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Where does all the human waste go?

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Disclaimer: We have used AI (ChatGPT Version 5) to generate Picture 1 and to review the logic of the document. Most of its suggested are described in Annex B. [1] Victor Post has been kind enough to assist in both. G. Anand and Victor Post further recommended to present non-rounded off data. This is done in Annex A.

[1] *Victor Post is a student of BSc Nanobiology, currently finalising double MSc (Nanobiology and Mathematics)*

PREAMBLE:

Bangladesh, India and most Sub-Saharan African countries have a large financially excluded population, who by and large live in poor sanitation and hygiene conditions. The poor sanitation and hygiene conditions, financial exclusion and poverty of these populations most likely reinforce each other. We narrowly define sanitation as toilets that are used, designed hygienically, provide medium to long term privacy and convenience, and systems that ensure safe, long term excreta management.

The Financing Sanitation Paper Series is a unique collection of seven articles about different aspects of sustainable financing of sanitation (in emerging markets). The papers have covered: (1) financial instruments used in FINISH (>30); (2) financial inclusion – public and private funding; (3) micro insurance; (4) bill of quantities for sanitation; (5) history of FINISH or how to cope with changing external environments; (6) the impact of sanitation loans on people (not yet released); (7) the management of human waste.

The theme of Paper 7 is what happens with human waste? Is it managed or not? Are we creating additional problems, or are we working towards solutions?

We exclude basic sanitation from all our work. We have even moved away from improved sanitation, as this does not take the full cycle of human waste management into account, and therefore it is likely creating troubles in future as well as the need for additional investments.

Our last but one paper on the history of FINISH had a cliffhanger on human waste. To recap: With many toilets under construction, we knew that safe disposal of human waste would become an issue in the years to come. As FINISH Mondial is all about safely managed sanitation, what are our solutions to human waste disposal? Some of the answers are in this paper.

The paper is structured as follows. As a general introduction, how much human waste do we all generate, why do we seldom talk about it, and what are some of the issues? Then, we look at our own footprint, we estimate the amount of human waste we are dealing with under FINISH and what is happening with it. Are we creating a bigger problem, or is it whereabout known and under control? Fortunately, most of it is under control. In this section, we also outline how we think we know this. Knowing where it is helps, but it does not mean that we are doing something about it; we do (to a large extent). Lastly, the gaps, challenges and opportunities provide the background to our plans in the very near future. Very near means the plans for 2026 and 2027.

We therefore invite you to react to the papers on our blog, which you can find on www.finishmondial.global; www.SuSaNa.org and our LinkedIn group. Looking forward to meeting you there.

EXECUTIVE SUMMARY:

Equating sanitation with toilets is rather common. Yet the fact that humans generate waste and, like any waste, this needs to be managed, is not that well understood. Human waste management seldom features in conversations, circular initiatives are rarely seen, or sometimes even legally barred.

Yet we humans generate some 10 billion kg of excreta daily. If this is not managed, it harms our health and the environment. In this paper, we take a deep dive into human waste management particularly we investigate how well - or not - Financial Inclusion Improves Sanitation and Health (FINISH Mondial, FM) performs in terms of toilets and capturing and/or processing human waste.

FM has enabled the construction of well over 2.2 million toilets, thereby roughly concentrating 5 million tons of human waste. Most of our sanitation systems are on-site, whereby we promote in rural/peri-urban areas, the double leach pit human waste management system. This system is simple, robust, and socially workable, though it is space and context-dependent.

In the mid-term review of FINISH Mondial (2023) using WHO/UNICEF JMP categories, it was found that roughly 59% of the sanitations system constructed are basic and 31% safely managed among surveyed areas; many "basic" systems are built to safely managed specifications but are awaiting emptying/treatment solutions. In cities, pits are often emptied, with safe disposal being an issue.

In our current estimates, a whopping 24,000 – 46,000 tons of human waste per year is "unaccounted" for in terms of safe disposal and for some 7,000 tons even in terms of transport.

Putting it into context, this is about 1% of the total human waste being generated annually by FM. Yet amounts are sizeable enough for us to push for FSM (faecal sludge management) and treatment capacity. If we can develop businesses out of human waste, it will have a positive impact on the collection, disposal and treatment systems. In FM, we are trying to scale the conversion of human waste into agricultural inputs.

Where are we heading to. In the near future, we expect to continue scaling rehabilitation of sanitation (for instance, converting single into double pits) but also expanding FSM plants via PPPs (BOT/BOOT), and move toward a circular sanitation economy (nutrients and carbon back to soils). The latter will be supported through certification, business modelling, and climate/health accounting.

1. INTRODUCTION:

We start by estimating how much human waste we are generating (1.1). Given the quantities, it may be surprising that we hardly talk about this. In 1.2, we try to give some reasons why human waste is not much of a conversation topic. Next, in 1.3, we argue why it should become more prominent. Maybe not as a conversation topic per se, but in the planning, designing, and construction of sanitation systems based on optimal use of resources. All the more as sanitation is an indicator of inequality in society, yet it may also provide an effective instrument to tackle this head-on.

1.1 An estimation of the quantities of human waste we generate

We are starting with some of the basics. Is it that big? The answer is yes. Even when we exclude anal cleaning materials (water, toilet paper), water used for flushing, cleaning materials for the toilet and handwashing, we humans produce about 10 billion kg of human waste every day[2]. If one were to spread this in a 10 cm thick layer, this will cover 20,000 football fields with a layer of one meter every day. In one year, the entire Netherlands will be covered by 10 centimetres of human waste.

[2] Each human produces about 300 g of faecal matter and at least 1 litre of urine every day. Much more urine, if you are a heavy beer drinker. Of course, we humans also generate quite some amounts of all types of other waste, plastics, electronic, glass, metalware, organics, paper etc, but these are not discussed.

FIGURE I: AI-GENERATED PICTURE OF THE NETHERLANDS COVERED IN HUMAN WASTE

[2] Each human produces about 300 g of faecal matter and at least 1 litre of urine every day. Much more urine, if you are a heavy beer drinker. Of course, we humans also generate quite some amounts of all types of other waste, plastics, electronic, glass, metalware, organics, paper etc, but these are not discussed.

In reality, this is not happening, as few of us go to the Netherlands to defecate. Yet, we humans tend to cluster, and urbanisation is growing. So human waste tends to accumulate in urbanised areas.

Is this bad? This simple question is rather difficult to answer. It is not bad if human waste is properly treated. In that process, some water may be treated to a level that it is fit for reuse in agriculture or industry, some of the energy present in human waste may be recovered, and, in a few cases, even some of the nutrients (phosphates, nitrogen) are recovered. Alas, these cases are rare. Most often, human waste is improperly treated or not at all, thereby polluting the immediate environment, perhaps even aquifers or other water sources and spreading pathogens wide and far as a serious health hazard. So, yes, it is bad.

1.2 Human waste is not much of a favourite topic for conversations.

Toilets, sanitation and human waste are usually not much of a discussion or dinner table conversation topic. Only when something is not working do we normally think about it or discuss it. Only a few diehards who love talking about human waste, though even are typically requested to do this outside the dinner setting.

Dr Thomas Rieger in his presentation on sanitation, organisational neurosis and change (Stockholm World Water Week, 29 August 2017) presumed that introjects may be a reason. In brief[1], toddlers are being taught to stay away from (human) faeces for good health reasons. Staying away means also not talking about it. Not talking about it also means that the idea of reusing human waste arises. Safely reusing human waste goes against the ingrained knowledge and childhood experiences, so psychologically, one has to deal with what has become an acquired deformation since early childhood.

