Faecal Sludge Management in Urban Environment, Omni Processor an Innovative Technology

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Abstract. Comparing to wastewater management practices, various treatment options available for Faecal Sludge (FS) are almost a century old. 2.7 billion People across the globe, mainly in the developing nations are relying on “On Site Sanitation Systems”, OSS or unsewered sanitation. This situation will last for decades as city wide sanitation through sewer lines is neither feasible nor affordable. It is estimated that by the year 2030, almost five billion people across the globe would be relying on OSS. This paper focuses on issues of FS in developing nations, the huge gaps in sanitation value chain, the technological options available and innovations in treating FS through “Omni Processor”. With ultimate aim of removing pathogens and converting FS into water and electricity it works on various technological options that are not limited to super critical oxidation, pyrolysis, combustion and so on.

Keywords. Faecal Sludge; Onsite Sanitation; Urban Challenge; Innovation; Omni Processor; SDG 6.2

1. Introduction

1.1 Sustainable Development Goal Six (SDG 6)
UNICEF/WHO Joint Monitoring Progress report (JMP 2015) projected that almost 2.4 billion people across the globe do not have access to safe sanitation and more than 700 million or 0.7 billion people do not have access to safe water [1]. Though there has been a 10% increase in population from 61% to 71% in past few years managing safe drinking water services, the percentage remained unchanged during the year 2017. On the other side population, which is having privilege of safe secure sanitation increased by 17% during the year 2017 as per United Nations 2019, report that featured progress of SDG 6. The greatest percentage increase was in Africa, Latin America, Caribbean’s and South-East Asian continents. With an ultimate aim of availability of clean drinking water and safe sanitation to all the residents of the world by the year 2030, Sustainable Development Goal 6 focuses on that population who do not have access of basic drinking water and safe access to sanitation. While several countries are on the track to meet the 2030 targets (end open defecation, provide basic sanitation infrastructure and safe drinking water), the progress in more than half of the countries is too slow. Key challenges attributed are political willingness, conflicts between stakeholders, economic crises, infrastructure, cultural and financial constraints [2].

1.2 Sanitation in India
World bank 2016 report on global sanitation predicts that more than 520 million people in India practices open defecation, which was highest in the world [3]. With an aim to target ‘sanitation for all’, more than 600 million toilets were constructed in Urban India (Figure 1.). Total 100 million toilets were constructed in India since October 2014 under Swachh Bharat Mission (SBM) which includes construction of toilets in rural area or Gramin, (Table 1). SBM is a key flagship scheme of Government of India under the dynamic
leader ship of Hon Prime Minister of India Mr Narendra Modi. A remarkable success and achievement has been obtained in terms of access to toilets. This flagship program achieved the ultimate status of “Open Defecation Free” India as depicted (figure 1). Moving forward, SBM also focuses on new sanitation targets by 2030 for ODF+ and ODF++ status. ODF+ ensure proper maintenance of toilet facilities and ODF++ stated for safe collection, transportation, treatment and safely disposing FS [1] [4-5]. In the process to achieve ODF+ and ODF++, Indian government during June 2015 integrated SBM with AMRUT (Atal Mission for Rejuvenation and Urban Transformation) program to prioritized water supply and sewerage. AMRUT specially focus on the infrastructure that could ensure sewerage networks and water supply for urban transformation. These programs directly integrates with the FSSM policy 2017 by GOI, which focuses on containment, collection and conveyance of FS to disposal and treatment sites safely. Looking to the constraints of developing nations, priorities is also in finding cost effective economical solutions through integrated sewerage network [6].

