Fecal sludge management

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Fecal sludge management (FSM), also spelled **faecal sludge management** in British English, is a management system that safely collects, transports, and treats fecal sludge (also called septage) from pit latrines, septic tanks or other onsite sanitation facilities (OSSF). In other words, it deals with the mixture of human excreta and water that is collected in certain types of decentralized toilets and sanitation systems, instead of going into centralized Wastewater systems. FSM is particularly important in quite densely populated areas where much of the population is not connected to sewerage network, as is the case in most urban areas of developing countries. FSM is generally carried out as a service by local governments, water authorities, water utilities or the formal or informal private service providers. In many developing countries, however, this service is often not provided at all or not done properly, leading to, among others, surface water and groundwater pollution, spreading of pathogens into the environment, adverse health impacts and relatively high costs to households.

Demonstration of new equipment used for pumping fecal sludge from a pit latrine near Durban, South Africa

For city-wide programs in developing countries, fecal sludge collection may be either on a scheduled or on a call-for-service basis. If the fecal sludge is liquid enough, it is usually collected by using vacuum pumps or centrifugal style booster pumps. A variety of manual and motorized devices designed to excavate thick and viscous sludge and accumulated trash are also available in the market.

The collected fecal sludge may be transported to treatment plants via a vacuum truck, a motorcycle tanker, or even a hand cart. Often, mobile or permanent transfer stations are used to improve the efficiency of fecal sludge transportation.

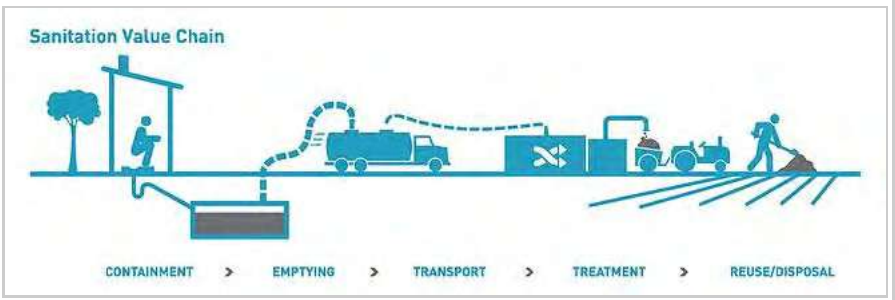
This material should preferably be processed at dedicated fecal sludge treatment plants, instead of being co-treated with sewage in municipal sewage treatment plants, unless these are able to take the additional load.[1] A variety of mechanized and non-mechanized technologies may be used, including constructed wetlands, anaerobic digestion, and waste stabilization ponds. Useful products of the treatment process may include treated effluent that can be used for irrigation, biosolids that can be utilized as a soil amendment in agriculture, biogas, biodiesel, and electricity. These have the potential to offset some of the costs of the program, thereby reducing tariffs for the public. However, value addition all the way to biogas, biodiesel and electricity is difficult to achieve in practice due to technological and operational challenges.

Collectively, the collection, transport, treatment and reuse of excreta constitute the "value chain" of fecal sludge management.

Contents

Terminology

Fecal sludge management (FSM) in developing country settings refers to organized programs that provide safe and hygienic septic tank and pit emptying services, along with the proper treatment of liquids and reuse of biosolids where possible.[3] It may include a host of options including on-site and offsite treatment, and the dispersal or capture and processing of byproducts of the treatment process, such as biogas, compost, and energy.



Example of fecal sludge management in the "sanitation value chain" which includes collection, transport, treatment and reuse.[2]