[3] We do apologise beforehand to Dr Rieger for this simplified version, his presentation was scientific and elaborate.

1.3 Why we should talk more about human waste

So, leaving professionals aside and occasional interested parties aside, should we take that journey that goes against what we have been taught? We believe we should give human waste more consideration for several reasons, starting from privacy and comfort (1.3.1) to optimal use of resources (1.3.2)**[4]**, tackling inequalities and climate (1.3.3, yes, as big as that).

1.3.1 Privacy and comfort

Just imagine it is cold and raining, there is no toilet, and you need to go urgently. For number 1, you do not want to do this in plain sight, this holds truer for women than men. For number 2, who would be comfortable squatting and defecating in plain sight? Very few, one can imagine. This applies both for women and men. For those who do not have a usable toilet, this is their daily reality. So, they tend to go very early morning, when it is still dark. There may be animals crawling about, **[4]** inefficiencies and high costs of not doing the right thing

[3]. We do apologise beforehand to Dr Rieger for this simplified version, his presentation was scientific and elaborate.
[4]. inefficiencies and high costs of not doing the right thing

and perhaps you are standing in someone else's shit. Not a very good start to the day, but not something to really talk about.

When visiting a doctor, human waste suddenly becomes a topic of inquiry. Doctors will ask about your defecation, most likely not because they are diehard sanitation specialists but because it is a good indication of illnesses[5]. When one is constipated, it is definitely on top of one's mind, and so is the opposite, diarrhoea. Motion being loose or motion not existing, and many things in between, is an area of great personal interest. If this is the case, then one would expect some more interest of the people at large in this topic.

1.3.2 Optimal use of resources or tackling inefficiencies:

So, what is happening to all the waste? Having toilets that are smelly may provide privacy, but comfort is not achieved. One of the reasons they could smell are construction faults or perhaps they are filled up.

There are globally three dominant human waste management systems.

1. Household toilets that are connected to various types of sewers and to treatment plants.
2. Household toilets that are not connected to a conveyance system and that need to be emptied regularly
3. Completely standalone household toilets.

Human waste contains pathogens (remember the doctor's interest), and not handling those properly may make many sick. Untreated waste may contaminate groundwater, thus spreading pathogens wide and far. The cost of not doing anything or not doing it properly is high. So, leaving human waste exposed is certainly inefficient.

If there is a treatment system in place, there may be a wide variety in the type and organisation of treatment. Generally speaking, poorer people need to take care of the disposal of faecal matter themselves (of course, assuming they have a toilet) whereas richer people are often connected to the sewer. Furthermore, sewer lines cover city centre areas and usually well-to-do neighbourhoods, but seldom cover slums. Sewers tend to be popular in the richer countries and less widespread in the poorer countries.

Toilets connected to the sewer system and treatment plant are fixed infrastructure. Sanitation systems that collect human waste on site has a much lower fixed infrastructure component[6]. For sewer systems, and without giving a value judgment, one may ask what the logic is of treating water to such a level that one can directly drink it from the tap and yet using that same quality water to flush human waste? Does this qualify as optimal use of resources?

***[5]**. Of course, depending on the type of your complaint, they did not ask when I broke my leg.*
***[6]**. This is quite similar to the situation with the infrastructure of fixed (land) telephone lines and mobile phone technology. A country like the Netherlands has a high coverage of fixed telecom infrastructure. Though mobile phones are everywhere today, the usages and applications are less advances than front runners in telecom such as India or Kenya (who indeed have a much lower penetration of fixed infrastructure (landlines)). In this analogy read for landlines, sewer, and read for mobile phones, sanitation take care of it yourself.*

1.3.3 Inequality

Poor people tend to have less access to safely managed sanitation than their richer compatriots. There is an old anecdote from India to the contrary (see text box: It is not only the money), having access or not to safely managed sanitation facilities tells a lot about the income of people. Poor sanitation is increasingly seen as a stumbling block for socio-economic prosperity.

It is not only the money: Sometime in early 2015 an article hit the news in India on the poor state of sanitation. A well-off family in the state of Haryana was living in a three-floor house with its own boundary wall and garage. Inside the premises it had constructed one toilet outside the house. Inside there was no toilet. Every morning the entire family gathered. Everyone took a seat in their Mercedes Benz all carrying containers with water. They would park the Benz near a field. So they could move into this field for open defecation. The toilet in the house was used only for guests.

The link between poor sanitation and poor health is well-established. If human waste is not properly dealt with, the pathogens in human waste can make people sick. It is not uncommon – though illegal – to see trucks that just emptied septic tanks and pits – to discharge the human waste in open land or water bodies. Poor health prevents people from progressing in life; worse, it may push people back into poverty, whilst they were just climbing out of it. A number of studies have shown that health-related expenditure of the poor ranks second to social and religious ceremony expenditure

As far as climate is concerned, we will get back to that later in the paper, once we have established our story and our numbers.

2. FINISH MONDIAL HUMAN WASTE FOOTPRINT

2.1 Definitions

Globally, the WHO/UNICEF Joint Monitoring Protocol (JMP) sanitation definitions are leading. The Joint Monitoring Protocol (JMP) works with a sanitation ladder.

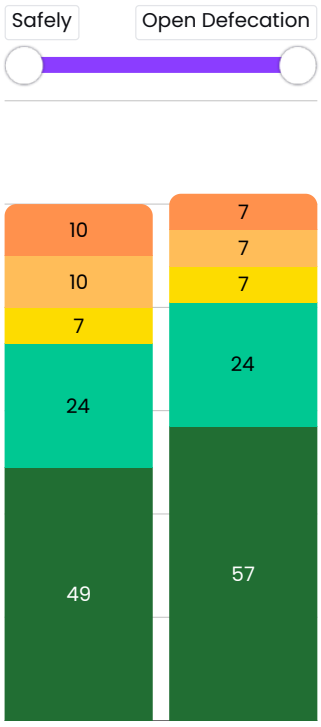

Figure 2: JMP data presentation

The updated JMP sanitations service ladder (Table 1 below) is used to benchmark and compare service levels across countries. The new ladder builds on the established improved/ unimproved facility type classification, thereby providing continuity with past monitoring, and introduce new rungs with additional criteria relating to service levels. Improved sanitation facilities are those designed to hygienically separate excreta from human contact. There are three main ways to meet the criteria for having a safely managed sanitation service (SDG 6.2).

OPEN DEFECATION

UNIMPROVED

LIMITED

BASIC

SAFELY MANAGED

People should use improved sanitation facilities which are not shared with other households, and the excreta produced should either be:

- treated and disposed of in situ,
- stored temporarily and then emptied and treated off-site, or
- transported through a sewer with wastewater and then treated off-site.

OPEN DEFECATION	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches and other open spaces or with solid waste
UNIMPROVED	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
LIMITED	Use of improved facilities shared between two or more households
BASIC	Use of improved facilities which are not shared with other households
SAFELY MANAGED	Use of improved facilities[1] that are not shared with other households and where excreta are safely disposed of in situ or removed and treated offsite

[7] Improved sanitation facilities are those designed to hygienically separate excreta from human contact, and include: flush/pour flush toilets connected to piped sewer systems, septic tanks or pit latrines; pit latrines with slabs (including ventilated pit latrines), and composting toilets

2.1 THE WHO PERSPECTIVE

The World Health Organization (WHO) approaches sanitation comprehensively, defining it as "the provision of facilities and services for the safe disposal of human urine and faeces." The WHO further expands this definition to include:

- Safe management of excreta: From collection and transport to treatment and eventual disposal or reuse
- Maintenance of hygienic conditions: Through services such as garbage collection, wastewater management, and industrial waste disposal
- Disease prevention: Creating barriers that prevent the transmission of disease-causing pathogens found in human waste

This WHO definition emphasizes the systematic management of waste throughout its lifecycle, highlighting sanitation as an ongoing process rather than simply the presence of toilets or latrines[8].