Figure 1. SBM urban achievements (Source: Ministry of Housing and Urban Affairs)

| Table 1. SBM Gramin achievements (Source: SBM Govt. of India) |
|---------------------------------------------------------------|
| Toilets Built (in Lakh) since 2nd Oct 2014 | 1020.46 |
| Increase in House Holds with Toilet since 2nd Oct 2014 | 61.30 % |
| Toilet Built in 2019-20 | 80,64,646 |
| No. of ODF Districts | 706 |
| Self-Declared | 4320 |
| Waste to Compost Current Production (Metric Ton) | Waste to Energy Current Production (Mega Watt) |
| 3182435 | 61.0 |

1.3 Non Sewered Sanitation (Faecal Sludge Management)
With more and more influx of urban poor towards cities, 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. Challenges will also increase in city limits for infrastructure created due to rapid urbanization, the worst
affected domain will be of sanitation as creating new sewer lines will be almost impossible for service providers due to huge capital investment. Feasibility of maintaining minimum velocity and flow in sewer lines due to climate change impacts on water scarcity is another big hindrance. On the other side over exploitation of existing ground water sources will be issue municipal corporations and urban local bodies must face. The fact is that eighty percent of developing world population is not having access to sewerage and purely relying on OSS or FSM (Faecal Sludge Management). If FS is not untreated than it finds its ways in drinking water sources or reservoirs and contaminating them. This is one of the major reason of faecal oral and water borne diseases including diarrhea. Faecal sludge is partially treated or digested slurry which mainly results from OSS generating from pit toilets, septic tanks or aqua privies which is mainly combination of human excreta and black water. The focus of FS treatment is to safely be emptying, transporting it to a treatment unit with a resource recovery. Globally a very small percentage of FS is managed and treated in a safe manner [8].

1.4 Challenges in faecal sludge management/ sanitation value chain:
Estimated 5 billion people globally by the year 2030 will be relying on FSM. To address the needs of 5 billion people there is an immediate need to provide safe sanitation in terms of providing toilet and water for ablution and safe disposal [9]. FSM is an important and incremental approach furnishing to such condition. Ideally in FSM all the faecal sludge produced should ends up safely at the end of the sanitation value chain (figure 2), but in reality, due to some key challenges, much of the sludge disappears somewhere along the service chain. Such as users, do not have access of toilet facility due to financial or social constraint triggers open defecation. Containment not constructed as per standard specification results in frequent failures and leakages. There are no standard specification for emptying trucks and equipment’s. Unavailability of emptying trucks create large gaps between schedule desludging and illegal dumping. Leaking sewers in the absence of dedicated treatment technology affects outcome disposal of untreated waste in the environment. Another major challenge in sanitation service chain is management of children’s poo (collection, transportation and treatment). This massive problem i.e. management of all kinds of faecal matter could only be resolved by non-Sewered sanitation where creating infrastructure and public service and focus on keeping all human waste out of the environment and looking for suitable treatment. Non-sewer sanitation offers circular economy, which perceives 100% human waste as resource, which allows a whole ecosystem of beneficiation to be derived from managing, by-products and servicing models which upkeep self-sustaining businesses [10].

![Image](image.png)

**Figure 2. Sanitation service chain**

2. Some innovative technological option in faecal sludge treatment

FSM involves interventions across the entire sanitation value chain of human excreta. Interfaces are built
at the point of generation of excreta, to its containment, conveyance, treatment, and finally safe disposal. Various researcher deployed many innovative technologies for example:

2.1 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 [11].

2.2 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. Not an energy incentive as electric power is utilized along with drying mechanically and pelletizing it can only be used for pit toilets, FS [12].

2.3 Vermicomposting
A sustainable approach embraced by decomposition of organic matter into humus and worm 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 source-separated 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 10–15°C above the ambient temperature [15] so, in such cases, further steps required for pathogen reduction [16-17].
2.4 Co-composting
Co-composting is now days applied in developing nations, it is a process of aerobic 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 [18].

2.5 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].
Figure 6. lime stabilization system; Reactor tanks for mixing lime with septage, Sand drying beds for dewatering and drying of biosolids

2.6 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
2.6.1 Omni Processor working

In principle, the Omni Processor has a simple robust technology involving sequential 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](image)

2.6.2 Globally implemented Omni processor:

Omni Processors have been proved an appealing resolution to afford safe faecal sludge 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.
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 Bhubananeswar started implementing Omni Processor in their municipal limits.