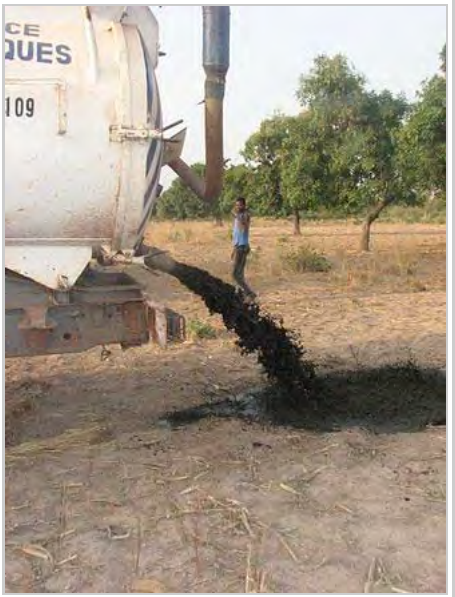
FSM has become synonymous with the term "septage management", where septage is the partially digested fecal solids that accumulates in septic tanks, but also may include other storage vessels, such as pits or other onsite sanitation facilities (OSSF). The term septage management may have originated in the United States in around 1992 or earlier.[4] The term septage management in developing country settings was popularized in Southeast Asia in 2006 by projects funded by the United States Agency for International Development that focused on sanitation improvement through Water, Sanitation and Hygiene (WASH) and septage management programs, such as USAID's ECO-Asia project.[5]

Pit latrines generate fecal sludge when the pits are emptied, even though these toilets are classified as dry toilets. However, other types of dry toilets - those that are designed to be easily emptied, without the addition of water - do not generate fecal sludge but rather dried feces (in the case of urine-diverting dry toilets) or compost (in the case of composting toilets), for example. In the case of Arborloo toilets, nothing is ever extracted from the pit and, instead, the lightweight outhouse/superstructure is moved to another shallow hole and a tree is planted on top of the filled hole. So, fecal sludge can be defined as human excrement that is extracted before it is fully sanitized and then is treated at another site.

Background

World-wide there is an increasing interest and awareness of FSM issues, particularly in Africa and Asia.[6][7] This is evidenced by some large-scale research and development projects in the area of FSM, which are funded by the Bill and Melinda Gates Foundation.[8]

In many developing countries, fecal sludge is not properly managed. This may be due to lack of awareness, inability to source funds for start-up costs for the purchase of vacuum trucks and treatment equipment, or lack of knowledge of the steps required to be taken to implement successful programs. This results in poor performance of onsite sanitation facilities (OSSFs), septic tank and pit latrine overflows, unsafe emptying of pit latrines, and dumping of untreated fecal sludge and pathogens into the environment.



Lack of fecal sludge management: Discharge of fecal sludge into the environment in Burkina Faso

Purposes

In developing countries, once awareness is raised, FSM programs are pursued to:

- Improve the function of OSSFs and to minimize the potential for human contact with fecal-borne pathogens;
- Minimize odors and nuisances and discharge of organic matter from overflowing tanks or pits;
- Serve as a platform from which to launch OSSF upgrading programs;
- Safeguard public health against indiscriminate disposal of fecal sludge;
- Derive agricultural products including soils amendments and fertilizers from composting or co-composting;
- Stimulate economic development, job creation and livelihood opportunities in targeted communities, while addressing the issues of the social stigma and operator health and safety issues that continue to impact workers universally.

Example of lacking fecal sludge management: Fecal sludge collected from pit latrines is dumped into a river at the Korogocho slum in Nairobi, Kenya

FSM programs can be drivers of sanitation improvement by encouraging OSSF upgrades that reduce the frequency of desludging events, and therefore the costs. They can also in theory be drivers of economic development all along the value chain that includes materials and parts for new toilets and septic tanks, contractors and equipment installers,

collection personal including the drivers and emptiers, treatment and reuse systems operators, and production and sale of the end-products of the sludge treatment process.

These products may include water for agriculture and industry, fertilizer, soil amendment, biogas, biodiesel or electricity. There are many pilot, demonstration and full-scale FSM programs now operating in Asia and Africa, but few that have demonstrated a sustained impact upon the value chain.

Desludging using proper personal protective equipment in Dumaguete, Philippines

Elements of successful programs

FSM services can be provided as demand based (call for service), scheduled desludging, or a combination of both. Under either mechanism, OSSFs are desludged on a periodic basis or when an inspection by a competent authority indicates desludging is needed.