[8] Sanitation and Health: Definitions, Goals, and Global Impacts - Socio.Health

2.2 Storage and collection

In FINISH Mondial we look at the most comprehensive definition of safely managed. FINISH Mondial is operational in 6 countries (Figure 3 below).

FIGURE 3: FINISH MONDIAL COUNTRY PRESENCE

So, what is our story and what are our numbers?

To date, we have supported the construction of well over 2.2 million sanitation systems. Let's do an estimation to get more of a feel for what this means in terms of quantity. For ease of calculation, let's round off our 2.2 million sanitation systems to 2 million. On average, each toilet is used by 5 people. They excrete 0.3 kg per day and urinate 1.2 litres (kg) per day. So, a single toilet caters to (0.3 + 1.2) kg x 5 (family) x 365 (it is a daily business) = 2737.5 kg of human waste per annum, well over 2.5 tonnes. Thus, with our 2 million toilets, we concentrate 5 million tonnes of human waste per annum[8].

[8] Sanitation and Health: Definitions, Goals, and Global Impacts - Socio.Health

Where is the waste? Is it still in the ground, has it been taken out, if so, to where?
When we started FINISH in 2009, we hardly realised the importance of these questions. Our first realisation was that we needed to look closely into the importance of proper construction. This was after observing in Eastern India the mistakes that were made by those building the sanitation systems. The matter became urgent as one pit was constructed next to the (water) handpump[9]. This opened the possibility that people were drinking a diluted version of their own excreta.

In fact, the Government of India has set scientific standards for many aspects of household sanitation, including distancing between water supply and sanitation disposal, wastewater discharge standards and prescribing what systems can be constructed in what kind of soil or, to be more precise, geodetic conditions. Whilst these standards are there, those who design and construct sanitation systems are often not aware of this.

So, in FINISH we needed to enhance the knowledge and skills of the sanitation entrepreneurs constructing the systems. Entrepreneurs also needed to be able to construct systems under different conditions, such as land availability, high water tables, rocky surface and amount of money available with the household. In India and Bangladesh, most sanitation systems are so-called wet systems. People use water for anal cleaning and occasionally for removing human waste.

When we looked at the different sanitation technologies, our training included four of those systems.
One system became our system of choice for safely managed sanitation: the double leach pit. The system makes disposal of human waste easy. It also allows for the safe reuse of human waste under certain conditions. We liked it so much that we even made a song about it (Figure 4: reference double leach pit). [10]

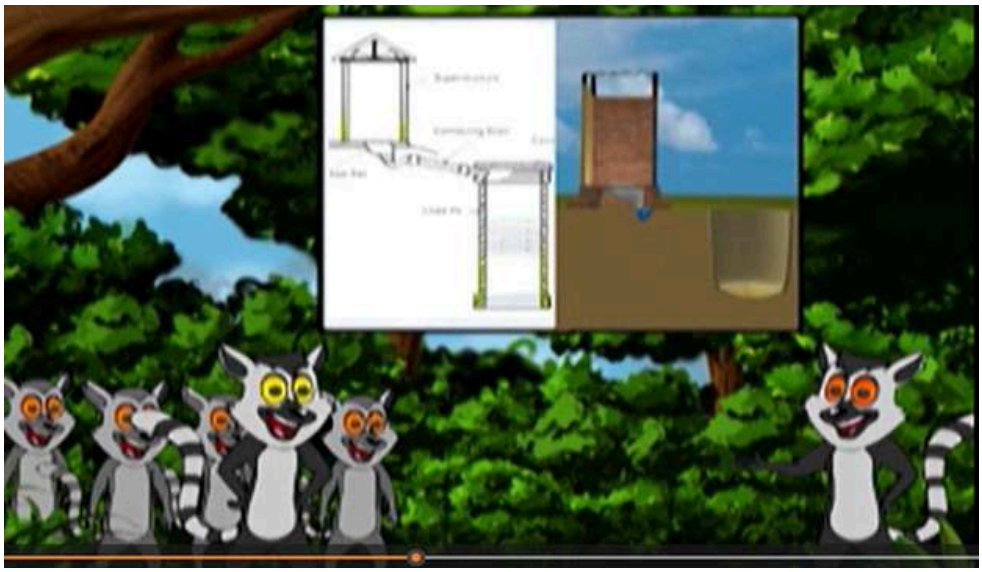

FIGURE 3: SCREENSHOT OF THE DOUBLE LEACH PIT SONG

*[9] If we take the water used for flushing into account the amounts increase to 15 – 40 tonne per toilet (the wide variation is due to different amounts of water used for flushing, low value is derived from 0.5 litre for urine (3 *day) and for faecal (1 litre, 1 * day), average values used for flush are 2 respectively 3 litres. Note: this still excludes water used for washing. The actual figures used in the literature are a little higher both for human waste generated and water used for flushing and cleaning. Furthermore, the actual calculation is higher by some 22% but this will not material alter what will follow next.*
[10] The case was in Odisha where a handpump was installed next to the road (legally correct) while there was a pit adjacent to it inside a walled property, thus not visible from the roadside.

[10] Video: [1] Sanitation and Health: Definitions, Goals, and Global Impacts - Socio.Health

FIGURE 3: HUMAN WASTE TAKEN OUT OF THE DOUBLE PIT AND ITS APPLICATION

It is like a nutrient-rich compost, though a little drier than the regular compost; the smell is gone, the appearance is improved, and the pathogens have died in the process. The product looks good, but how do people respond in practice? This we shall describe further down.

The mid-term review (MTR) of FINISH Mondial (2023) utilised JMP[11] categories to evaluate the current sanitation service levels. Across all surveyed states, 59% of households use basic sanitation facilities, while 31% use safely managed sanitation[12]. It is further noteworthy that many basic sanitation services (India, Uganda) conform to the higher design levels of safely managed. Many toilets have not filled yet and will need emptying only in future. As safe disposal of human waste is a key policy focal area of development stakeholders spearheaded by Governments, it is likely that conversion of basic sanitation to safely managed sanitation will gather momentum. For our discussion, it is important to note that a relatively larger shift in basic sanitation services conforms to the design norms of safely managed level but has been categorised as such because the safe disposal of faecal sludge is currently being scaled up. There are two basic ways of emptying:
(a)Rehabilitation, converting single pits into double pits
(b)Rural and peri-urban faecal sludge management services. Increasingly, a number of faecal sludge treatment plants are under construction in India, but also in Bangladesh and Kenya. Once the FSM disposal options improve, it is likely that the service level also improves alongside, an area where FM will continue to focus on.

[11] JMP, joint monitoring protocol, a methodology developed and applied by WHO / UNICEF to describe different stages of sanitation.
[12] Comparing sanitation service levels at the baseline and midline stages, a significant reduction in open defecation can be observed. Open defecation decreased from 39% at baseline to 6% at the midline stage. Access to basic sanitation services also witnessed a notable increase, rising from 32% at baseline to 59% at the midline assessment. Access to safely managed services increased from 29% to 31% during this period. This positive shift reflects results of regular capacity building on sanitation technology and service levels for MFI teams and masons under the program.

