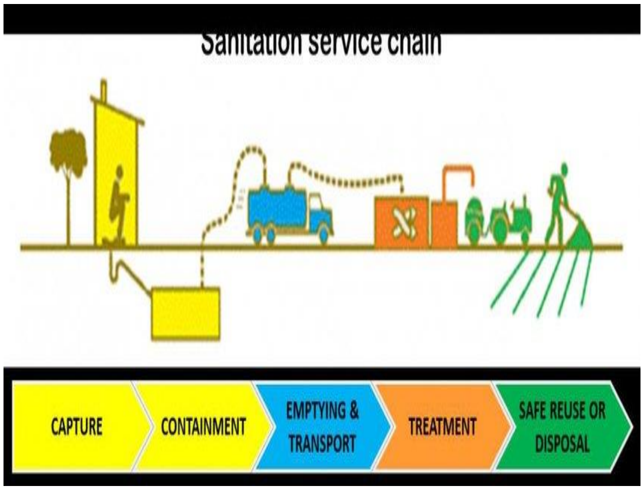
Human excreta is a rich source of nitrogen and other nutrients necessary for plant growth. improves the soil structure, making it easier to cultivate and to resist the effects of erosion.

Chemical, biological, and thermal parameters

The previously discussed simulants were developed to mimic specific physical properties of human stool and faecal sludge, and are unlikely to reflect their chemical properties. The differences in the simulant properties are readily apparent in Table 8, since each was developed to mimic specific faeces and faecal sludge characteristics, but ignore most others. A clear distinction can be made between the physical (simulants #1e5 and #15, #22) and chemical, biological, and thermal simulants (#6e14, #16e21). Almost none of the simulants adequately represent both chemical and physical properties. The information provided by the table can support in choosing the adequate simulant to be used or to be further developed for any intendant research. For example, in wastewater research of sewer systems and onsite sanitation systems a combination of some of these properties is of importance. Such investigations include faeces movement and faeces and faecal sludge settling, dewatering and physical and biochemical disintegration. Various simulants reflecting specific chemical, biological, and thermal properties of human stool and faecal sludge also have been developed. These chemical and biological properties are mostly defined as chemical oxygen demand (COD), total nitrogen (TN), pH, electrical conductivity (EC), total solids (TS), volatile solids (VS), elemental composition, and biogas potential. Important thermal properties are calorific value and ash content. Some of these simulants provide very high chemical, biological, and/or thermal resemblance to human stool and faecal sludge. However, many lack physical resemblance to faeces and faecal sludge.Physical parameters The following simulants are designed to reflect specific physical properties of human faeces and faecal sludge such as shape, rheology or density. As faeces are distinct from faecal sludge we discuss each type of simulant separately.

Faecal sludge simulants

The physical properties of faecal sludge are different from faeces. Hence, investigations making use of faecal sludge require different simulants from those used for faeces. However, as faeces are an essential ingredient in faecal sludge, some of the simulants described above can be a base for the development of faecal sludge simulants.



Some innovative technological option in faecal sludge treatmenturrent

- Blue Fuel
- LaDePa
- Vermicomposting
- Co-composting
- Omni processor
- Lime stabilization

Non Sewered Sanitation

there has been a rapid movement of almost 2 billion people towards cities from rural areas in developing nations in the coming decades. It has been estimated that urban population increase will be almost 50% in the next couple of decades. There will be massive 6 billion people who will be residing in urban areas in 2045 from 4 billion in 2016 as per UN 2015 and World Bank 2016 [7]. With major growth occurring in low-income countries, there are huge challenges for service providers to meet the increasing demand and requirements for affordable housing.

Blue Fuel

An innovative faecal sludge treatment unit deployed in Nepal, under this approach faecal sludge is found out as a potential, high-value, energy rich resource. In this technology faecal sludge is processed under pressure, heat and create a fuel source which is better than charcoal. This technology meets some key challenges that does not allow being deployed at large scale, including financial constraints, area selection and opposition from nearby localities.

