Sustainable Technologies for On-site Human Waste and Wastewater Management: Sulabh Experience

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Abstract

The technology of two-pit pour flush toilet is economically affordable and culturally acceptable for most of the developing countries. Sulabh has implemented over 1.2 million such household toilets in India

The conversion of bucket privies into Sulabh toilets has resulted in liberation of over 60,000 scavengers (most of whom are women), from manual cleaning of waste from privies. Those liberated have been provided vocational training in different trades for their socio-economic up gradation.

To provide sanitation in slums, at public places, markets etc., Sulabh is operating and maintaining over 6000 public toilets on "pay and use" basis in different parts of the country.

For unsewered areas for the safe, hygienic and affordable way of disposal of human wastes from public toilets, Sulabh generates biogas to be used for different purposes like cooking, lighting, and electricity generation. The effluent of biogas plant is reused after a simple and convenient method of treatment consisting of sedimentation followed by passing through sand column and activated carbon and finally with UV. Such effluent is colorless, odorless and pathogen free having BOD less than 10 mg/l - suitable for agriculture, horticulture or cleaning of floors of public toilets or discharge in any water body.

Sanitation has become a yardstick of socio-cultural development of a nation. Improved sanitation results in improvement of health, reduced child mortality/morbidity, improved water quality, environment and economic growth of a country. Continued urban migration, congregation of urban poor in slums without safe water supply and sanitation facilities and increasing resource constraints have all led to rapid deterioration in quality of life and community health in many developing countries which are likely to become further aggravated unless steps are initiated to improve sanitation through inter- sectoral co-ordination, people's participation, innovative and appropriate technology for safe management of human wastes and waste water treatment. Epidemiological evidence suggests that sanitation is at least if not more as effective in preventing disease as improved water supply.

Sanitation coverage in South Asian countries is far below levels of satisfaction[1-2]. Most of the uncovered people are from lower socio-economic groups and are not aware of the health and environmental benefits of sanitation. It is still not seen as a high priority, resulting in absence of people's participation. Sanitation is regarded as a matter of individual initiative and not as a collective obligation of the community.

The grossly inadequate progress in the sanitation sector is primarily due to the following factors:

i. Lack of political will and administrative support for the sanitation programmes.
ii. Insufficient awareness/ motivation among the people, particularly those in the rural areas, about the need of sanitation and its health consequences.
iii. Lack of affordable sanitation technology
iv. Health sector's least involvement and lack of adequate advocacy on its part.
v. Failure to develop a demand-driven approach with adequate participation of the people at the grassroots level.
vi. Lack of professional marketing strategy.

For decades, the sanitation programme in developing countries has been conceptualized as supply-driven, government promoted and government controlled programme. It needs to be converted into a demand-driven, people-centered, and community-led programme.

In promoting hygiene and sanitation, one is often confronted with the apparent contradictions of the situation. It is often observed in India that the community does not appreciate the health issues related to sanitation adequately. As a result, sanitation is not a felt-need of the community. It is often observed among the rural community, that a person with financial resources often buys a T.V. set, rather than building a latrine. This misplaced priority is primarily due to our failure to communicate the health message effectively and convincingly. If a mother could be made aware and convinced of the risks to her children associated with unsanitary disposal of human excreta, the family would certainly provide higher priority to having a sanitary latrine.

It is most important to create political will for the sanitation agenda in any country. A well-informed and educated community would create the necessary environment for the same.

Sulabh is implementing two technologies on sanitation - one for household waste disposal through two pit pour flush toilets and another for public places and slums through public toilets linked with a biogas plant & effluent treatment system for the complete recycling and reuse of human wastes. These technologies with their social and financial aspects are described below.

1. Two pit pour flush toilet

The Two-pit pour flush toilet, popularly known in India as Sulabh Toilet, is technically appropriate, socio-culturally acceptable and economically affordable technology for household waste disposal. The toilet can easily be constructed by local laborers and materials. It requires only 1.5 to 2 liters of water for flushing and thus conserves water and does not need the services of scavengers to clean the pits. There are two pits, which are alternately used. The capacity of each pit is kept generally for 3 years. Both the pits are alternately used. When one pit is a full, an excreta is diverted to the second pit. In about two years rest period, the sludge in the first pit gets digested and is almost dry, and

pathogen free, that can easily be dug out by the beneficiaries and used as manure. The technology has been highlighted by the UNDP[3].

Based on this technology, Sulabh launched a progamme of converting dry latrines (cleaned by scavengers) into Sulabh toilets and construction of new toilets where they did not exist earlier. Over1.2 million such toilets have been implemented by the organization so far in different states of India. Owing to this technology, Sulabh has been able to liberate over sixty thousands of scavengers[*].

Cost of Sulabh flush toilet: The cost of a Sulabh flush composting toilet varies widely to suit people of every economic stratum. It ranges from US$ 25 to US$ 1000 per unit depending upon materials for construction of pits and seat as well as of superstructure. The pit can be constructed with bricks or any locally available material like stones, wood logs, burnt clay rings, or even used coal tar drums. Similarly, the quality of superstructure also ranges from simple gunny bag sheet or thatch to brick walls with tiles and R.C.C. roof, doors, etc. Cost varies also due to size and capacity of each pit that vary from 3 years to 20 years capacity. Keeping the basic design the same, Sulabh has demonstrated a number of such toilet models.

Vocational Training to Liberated scavengers: Sulabh is providing vocational training in different trades like tailoring, dress designing, computer, audio-visual, motor driving, electrician, beautician etc., to liberated scavengers[4]. The courses are approved by the Government Body. The aim of such programme is to make them self-sustaining and check they're reverting to the old practices.