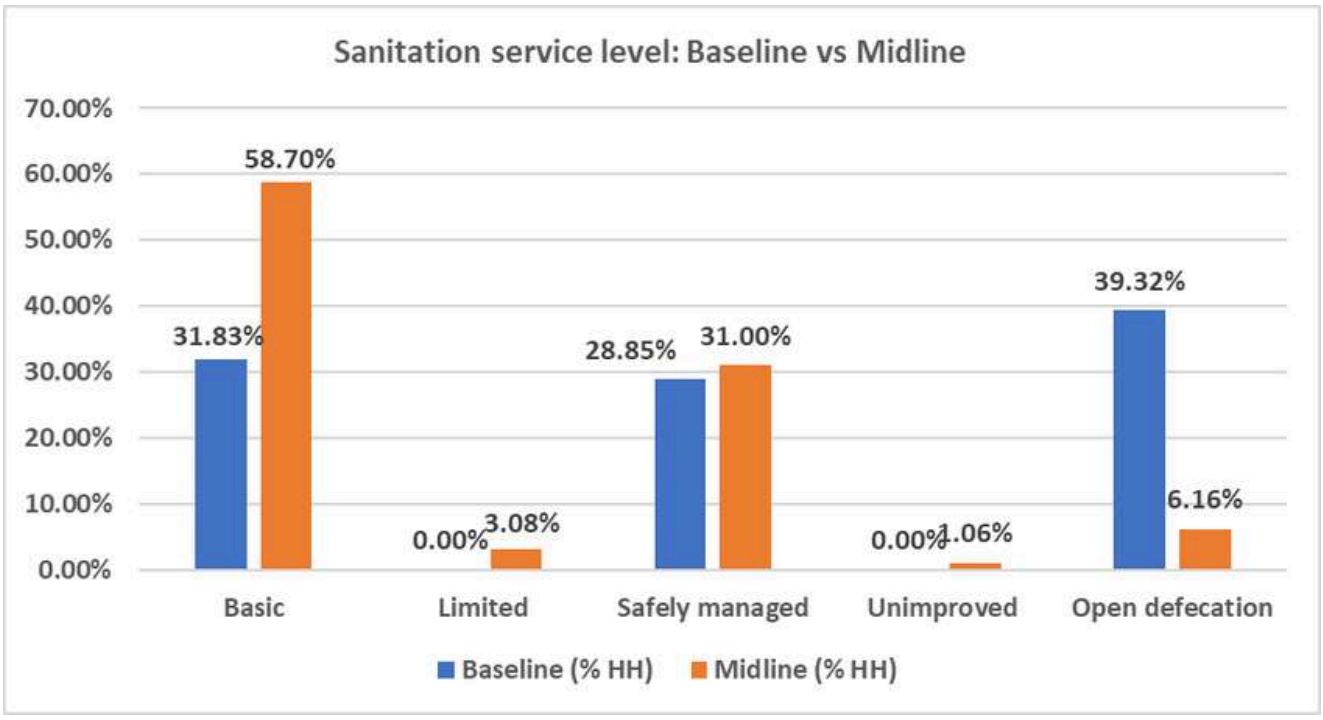

FIGURE 3: SANITATION SERVICE LEVELS- BASELINE VS MIDLINE

·The MTR also reported that about 29% of households in the survey areas had emptied their toilet facilities in the last three years.

·We may safely assume that this holds true for the elderly systems, e.g. those constructed prior to 2021. The toilets constructed post 2021 will not yet have filled[13]. In terms of numbers, this means that we are talking about 1.2 million sanitation systems or 3 million tonnes of human waste.

·Out of these 1.2 million sanitation systems, India accounted for about 85%, or 1 million sanitation systems. According to the MTR, around 30% of these systems are functional double leach pits. These are typically emptied directly by the household itself and do not feature in the statistics. According to the sustainability of the FINISH approach in Dungarpur (Rajasthan) and Mirzapur (UP), an independent evaluation, the % of double leach pits is much higher, and also emptying does not seem much of a concern (text boxes below).

·This brings the amount of human waste currently under consideration in India (and for 85% of FM) to 2.5 million tonne.
·At present, about 65% of the sanitation activities in India are to rehabilitate sanitation, including conversion into safely managed, thus making single pits into double pits and or making defunct double pit systems (no door or no roof) into functional ones[14].

[13] Sustainability aspects of the FINISH project in Mirzapur (UP) and Dungarpur (Rajasthan), India, Samavit Vikas Private Limited, 22 November 2023. In fact, In Rajasthan not all 10-year old pits had not been emptied likely caused by dry and usually hot conditions.
[14] Next to this faecal sludge collection and treatment services are improving in several states. At the same time, a trend was noted during the MTR, that some households have started converting off-set leach pits into septic tanks as this is [mistakenly] regarded as a superior sanitation system. This conversion requires additional collection, transport and treatment capacity. Teams are currently working on methods to reverse this trend.

In **Dungarpur, Rajasthan*** it was observed that most families had twin-pit design toilets while some opted for un-lined septic tanks. Most households had not emptied their pits, and the research team could only find 3 households out of the 25 households they visited which had done so at least once. These households emptied the pit themselves and used the waste as manure in their farmland. One of the most common reasons for households not emptying pits was the arid climate in the region, which leads to faecal sludge drying in the pit very quickly.

**Reference: Sustainability aspects of the FINISH project in Mirzapur (UP) and Dungarpur (Rajasthan), India Samavit Vikas Private Limited, November 2023*

In **Mirzapur (UP)***, in 2011, only about 5% of the village households had toilets, whereas now, almost 80% households have functioning toilets. Water logging is a major issue in this region and during monsoon season, makes toilet usage very difficult. This is also a major reason that people prefer to defecate in the open during monsoon. Contrary to actual toilet usage numbers, private businesses report that they've noticed an increased interest in toilet construction in the last 5 years, especially from poor households. The village development officer reported that there has been a significant (almost 80%) drop in sanitation related diseases in the last 10 years.

Most households utilize twin pit systems for toilets and most of these toilets have only been built in the past 3-5 years, which is why households haven't had to consider emptying their pits yet. Some households with older toilets have emptied the pit themselves instead of calling professional pit emptiers and used the resulting faecal sludge as fertilizer for agricultural purposes.
It was noted amongst households that have septic tanks, there is a lack of awareness regarding proper faecal sludge disposal and maintenance of septic tanks. Government officials are trying to encourage people to switch from septic tanksto twin-pit systems as they are easier to maintain and have a smaller environmental footprint.

·In terms of numbers, 65% of toilets are being rehabilitated, or in terms of human waste, 2.5 million tonnes is generated, minus 1.6 million tonnes (which is undergoing rehabilitation), leaving us with 0.9 million tonnes that is generated in non- double leach pit systems.
Using the MTR figure that about 9.3% is emptied every year, this means numerically that 83,000 tonnes of human waste is collected every year.

FIGURE 5: EMPTYING FM PRESENTATION AT 13TH ICON SWM-CE & IPLA GLOBAL FORUM 2023

·Formal service providers (local government and authorised entities) emptied 52% of household toilets, some 44,000 tonnes of human waste. As per the FM dashboard, out of the 44,000 tonnes, FM was directly connected with the collection of some 37,000 tonnes of faecal sludge in 2024, and this was sent for treatment. Balance 7,000 tonnes may have been sent to the sewer or other treatment plants where FINISH Mondial is not engaged.

·Private service providers handled 39% of the 83,000 tonne or about 32,000 tonnes[1]. Next to this, there is some 7,000 tonnes that are not collected by formal or private service providers. So, in total 7,000 tonnes from formal emptiers, 32,000 tonnes from private providers and 7,000 tonnes from unaccounted for gives a total of 46,000 tonnes.