Desludging truck (vacuum truck) in action in Nepal

Common elements for successful FSM programs include:

- Periodic or as-needed desludging as verified by inspection
- Tariffs that are pro-poor and representative of the costs for providing the service
- Targeted promotions campaigns that educate and raise the willingness to pay for services
- Technology that is appropriate for the level of capacity to operate and maintain the system as well as the realities of the value chain
- An enabling environment that includes the procedures, rules, policies, laws, tariff schedule and incentives for participation.

Oxfam has been doing research and advocacy in this area and has documented these elements of successful programs in the Philippines in a step by step process.[6]

Characteristics of fecal sludge

Fecal sludge (FS) is the human waste, wastewater, trash and debris that accumulates in pit latrines and septic tanks or other onsite sanitation facilities (OSSF).[9] Fecal sludge is an offensive material that contains pathogens, can generate odors and cause surface water pollution, as well as groundwater pollution. Characteristics of fecal sludge may vary widely due to climate, toilet type, diet and other variables. Performing a waste characterization study to understand local conditions provides data that factors into treatment plant sizing, as well as estimating the value of the products that can be derived from the treatment process.

The main parameters commonly measured to characterize fecal sludge include: BOD, total suspended solids, % solids, indication of sand, COD, ammonium, Fats, Oil and Grease (FOG), Sludge Volume Index (SVI), pH, alkalinity.

System designers often use default values, such as 2,000 mg/l for BOD and 5,000 mg/l of TSS (which might be an average country-wide) in order to size the treatment system. If no such data exists, or if local conditions are not adequately reflected in assumed values, a waste characterization study can be conducted.

The characteristics of fecal sludge may be influenced by:

- Methods, techniques and the skill levels of personnel conducting the desludging;
- The efficiency of the different types of equipment used in desludging;
- Seasonality - presence of groundwater or flood water that may infiltrate into tanks and dilute the contents;
- The last time the tank was desludged (age of fecal sludge).

More research into conducting waste characterization studies in developing countries is needed. For developed countries, more data is available.[10]

Current practice

Cities

FSM is a critical sanitation service in cities and towns in developing countries that rely on onsite sanitation.[11] City-wide FSM programs may utilize multiple treatment facilities, use both stationary and mobile transfer stations, and engage with micro, small and medium sized enterprises that may conduct some or all of the services. Programs may be phased in over time to accommodate growing demand.

Fleet of vacuum trucks used for desluding services by Manila Water in Manila, Philippines

Peri urban areas

Peri urban areas are less densely populated than urban centers, and therefore have more land area for the installation of OSSFs to manage the solids and liquids in the wastewater flow. In these areas, it is unlikely that centralized sanitary sewer systems will be installed in the near to intermediate future. Therefore, development in these areas will rely upon decentralized wastewater management systems connected by condominial or simplified sewerage or onsite sewage facilities. In these instances, FSM is a necessary service in order to keep these systems functioning properly.

Rural areas

Rural areas with low population density may be the most difficult in which to organize FSM programs. Such locations may be difficult for large trucks to access. Other options such as on-site or decentralized FSM services, or direct burial services can still be organized.

Design considerations

Selecting the operator of FSM services

Operators of FSM programs may include the city government, water district or private sector service providers. Water districts with a high percentage of connectivity (homes with piped water connections) are logical operators of FSM programs. If water is sold to customers through a tariff, an additional tariff to cover FSM program costs may be added. For larger cities, it is usually the water service provider that will be the most appropriate operator.

Local governments may choose to provide services by administration - using their own staff and resources for collection, transportation and treatment services. This is often the case in smaller cities or municipalities where the water district may not have a broad reach. In many cases, cooperation between the city government and the water district may be strategically advantageous. Dumaguete City, Philippines is one example where the Water District and Local Government have joint ownership and responsibilities for the FSM program.[12] Organized FSM programs may be able to provide the service cheaper and more hygienically than the private operators working independently. Less expensive services is an important selling point when promoting the program to citizens and encouraging them to participate.