LaDePa

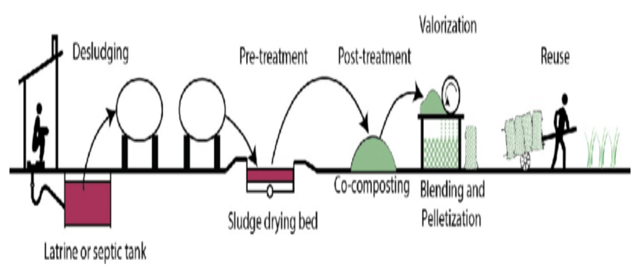
This process involves a technique where drying is based on wet sludge sprayed in a combustion chamber. Further treated with pulsating combustion at higher frequency. A dried /disinfected fertilizer is produced which is the ultimate focus of LaDePa technology. Constraints like high cost, skilled knowledge with chances of breakdown of the system are also there.

Technological feasibility of microwave heating for HFS processing

4.1 Suitability of microwave heating for processing HFSNot an energy incentive as electric power is utilized along with drying mechanically and pelletizing it can only be used for pit toilets.

Vermicomposting

biomass via certain species of earthworms. Earthworms utilized organic matter as feedstock passes to their digestive system and gives out in a granular form known as vermicomposting. Conversely, like the other wide range of waste (livestock wastes, poultry litter, dairy wastes, food processing wastes, organic fraction of municipal solid waste), the vermicomposting process also efficiently convert the fecal matter into the valuable product with 40-60 % volume reduction. Such as several reports reported processing of sourceseparated human faces into the composite [13-14]. The major constraint with the technology is to maintain elevated temperature and pathogen competition with favored thermophilic microbes. Some reports on composting of source-separated feces have revealed that a sufficiently high temperature for pathogen destruction is challenging to attain, as temperatures generally rise by 10–15C above the ambient temperature [15] so, in such cases, further steps required for pathogen reduction.



Co-composting

degradation by mixing organic solid waste with FS to convert them into useful end products like soil conditioners/fertilizers. Huge land area and comparatively long storage time is one of the major constraints besides skilled professional collection mechanism and further marketing the compost.

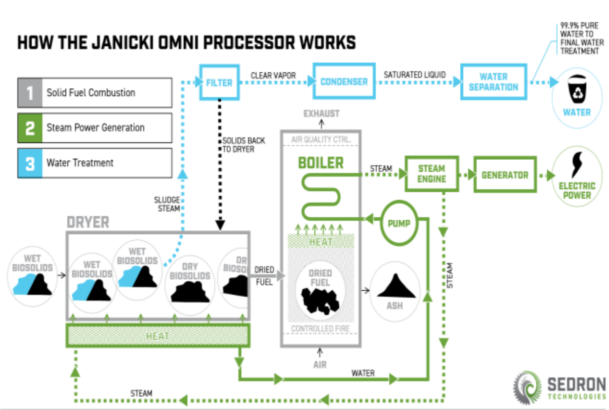
Lime stabilization

A process, which require skill team under strict health and safety regulations. Lime is strong alkaline and can create health problems to eyes, skin and respiratory organs if moisture is there. Treatment of FS with lime is very attractive option to ensure pathogen and odor reduction. Some places for example, Tacloban city in Philippines where lime stabilization is deployed as a suitable technology option for faecal sludge treatment [19]. ICSEEGT 2021 IOP Conf. Series: Earth and Environmental Science. lime stabilization system; Reactor tanks for mixing lime with septage, Sand drying beds for dewatering and drying of biosolids.

Omni processor

In the process to improve sanitation, to ensure effective treatment and safe disposal of the FS, Omni Processor funded by Gates Foundation proved to be a unique innovation where FS is converted into drinking water and electricity. Technology is the combination of three processes, which includes combustion, supercritical water oxidation and pyrolysis enabling complete treatment, pathogen reduction and resource recovery. Sedron technology U.S. tested a pilot project Omni Processor in Dakar Senegal in 2014. The Omni processor can treat the faecal sludge for waste generated by 50,000-100,000 people. Another group Duke University also tested a prototype where faecal matter for 1000 people was treated. Figure 7.Janicki Omni processor ICSEEGT 2021 IOP Conf. Series: Earth and Environmental Science 795 (2021) 012021 IOP Publishing doi:10.1088/1755-13