[1] The midline survey showed a significant increase in the percentage of households engaging in waste segregation, rising from 20% in the baseline to 50%.

THE QUESTION THEN IS, WHAT HAPPENS TO THE BALANCE OF 46,000 TONNE?

·Is it really 46,000 tonnes? The error margin is likely to be very high for several reasons. (a) We do not account for those that are connected to a sewer system. In some urban settings in India and Kenya, we support last mile connection. (b) We do not account for licensed operators who dispose of their faecal waste illegally. Photographs and personal stories suggest this practice is still rampant[15]. (c) Private (licensed) service providers may actually bring most of the human waste to designated places such as wastewater treatment plants or faecal sludge treatment plants. (d) Another common practice is to dig a hole next to the emptied toilet and dispose the human waste in this. As the regulation is lacking and this practice is informal, it is difficult to ascertain how much of the waste is thus disposed.

[16] To be fair some may be forced to do this in the absence of safe disposal sites.

·We therefore guesstimate that we cannot account for some 24,000 to 46,000 tonnes of human waste per annum (Annexe A). This partially explains our current focus on faecal sludge management.

FIGURE 6: ILLEGAL EMPTYING FMSC PRESENTATION 13TH ICON SWM-CE & IPLA GLOBAL FORUM 2023

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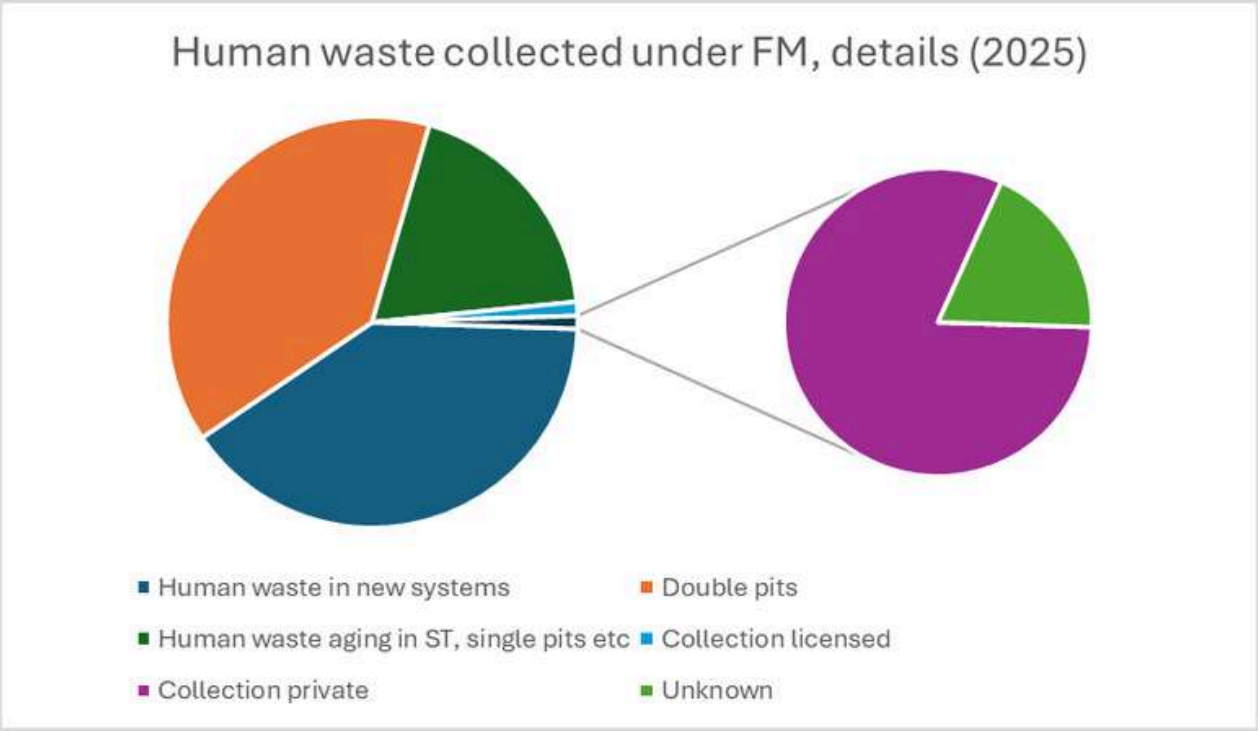


GRAPHIC PRESENTATION OF THE QUANTITIES (USING PERCENTAGES)

·With many toilets constructed and under construction, it is clear that safe disposal of human waste will be an issue in the years to come[1]. After all, the total figure of 5.0 million tonnes is quite an amount. Human waste smells badly, contains pathogens and is not pleasant to look at, at least for most. We also try to avoid any contact with our body (part of the definition of safely managed sanitation), either by flushing it away with a lot of water over great distances, less water usually over smaller distances, or without water in pits, which tend to be very deep. All understandable, but …. we do not seem to realise that our waste contains some carbon and quite a few nutrients. Most plants require these nutrients to grow and provide food that we can then excrete and then process so that it can be safely used on plants, which we then… (you get the idea). So, we stretched the definition of safely managed sanitation to include safe reuse of the nutrients and carbon present in human waste.

[17] In terms of quantities, we estimate that in the near future up to 80% of human waste could be recycled and put back to use in a very decentralised manner.
·In the current rehabilitation drive that cuts across FM countries, single pits are converted into double pits. Space and time can really make a difference for human waste disposal and treatment, but what if space and time are limited? This is typical for cities.

Human waste management is an issue in many urban settings, where pits and tanks may be emptied, but subsequently the faecal matter is disposed of in the open. Nearby rivers and other water bodies are very popular dumping places (photo). Disposal increasingly happens at night (photo). Disposing of human waste in this manner is defeating the health and environmental purposes of sanitation. Whilst large towns would increasingly invest into large scale sewer networks and sewer treatment plants, smaller towns needed to find their own solutions