The private sector may also become involved in providing FSM services. In such cases, private sector contractors bid on desludging contracts let by the city. The private sector can also provide services in operating and maintaining the treatment works, and in processing and selling the commodities resulting from the treatment process. San Fernando City, La Union, Philippines is an example of a local government that has contracted out the treatment facility construction and collection program to the private sector.[13]

Synergy with other programs

FSM is but one aspect of city-wide sanitation that also includes:

- Municipal solid waste management;
- Drainage and greywater management;
- Wastewater collection and treatment including effluent overflows from on-site systems where soils based dispersal systems are insufficient to assimilate the volume;
- Water safety; and
- Food safety.

There are important synergies between many of these services and FSM, and investigating co-management opportunities can yield benefits. MSW can often be co-managed with fecal waste, especially when thermal treatment technologies are used. Food waste from restaurants and markets can be co-composted with fecal waste to produce a high value soils amendment. Fats, Oil and Grease (FOG) from commercial grease traps can be added to biodigesters to increase methane production, or used in conjunction with fecal sludge as a feedstock for biodiesel production.[14] Water supply is also closely linked with FSM as it is often the water utility that will manage programs and their customers that will pay for services through tariffs.

Scheduled desludging programs

In Southeast Asia, there is increasing interest in scheduled desludging programs as a means of providing services. Under this scheme, users pay monthly tariffs that are included with their water bill to cover the cost of services. The trucks move from neighborhood to neighborhood on a scheduled cycle. Truck operators are licensed and compensated based on the volume of waste delivered to the treatment plant, which serves as an incentive against illegal dumping. The concept was first introduced in the Philippines in 2010 and has been replicated there successfully.[6]

Technology components and infrastructure

Technology selection

A formal process should be used for making an informed technology selection for the treatment of the fecal

sludge.[3] It is usually *a* collaborative process conducted by stakeholders, consultants, the operator and the future owner of the facility. The process is based on a long term vision planning with stakeholders as part of city-wide sanitation planning. The expected waste flows (volume), their strength, characteristics, and variability in each area need to be known. A formal and transparent process for developing appropriate plans and designs for wastewater and septage treatment plants will achieve local buy-in and ownership of technology decisions, which is critical for the long term success and sustainability of the program.

Training of enumerators for a survey regarding fecal sludge management needs in Nepal

Collection vehicles and equipment

After sitting for years in septic tanks and pit latrines, the accumulated sludge becomes hardened and is very difficult to remove. It is still common that workers enter pits in order to desludge them, even though this practice is generally unsafe and undesirable (in India, this practice is called "manual scavenging"). A number of low-cost pumping systems exist to remove this hardened sludge hygienically from the ground surface, although many of them are still in the experimental stage (e.g. Excravator, Gulper, e-Vac).[15]

The "Gulper", a device for manual pumping of fecal sludge from pits used in eThekwini (Durban), South Africa.

Fecal sludge can also be treated inside the tank or pit as well, by use of the "in-pit lime stabilization process", which treats the waste before it is removed from the tank or pit. This methodology was first pioneered by iDE Cambodia in 2010.[16] Once removed, it is transported to onsite or off site treatment and processing facilities.

Some advanced transfer stations and vacuum trucks can dewater fecal sludge to some extent, and this water may be placed in sewer lines to be treated in wastewater treatment plants.[3] This allows more sludge to be dealt with more efficiently and may constitute one of the best cases of co-treatment of fecal sludge in wastewater treatment plants.

Transfer stations

Transfer stations are intermediary drop off locations often used where treatment facilities are located too far away from population centers to make direct disposal feasible. In other locations, traffic concerns or local truck bans during daylight hours may make transfer stations feasible. In addition, municipalities where a significant percentage of homes cannot be accessed by tanker truck should utilize transfer stations. Transfer stations are used if:

- More than 5% of the homes are inaccessible by a vacuum truck;
- The treatment plant is too far away from the homes for transport in one haul to be practical;
- Trucks are not permitted on the streets during the day; or
- Heavy traffic during daylight hours impedes the movement of vacuum trucks.

Mobile transfer stations

Mobile transfer stations are nothing more than larger tanker trucks or trailers that are deployed along with

small vacuum trucks and motorcycle or hand carts. The smaller vehicles discharge to the larger tanker, which then carries the collected sludge to the treatment plant. These work well in scheduled desludging business models.