Omni Processor working



processes. Initially the solids called biosolids which is production of the wastewater treatment plants go into dryer where all the moisture content evaporates and then dried waste moves to an incinerator where waste turn into dry nontoxic fly ash. It is a financial sustainable cost recovery model where all materials used in the system are reusable. The steam generated in incinerator is used for drying the bio solids. Condensed steam is filtered to 99.9 % purity to be sent finally for water treatment and ultimately used as drinking water. The steam produced is used to drive a generator, which generates electricity and can be used for varied purposes by utility. The ash produced is also used as a fertilizer. According to VanTassel during the combustion process nitrogen is vanished but all the phosphorus, potassium and other micronutrient are maintained, therefore this ash content has high-certified (U.S. Department of Agriculture) market value as fertilizer. There are also environmental advantages of using Omni Processor ash instead of biosolids for fertilizing. When bio solids are applied to a field and start to break down, they release methane. "The methane that is released in that process is about 20 times greater as a greenhouse gas than the CO2 that emit from Omni Processor controlled-combustion process. Figure 8.Schematic layout of omni processor.

Globally implemented Omni processor:

management to the utilities relying on onsite sanitation systems. Globally efforts have been made to start such system for faecal sludge management; the first pilot plant was installed in Dakar, Senegal in 2014 since than authorities across developing nations including India are involved to deploy such systems in India and Africa. TUV SUD a German agency in collaboration with American National Standard Institute (ANSI) and supported by Bill and Melinda Gates Foundation has developed the ISO standards for Omni Processor in the year 2018. ICSEEGT 2021 IOP Conf. Series: Earth and Environmental Science 795 (2021) 012021 IOP Publishing doi:10.1088/1755-1315/795/1/012021. Countries of activity for Omni Processor 2.6.3 Omni processors in India: After Indian government adopted its first FSSM policy in 2017, which focused on safe sanitation value chain, starting from storing, collecting, transporting, treating and end use many Indian states took initiatives in this key challenging domain. There was a process to allocate resources including guidelines to safely handle this waste. With a very effective emergence of Omni Processor technology adopted in Dakar, Senegal promising cost effectiveness and sustainable solutions, big cities like Warangal, Vadodara, Sinnar and Bhubaneswar started implementing Omni Processor in their municipal limits.Not an energy incentive as electric power is utilized along with drying mechanically and pelletizing it can only be used for pit toilets.

Technological feasibility of microwave heating for HFS processing

The theory behind the adoption of microwave heating for processing HFS is based on the concept that water, which constitutes up to 97per centw/w in HFS, efficiently couples with microwaves and this electromagnetic interaction causes dielectric heating. In other words, the electromagnetic copulation of water and other molecular dipolar organics in HFS with incident microwaves triggers dielectric heating that occurs at the molecular level. This can achieve both pathogenic deactivation and value recovery from HFS at optimal process conditions – such as microwave power, temperature and residence time of processing. Two main dielectric heating mechanisms explain this feasibility: thermal effects due to dipolar polarization/rotation and a thermal effects triggered by ionic conduction / migration (Kappe, 2004; Yin, 2012).

Odour eradication through thermal solubilization

Thermolytic solubilization. Thermal hydrolysis during microwave heating can solubilize organic components of HFS, including those associated with foul odour, trapping them in the aqueous phase. As described in Section 2.0, the primary organics of HFS are carbohydrates, proteins and lipids. During microwave heating, these macromolecular compounds are hydrolyzed into shorter-chain intermediate monomers: carbohydrates into reducing sugars; proteins into saturated and unsaturated acids such as amino-acids, ammonia and carbon dioxide; while lipids are broken down into short-chain fatty acids such as palmitic acids and oleic acids (Lian-haiet al, 2006;Wilson and Novak, 2009).

Conclusion

The use of synthetic faeces and synthetic faecal sludge enables replicable experimentation, while simultaneously reducing health risks. There are multitude simulants for faeces in the literature, however, they are still relatively scarce for synthetic faecal sludge. At this stage, simulants have for the most part been developed to resemble real faeces and faecal sludge with specific characteristics, depending on the objective of application. Some simulants were found to highly resemble the real matter in the specific characteristics. For other simulants a poor resemblance was found. Perfect simulants that are mutually representative of physical, chemical, biological and thermal properties are still lacking. It will be important to develop recipes including COD fractionations for detailed biochemical process, and potentially other properties such as pharmaceuticals and hormones, pathogens and odours. The compilation of existing simulants in this paper has been valuable for the identification of strengths and weaknesses of simulants, and areas for further research.

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