3. Conclusion
- SDG 6 is one of the main sustainable development goals, which is directly or indirectly related to all other SDGs. In the year 2010 access to clean water and safe sanitation to each individual came under human right, which was passed at UNGA (United Nations General Assembly) through Resolution 64/292.
- After termination of MDGs (Millennium Development Goals) in 2015, SDGs came into existence. Progress on SDG6 was not up to the mark as new targets for SDGs were framed for the year 2030. The world is unfortunately not on the track on SDG 6 as of the year 2020.
- SDG 6.2 focusing on sanitation is one of the biggest challenge for developing nations and it is assumed that 5 billion people will be relying on FSM or OSS by the year 2030.
- Dismantling the existing system and creating new infrastructures for new sewer lines is almost impossible for urban local bodies and municipal corporations in developing nations for the new influx of urban poor. The issue becomes more critical due to climate change, less rainfalls and severe scarcity of water.
- Various technologies to treat FS are still old, conventional and unable to handle large population, one major challenge for developing nations. Omni Processors are technological viable options and fully in concurrence to the Government of India circular economy or resource recovery. Omni Processors are now being adopted in various towns through technological modifications. Time is for Urban Local Bodies/Municipal Corporations is to accelerate the Sanitation for all program.
A dollar invested in sanitation system generates 6 to 9 dollars as per UNICEF/WHO evidence based research in developing nations. This also reduces key issue of infant and child mortality rates in developing nations. This attempt is to generate an awareness on key innovation in the challenging domain.

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References
[1] Supply, W.U.J.W., S.M. Programme, and W.H 2015. Organization 2015, Progress on sanitation and drinking water: 2015 update and MDG assessment. World Health Organization.
[2] https://sustainabledevelopment.un.org/sdg6 accessed on 9th Jan 2020.
[3] https://in.one.un.org/page/sustainable-development-goals/sdg-6/ accessed on 11th Jan 2020.
[4] Manisha, M., Swachh Bharat: A scheme or dream. Indian journal of occupational and environmental medicine, 2015. 19(1): p. 66.
[5] http://mohua.gov.in/ accessed on 11th Jan 2020.
[6] Shashidhar V R, Ramakrishna V 2018, Smart Cities Mission and AMRUT Scheme: Analysis in the Context of Sustainable Development. OIDA International Journal of Sustainable Development, 11(10): p. 49-60.
[7] Tayler, K 2018, Faecal Sludge and Septage Treatment: A Guide for Low and Middle Income Countries.: Practical Action Publishing.
[8] Strande, L, Brdjanovic D 2014, Faecal sludge management: Systems approach for implementation and operation. IWA publishing.
[9] Harada H, Strande L, Fuji S 2016, Challenges and Opportunities of Faecal Sludge Management for Global Sanitation. Towards future earth: challenges and progress of global environmental studies. Tokyo (Japan): Kaisei Publishing: p. 81-100.
[10] Blackett I C, Hawkins P, Heymans C 2014, The missing link in sanitation service delivery: a review of fecal sludge management in 12 cities.
[11] https://www.grandchallenges.ca/grantee-stars/1707-07610/ accessed on 15th Jan 2020.
[12] Septien S 2018, LaDePa’process for the drying and pasteurization of faecal sludge from VIP latrines using infrared radiation. South African journal of chemical engineering, 25: p. 147-158.
[13] Organization, W.H., WHO guidelines for the safe use of wastewater excreta and greywater. Vol. 1. 2006: World Health Organization.
[14] Niwagaba C 2009, Bench-scale composting of source-separated human faeces for sanitation. Waste Management, 29(2): p. 585-589.
[15] Feachem R G 1983, Sanitation and disease: health aspects of excreta and wastewater management. John Wiley and Sons.
[16] Ronteltap M, Dodane P H, Bassan M 2014, Overview of treatment technologies. Faecal Sludge Management-Systems Approach Implementation and Operation. IWA Publishing, London, UK: p. 97-120.
[17] Yadav K D, Tare V, Ahammed M M 2010, Vermicomposting of source-separated human faeces for nutrient recycling. *Waste Management*, 30(1): p. 50-56.

[18] Lu Y, Wu X, Guo J 2009, Characteristics of municipal solid waste and sewage sludge co-composting. *Waste Management*, 29(3): p. 1152-1157.

[19] Kohn T, Decrey L, Vinneras B 2017, Chemical disinfectants, *Michigan State University, UNESCO*. 