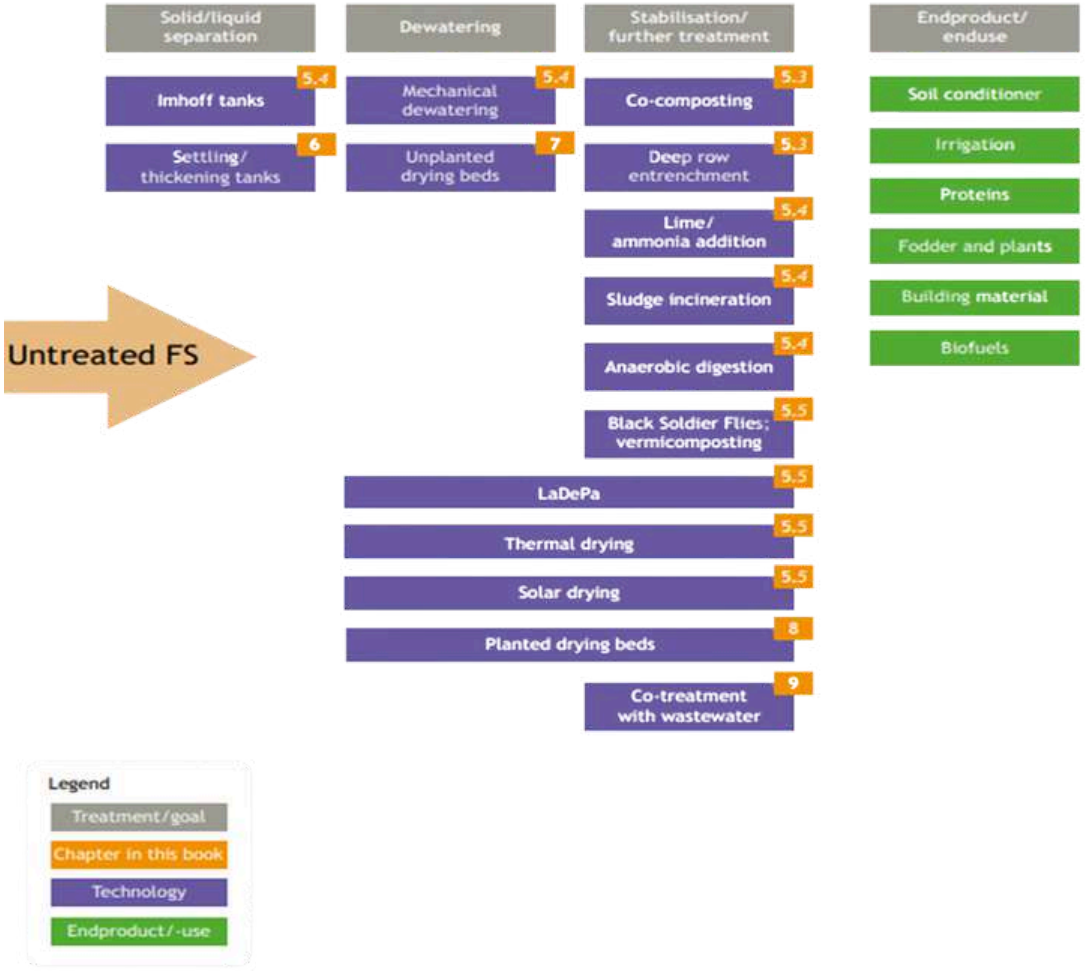
[17] In terms of quantities, we estimate that in the near future up to 80% of human waste could be recycled and put back to use in a very decentralised manner.

2.2 TREATMENT OF HUMAN WASTE

Now let's look at the options for more centralised treatment. These are depicted below[18].

Source: Faecal Sludge Management Systems Approach for Implementation and Operation Editors Linda Strande Mariska Ronteltap Damir Brdjanovic, IHE/EAWAG, IWA Publishing 2014

MANUAL EMPTIERS IN KOROGOCHO, NAIROBI MAPPING OF FSM OPTIONS, QUERCUS GROUP 2019



SOURCE: LINDA STRANDE, MARISKA RONTELTAP, DAMIR BRDJANOVIC, IWA 2014

[18] Source: Faecal Sludge Management Systems Approach for Implementation and Operation Editors Linda Strande Mariska Ronteltap Damir Brdjanovic, IHE/EAWAG, IWA Publishing 2014

FIGURE 3: FILLING OF TRENCH BY VACUUM TRUCK AND PARTIALLY FILLED TRENCH (SOURCE SBM:FSM MANUAL 2021)

The simplicity of deep row entrenching (5.3 above) has an appeal. It is low-cost too. However, site selection is critical to avoid contamination. Ideally, this should take into consideration geodetic data and WHO guidelines on the same.

Unplanted drying beds are relatively simple, too. If the dewatered sludge is then solar dried, it may kill most of the pathogens and provide an alternative treatment method. The main issue is that faecal matter tends to stockpile at the site as its appeal to possible takers (e.g. farmers) is limited. As the process's effectiveness is determined by solar UV, which may differ on a daily basis, the product may also still contain a high amount of pathogens.

FIGURE 3: : SLUDGE DRYING BEDS IN NYERI COUNTY (MAPPING OF FSM OPTIONS IN KENYA, QUERCUS GROUP 2019)

The team also looked at briquettes, but at that time (2014), there were many actual and perceived reservations. This technology has fortunately evolved and may be considered in future, exploring combining with crop residual waste that is otherwise burnt

[19] Source: Faecal Sludge Management Systems Approach for Implementation and Operation Editors Linda Strande Mariska Ronteltap Damir Brdjanovic, IHE/EAWAG, IWA Publishing 2014

Within FINISH, a techno-economic team evaluated all the different options. The techno-economic team recommended a combination of drying beds and co-composting, whereby we would attempt to valorise the nutrients present in human waste.

FIGURE 3: BRIQUETTES READY FOR PACKAGING, MAPPING OF FSM OPTIONS, QUERCUS GROUP 2019

. In 2015, we started a proof of concept with Morarka Foundation in Rajasthan. The objective was to convert human waste into an agricultural input that was safe to use. The proof of concept also sought to establish the potential to market this product and, particularly, its social acceptance. Processing a mixture of cow dung, agri-waste and human waste resulted in a high-quality agri-input that was meeting all our expectations in terms of nutrients, carbon, pH and moisture. It also met basic pathogen control tests. The second part of the proof of concept was its social acceptance and marketability. Farmers to whom it was sold were more interested in its properties and appearance than in its manufacturing process and input sources.

PICTURES FROM THE PROOF OF CONCEPT WITH MORARKA FOUNDATION, RAJASTHAN 2015

[19] Source: Faecal Sludge Management Systems Approach for Implementation and Operation Editors Linda Strande Mariska Ronteltap Damir Brdjanovic, IHE/EAWAG, IWA Publishing 2014

PICTURES FROM THE PROOF OF CONCEPT WITH MORARKA FOUNDATION, RAJASTHAN 2015

Based on the successful proof of concept, we thought we could quickly scale up. For quick scaling, we worked with a commercial setup in the state of Odisha. Project funds would mainly be used for testing, but seeing their disposal arrangement (just a pit), we also decided to invest in 2016 in a low-cost nature-based faecal sludge treatment plant (vertical flow constructed wetland). The entrepreneur made some money in composting, so adding faecal matter looked like a win-win. With a poor site selection, very limited involvement of nearby town administration (where we needed to get the faecal matter from) and only involvement of local village administration, the business case went for a toss, as instead of getting money for faecal sludge, we had to pay for the additional distance between the river and our site. If we did not pay, operators would just dispose of it in the river! As we did not manage to reverse this situation, and this would remain a bleeder, we decided to take the losses and hand the plant back to the entrepreneur, who continued composting without co-composting human waste.

PICTURES FROM THE PRIVATE SECTOR RUN COMPANY PRIOR TO CONSTRUCTING WETLAND

With another partner (RDO Trust), we managed to restart the process in South India. From 2017 onwards, supported by the SWFF[20] We started co-composting initially on one private sector side. Whilst their cooperation was strong and they also invested; they learned after completion of construction that their organic status did not allow them reuse treated wastewater or treated human waste if they wanted to continue exporting under the organic (high revenue-generating) label.

[20] Securing Water For Food project supported by a consortium spearheaded by USAID

NATURE BASED FAECAL SLUDGE TREATMENT PLANT, HORIZONTAL FLOW CONSTRUCTED WETLAND AT THE FAR SITE AND JUST PLANTED VERTICAL FLOW CONSTRUCTED WETLANDS AT THE FRONT

Thus, we started on two sites owned by the local government. On each site they had established a resource recovery park. As part of the resource recovery park, they made some rudimentary compost. Despite its low price, there were very few buyers. Our partner entered into a working arrangement with the local government and with the workers on site. We drafted a business plan, but internalising the business aspects was quite a journey for all local stakeholders.

As co-composting was our preferred method[21] to valorise the nutrients present in human waste, we constructed two low-cost faecal sludge treatment plants. From the concept in Odisha, we had moved on to a two-stage constructed wetland, for the faecal matter dewatering a vertical flow constructed wetland and for the waste water emanating from this, a horizontal flow constructed wetland. The advantage of the two-stage system was that post-treatment in the horizonal flow constructed wetland, the (nutrient-rich) treated wastewater could be reused in the composting process.