Fixed transfer stations

Fixed transfer stations are dedicated facilities installed strategically throughout the municipality that serve as drop off locations for collected septage. They may include a receiving station with screens, a tank for holding the collected waste, trash storage containers, and wash down facilities. These may be more appropriate for FSM programs using the "call-for-service" business model.

While static transfer stations are fixed tanks, mobile transfer stations are simply tanker trucks or trailers that work alongside the SVVs and actually do the longer haul transferring of the waste from the community to the treatment plant. Mobile transfer stations work best for scheduled desludging programs where there are no traffic restrictions or truck bans, and a relatively large number of homes that are inaccessible to the larger vehicles.

Treatment plants

Fecal Sludge is often processed through a series of treatment steps to first separate the liquids from the solids, and then treat both the liquid and solid trains while recovering as much of the energy or nutritive value as possible.[3] Common processes at fecal sludge treatment plants include:

- Fecal sludge reception - where the truck interfaces with the treatment plant and sludge is unloaded.
- Preliminary treatment - to remove garbage, sand, grit, and FOG (fats, oil and grease);
- Primary treatment - simple separation by physical means, or separation with microbial digestion;
- Liquids treatment - for example by using constructed wetlands, waste stabilization ponds, anaerobic digesters; and
- Solids processing - using the solids resulting from fecal sludge treatment for beneficial use where possible.

Drying bed for emergency septage treatment by Oxfam in the Philippines

Drying bed for fecal sludge in Bangladesh

Constructed wetlands are gaining attention as a low-cost treatment technology that can be constructed in many instances using local materials and labor. For sites with enough land and a ready supply of gravel and sand, this technology offers low cost, scaleability, and simple operation.[17]

Emerging technologies

Emerging technologies for fecal sludge treatment include:[18]

- Thermal processes which can achieve cost effectiveness by eliminating the need for separate processes. They convert the fecal sludge along with certain fractions of of sewage sludge or municipal solid waste

to produce energy or fuel by using certain sewage sludge treatment technologies.
- Biodiesel can be manufactured by using fats, oils and grease as feedstocks. Research by RTI International is being conducted to use fecal sludge for biodiesel production.
- Electricity can be produced by thermal processes that burn fecal and solid waste together to maintain stable combustion and the heat is used to make steam that drives generators.

Treatment products and reuse options

Composting is a process whereby organic matter is digested in the presence of oxygen with the byproduct of heat. For fecal sludge, the heat deactivates the pathogens while the digestion process breaks down the organic matter into a humus-like material that acts as a soils amendment, and nutrients that are broken down into a form that is more easily taken up by plants. Properly treated fecal sludge can be reused in agriculture (see also reuse of excreta).

Sludge pellets after processing (including heating, drying and pelletizing) in a LaDePa process, eThekwini Municipality (South Africa)

Biosolids from septage are rich in nitrogen. When they are mixed with materials that are rich in carbon, such as shredded crop wastes, the composting process can be maximized. Proper mixture to achieve a ratio of 20 to 1 to 30 to 1 of carbon to nitrogen is best.

Biogas is a byproduct of the anaerobic digestion process.

Treated effluent can be used for agricultural or landscape irrigation.

Costs and fees

FSM is considered an entry point for sanitation improvement programs that are led by local governments. Such programs may include tariffs or user fees, promotions campaigns to raise the willingness to pay for the service, and local ordinances that define the rules and regulations governing FSM. In the Philippines, tariffs around $1 USD per family per month are generally enough to achieve full cost recovery within a period of 3 to 7 years.[6] Promotional campaigns are used to raise the willingness to pay for services, and local procedures and ordinances provide additional incentives for compliance.

See also

- Manual scavenging
- Nightsoil - a historical term for a material similar to fecal sludge
- Sanitation

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External links

- Sustainable Sanitation Alliance library (documents on FSM) (http://www.susana.org/en/resources/library?vbl_2%5B%5D=&vbl_7%5B78%5D=78)

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