NEWLY CONSTRUCTED FSTP BEING FED WITH FAECAL SLUDGE AND ORGANIC COMPOSTING IN COOPERATION WITH RDO TRUST, INDIA

The compost improved somewhat when we started co-composting, but not all pathogens were killed off as the control measures were inadequate and temperatures never achieved the desired levels. We consulted one of our partners from Sri Lanka, as we knew he had been working on co-composting for many years. With his expert inputs, the processes were finetuned, and controls were introduced and enforced. The co-compost turned out to be safe, meeting all compost standards (heavy metals, etc.) and was pathogen-free. Furthermore, the nutrients made it, so we thought, an interesting product.

[21] Scale of the plants was relatively small, as importantly waste products and compost being bulky products, there is a strong economic argument for scaling through replication.

COMPOST YARD AND FINAL PRODUCT IN COOPERATION WITH RDO TRUST, INDIA

BUT WHAT ABOUT PUBLIC PERCEPTION?

Were farmers ready to buy it? Attracted by a low introduction price, a few farmers were willing to buy the product and test it in their fields. These farmers became key promoters of the product. One of them – nicely captured on video – states in a very excited voice, the key characteristics of co-compost-grown carrots as compared to the carrots he was cultivating earlier: His carrots were much bigger, looked more orange and fetched much higher prices. Other farmers reported similar yield increases. Today, the co-composting production cannot meet demand.

VERY HAPPY FARMERS SHOWING VEGETABLES GROWN WITH CO-COMPOST. RIGHT: PLOT ON THE LEFT SIDE CO-COMPOST IS USED, RIGHT-HAND TRADITIONAL IN COOPERATION WITH RDO TRUST, INDIA

[21] Scale of the plants was relatively small, as importantly waste products and compost being bulky products, there is a strong economic argument for scaling through replication.

A premier research institute, the Indian Institute of Soil & Water Conservation Research Centre worded it as in the text box below

AS PERCEIVED BY THE FARMERS, THERE ARE MANY OTHER POSITIVE IMPACTS LIKE EASY APPLICATION, REDUCTION IN QUANTITY OF CHEMICAL FERTILISERS RESULTING IN REDUCED INPUT COSTS, ETC., DUE TO CO-COMPOST APPLICATION. HENCE, THE FARMERS MAY BE ENCOURAGED TO CONTINUE THE PRACTICE OF CO-COMPOST APPLICATION, WHICH WILL HELP IN PROMOTING SUSTAINABLE ORGANIC AGRICULTURE IN THE DISTRICT. HOWEVER, THE FARMERS ARE NOT APPLYING A STANDARD QUANTITY OF CO-COMPOST. THEY ARE APPLYING VARIED DOSES TO CROPS LIKE CARROT, BEETROOT, POTATO AND BEANS DEPENDING ON THE QUANTITY OF CO-COMPOST AVAILABILITY. HENCE, STANDARDISATION OF THE DOSE FOR VARIOUS VEGETABLE CROPS SHOULD BE DONE BY TRYING DIFFERENT DOSES. DEPENDING ON THE DEMAND, IT SHOULD BE ENSURED THAT THE REQUIRED QUANTITY OF CO-COMPOST IS MADE AVAILABLE TO THE FARMERS AT A RELATIVELY LESSER PRICE BY RELEASING A SUBSIDY EITHER TO THE FARMERS OR TO THE CO-COMPOST PRODUCERS..... HOWEVER, BEFORE DISTRIBUTING CO-COMPOST TO THE FARMERS, THE COMPOST MUST BE TESTED AT A LICENSED LAB TO AVOID THE HEALTH AND ENVIRONMENTAL RISKS OF CO-COMPOST'S PATHOGEN CONTENT AND CHEMICAL CONTAMINATION, LIKE HEAVY METALS THAT IS AN IMPORTANT POTENTIAL RISK ASSOCIATED WITH HUMAN WASTE.

What about profitability? Tipping fees that were collected did not leave the local government; workers were mainly on government payroll, though also on the project, and the break-even was far off. It proved very difficult to convince the local government to change the revenue part, so in the end the partner decided to start production in a nearby area, and after initial difficulties, the plant is now breaking even on a production of 1 tonne per day of co-compost (operational costs only!).

Since 2020, we have been trying to revitalise the commercial operation of faecal sludge management under the aegis of FSMC Pvt. Limited. High-nutrient human waste is processed with organic carbon-rich municipal waste to produce a valuable product, co-compost. Investments are made by the urban local bodies, whilst FSMC handles coprocessing and marketing, and part of the revenues flow back to the municipality.

DHENKANAL FSTP CONSTRUCTED BY PRACTICAL ACTION (BMGF), CURRENT OPERATION SUPPORTED BY FSMC, FMSC PRESENTATION I3TH ICON SWM-CE & IPLA GLOBAL FORUM 2023

[22] Technical Report on Impact of recycled black water (faecal sludge) co-compost application on soil quality, crop productivity and socio-economical status for vegetable production in Nilgiris; S. Manivannan; V. Kasthuri Thilagam; K. Kannan; P. Sundarambal; ICAR- Indian Institute of Soil & Water Conservation Research Centre, Udhagamandalam - 643 004, 2021

TWO FSTPS AT DIFFERENT STAGES OF CONSTRUCTION BIHAR INDIA (SOURCE , FMSC PRESENTATION I3TH ICON SWM-CE & IPLA GLOBAL FORUM 2023

In the state of Bihar, we entered into a tripartite agreement with the government and UNICEF for the construction and operation of two faecal sludge treatment plants that treat human waste from nearby towns. Post 6 months operations, the plants are scheduled to be handed over to the government.
In Bangladesh, we are partnering with development stakeholders who are working with the local government in running plants

In Kenya and Uganda, our proof of concepts or pilots are operational. The process and application of the product and its impact on yield are keenly studied by local farmers and agricultural institutes. The next stage is to get the product certified and then commercialise the operations.

FORT PORTAL, UGANDA PRIOR TO CONSTRUCTION AND FINISHED PRODUCTS (SOURCE LEAFLET ON FSTP, FINISH MONDIAL UGANDA)

GOING FORWARD

Our teams are interested in exploring other avenues. We do have long-standing discussions with, for instance, Safisana (Ghana), which operates on a more industrial scale and converts waste streams into energy and agri-inputs, and Sanivation (Kenya), who use sawdust as the bulk and human waste as the binder to convert waste into energy. On of our sites, black soldier fly technology is also tried.

Whilst we are keen to continue partnerships in these areas, FINISH Mondial Foundation (FMF) as the institutional house for FM has settled for the treatment whereby, we combine two waste streams to make at least one product (co-compost).

Human waste itself contains nutrients, carbon and pathogens. The easiest process is to increase the temperature during the composting to eliminate the pathogen. Alas, human waste does not contain enough carbon to do that. Thus, we need to co-process it with a high carbon-rich waste stream that is available in abundance and is not costing much money; otherwise, the input costs, including production, testing and marketing costs, would be higher than expected sales revenue. The lowest cost waste that is available in abundance is the organic parts of municipal solid waste (see text box). With strict waste segregation at source, which is maintained during transport and initial disposal for processing, this source fits the purpose. As in practice, segregation is partial; on-site additional waste segregation needs to take place, adding to the processing costs. Another challenge here is that when we talk about breaking even, we, for now, do not take the CAPEX into account.

Whilst the break-even point keeps on shifting as we go along, we seem to be getting a little bit nearer to it. Hopefully, it does not turn out to be the proverbial pot of gold at the end of the rainbow. In the absence of full and correct costing, commercial operations may still be wanting, but we believe in a year or so, we may have reached the stage that no external funding will be required in all our proof of concepts (Bangladesh, India, Kenya and Uganda).

The model we use is in various forms of BOT (build operate and transfer), BOOT (build own operate and transfer) or other hybrids. In all cases, it runs under some form of public-private partnership. In our 10 year pursuit of the same, we note that commercialisation of all co-composting operations is an issue.

A reason is that we have not been able to factor in the health savings as compared to disposal in open water bodies. The environmental benefits are equally difficult to assess. We are making more progress on factoring in the climate impact of the sanitation circular economy.

Another reason is that products need to be certified by the relevant authorities before they can be marketed. As the only available standards are those for compost and those for wastewater, it is a pioneering exercise.

Financial inclusion, sanitation and the sanitation circular economy is already difficult. In the ever-evolving FINISH approach, solid waste management emerged as a new area for FINISH Mondial India in 2017. It started with some corporates showing interest in supporting solid waste management. Later on, more joined as well as local governments and UNDP. The government made solid waste management one of the key priority areas (Swachh Bharat Mission 2). WASTE earlier sent a few experts to develop capacities of the FINISH India team. This coupled with the local team intensive interactions with communities, local government and private sector meant that results were coming in at some scale.

The city of Udaipur is an interesting case. FINISH Mondial India – to be very precise Trust of People (ToP)/FINISH Society, the main implementing partner of FINISH Mondial in India – had worked with communities, corporates and local government on improving sanitation in the State of Rajasthan, both in rural and urban settings. Based on the social capital built up in working with communities and the trust of the government, it entered this space and managed through strong community engagement 100% segregation and daily collection of household waste. When community members were probed if this system would continue if the government changed, they retorted: we won't allow them to change.

So, collection was organised but where was the waste going to? The government had invested heavily in equipment and a transfer station; it also had invested in a disposal and recycling site. What was most striking was that the disposal site had a landfill, but it was closed! In fact, the hill had been greened and there was a walkway on top. All segregated waste was further sorted and sold to recyclers, the organics were composted. The most difficult fractions were sold to cement kilns. Though all was organised there were still issues with sale of compost. With treated human waste from the nearby sewer treatment plant, readily available, co-composting has a high prospect. However, selling through tender is likely to disengage the processing from actual sales. Entrepreneurs will find this too risky.

Also in smaller towns, household segregation is well under way (states of Maharashtra, Punjab, Odisha and Tamil Nadu). Organic waste is often recycled at household level (home composting, animal feed). Other fractions are collected and segregated. When sufficient volumes are reached, they are sold to waste buyers and recyclers. Unlike sanitation, there is a lot of money going around in the solid waste management business. With many changing hands frequently, it therefore may seem easier to evolve into financial inclusion system for waste collectors, to using incentives and result based payment systems, but we are still at the beginning and have not yet developed standard operating procedures.

BY WAY OF CONCLUSION, WE ARE MOVING TOWARDS TRULY CIRCULAR.

In more anecdotal form, our ideation of FINISH in 2007 was celebrated with Kingfisher (a local beer). In 2022 one of the spin-offs of FINISH, FSMC, launched their co-compost product aptly branded Ultra (similar to the premium brand of Kingfisher). This, in short, summarises the journey we are on

ANNEX A: THE CALCULATIONS (PART-1)

The basic calculations		**Unit**
Number of people per household	5	
Excreta produced per person per day	300	g
Urine produced per person per day	12	l
Excreta produced per household per year	27.375	kg
Toilets = no of houeholds	22	million
Excreta for disposal in FM	60.225	million kg
Excreta for disposal in FM	60.225	million tonne
Construction 2023	425,784	number
Construction 2022	293,424	number
Construction 2021	184,56	number
Total between 2021 and 2023	903,768	number

ANNEX A: THE CALCULATIONS (PART-2)

The basic calculations		Unit
Prior to 2021	1,296,232	number
Share of India in this 85%	1,101,797	number
Others 15%	194,435	number
Share of double pits 31% (India may be underreported)	894,4	number
Amount of waste to be disposed off	245	million tonne
Rehabiliation (retrofitting) making sanitation safely managed	159	million tonne
(65% of all sanitation and growing, 2025 data)		
Total amount of human waste to be disposed off	86	million tonne
MTR: Emptying done by 29% of households in past 3 years,	83	million tonne
(assumption 1) systems prior to 2021, evenly distributed		
Emptied by formal service providers 52%	43	million tonne
(MTR data)		
FM faecal sludge treatment in faciliites (2024 annual report)	37	million tonne
Assumption 2 balance sent to treatment plants outside FM	7	million tonne
Collection by private service providers 39%	3	million tonne
(MTR data)		
Assumption 3: 50% taken to to treatment plants outside FM	16	million tonne
Assumption 4: 100% disposed illegally	16	million tonne
Unaccounted for in terms of collection and thus disposal	7	million tonne
Assumption 5 100% disposed illegally		
Though it may be informal sector who dispose in adjacent pits, safety question mark		
Best case scenario Total waste unaccounted for	24	million tonne
Assumption 2 + Assumption 3 hold true		
Worst case scenario Total waste unaccounted for	46	million tonne
Assumption 2 does not hold true and assumption 4 and 5		

ANNEX B OPEN REMARKS FROM CHATGPT

Technology comparison, side-by-side
Add a comparative table (CAPEX/OPEX, land needs, pathogen reduction, operator skill, product marketability) for deep-row entrenchment, drying beds, wetlands, co-composting, briquetting, BSF, anaerobic digestion—plus where each fits (rural vs urban, climate, soils).
Reply: though interesting this may become a theoretical exercise as much of the above is based on first hand data.

Commercial model clarity
For co-compost sites, publish a unit economics sheet: tip fee policy, throughput (t/day wet and dry), labor, utilities, screening/segregation costs, packaging, logistics, price points, monthly P&L and break-even volume. Separate CAPEX from OPEX; show scenarios with/without municipal payroll support.
Reply: these are available at individual plant level, differences are quite high and levying of tipping fees, though theoretically correct, has been proven difficult in practice, different entrepreneurs are walking different paths mostly in a public private partnership environment. It is difficult to generalise at this stage.

Product standards & certification path
Specify which compost standards (nutrients, heavy metals, pathogens) you target in each country, required test frequencies, and the certification authority. Summarize independent lab results (tables/appendices) and any organic-label constraints encountered.
Reply: absence of standards and processes is a key bottleneck, have developed testing procedures based on compost and critical human waste parameters, thus we test for the following, testing frequency initially weekly, once established monthly or even quarterly. Typically, governments (agricultural sector or standard bureau) certify.

Health, safety, and social safeguards
Add a short occupational safety and health protocol for emptiers and plant workers (PPE, vaccinations, confined-space rules), and note steps against manual scavenging. Include gender and safety outcomes (e.g., reduced night-time open defecation risks), with one or two measured indicators.
Reply: in most countries FM forms associations of pit emptiers, this strengthens their bargaining power and makes it easier to strive for OSH measures. The gender and safety outcomes are beyond open defecation risks. Indicators (qualitative) are applied.

Climate & environmental accounting
Include a methods appendix for GHG and pollution benefits: baseline vs project methane/N_2O (on-site pits vs managed treatment), avoided nutrient runoff, soil carbon effects of co-compost, and water-quality indicators near disposal hot-spots. Even indicative numbers strengthen the circularity claim.
Reply: this is work in progress, we have tied up with a number of organisations and specialists to further develop this.