Social Marketing and Delivery: Sulabh workers make house-to-house contact to educate and motivate the householders and disseminate information about the technology and programme contents. Once they agree, Sulabh undertakes the responsibility to construct the toilets to the entire satisfaction of the householders involving them fully in the process. Sulabh has set up a special cell to monitor the quality and satisfaction of the latrine adopters.

Women's Participation: Much of the demand for latrines comes from women, as they are the worst sufferers due to non-availability of these facilities. Women have by far the most important influence in determining household hygiene practices and in forming habits of their children. So Sulabh plans the facilities with full awareness of their perceptions and needs.

Training: Although low-cost technology is easy to implement, yet it requires all the ingenuity and expertise for precision in construction and competence in supervision to guard against faulty construction and pollution of ground water. It, therefore, calls for mounting a well-planned training programmed for the personnel involved in the implementation of sanitation projects.

2. Sulabh Public Toilet Complexes

Provision of public toilet complexes at public places and in slums on "pay & use" basis is an important activity of Sulabh in the field of community health & hygiene and

[*] Scavengers are a class of people of lowest socio-economic status who manually clean human wastes from bucket privies of others for livelihood. There are still over 800,000 such persons in different states of India.

environmental sanitation. Our experience revealed that when facilities for bathing are also provided with the community toilets, and above all they are kept clean, people have no hesitation in paying for the use. For washing hands, soap powder is provided to users. User charge is Rs. one (2 US Cent) per use. Children are exempted from such charge.

Sulabh has constructed so far over 6000 such public toilet complexes in different parts of the country, where maintenance is provided round the clock. These complexes are located at public places like bus stands, hospitals, markets etc. and in the slums. For the construction, operation, and maintenance of these complexes, the organization plays the role of a catalyst and a partner between the official agencies and the users of the toilet complexes.

The system of operation and maintenance of community toilets evolved by Sulabh has proved a boon for the local bodies in their endeavor to keep the towns clean and improve the environment. This is a unique example of partnership of local authorities, non-governmental organization, and the community.

Public Toilet Complexes in Delhi - a case study: In Delhi, Sulabh is maintaining 220 public toilet complexes since early 90s. There are additionally 1743 public toilets maintained either by the Delhi Municipal Corporation (MCD) or other NGOs of whom several toilet complexes were closed due to their bad shape or other reasons. Maintenance of rest of the toilet complexes was also far from satisfaction. Taking into consideration the maintenance quality of Sulabh Public Toilets, the MCD recently decided to hand over all the public toilet complexes to Sulabh for their maintenance. So far 960 such complexes have already been handed over and rest is in process.

Public Private Partnership in quality service delivery: The sustainable and affordable technologies developed by the organization have attracted various agencies towards management of human wastes. The 'pay & use' basis of maintaining a public toilet is saving annually a lot of money to the local bodies in maintaining the toilet complexes. Now, it is one time investment by the local government because maintenance of the toilet is being carried out by the user's contribution. As Sulabh is taking maintenance guarantee of the toilet complexes built by it for not less than 30 years, local governments as well as people have faith in the quality service by the Sulabh.

Financial viability of the projects: Since human excreta were considered a hated object, it was difficult for any one to consider financial viability of a project related to its disposal. However, Sulabh made it financially viable. The cost of construction is met by the local body. The maintenance of toilet blocks and day-to-day expenses is met from the user's charges. Sulabh does not depend on external agencies for finances and meets all the financial obligations through internal resources. All the toilet complexes are not self-sustaining particularly those located in slums and less developed areas. The maintenance of such toilet complexes is cross subsidized from the income generated from toilet complexes in busy and developed areas.

Elimination of social stigma and psychological taboos: Earlier there was social stigma and psychological taboo attached to handling of human excreta. It was also due to the fact that only people of lowest economic strata were supposed to be associated with this job. Due to financial viability now, people from higher social status are also engaged in the construction and maintenance of toilets.

Employment opportunity: Altogether there are 50,000 volunteers working with Sulabh who include technocrats, managerial, scientists, engineers, social scientists, doctors, architects, planners, masons and other non-revenue staff. Since Sulabh takes 30 years maintenance guarantee for the toilet complexes constructed by it, all the social workers associated with this work get almost regular employment. Besides, workers associated with construction job also get almost full employment.

2.1 Community Toilets Linked with Biogas Plants

Safe disposal of human excreta from public toilets is a major challenge particularly in unsewered areas. Normally septic tank system is attached with public toilets. The effluent from such tanks containing high Biochemical Oxygen Demand (BOD) and pathogen contents are discharged in nearby open/covered drains that finally lead to low land area/ nearby river causing severe water pollution and health hazards.

To overcome the problems Sulabh developed an efficient design of biogas plant linked with public toilets[5] under a project funded by the Ministry of Non-Conventional Energy Sources, Government of India that approved the design for implementation under its Central Financial Scheme[6]. Under the system only human excreta with flush water is allowed to flow into biogas plant for anaerobic digestion. Bathing and cloth washing water is collected separately that is reused after sand filtration or discharged in drain after settlements. For biogas generation no manual handling of excreta at any stage is required. Hydraulic Retention Time (HRT) of feed material is maintained for 30 days. One cubic foot (cft) of biogas is produced from the human excreta of one person per day. Human excreta based biogas contains 65-66% methane, 32-34% carbon oxide about 1% hydrogen sulphide and trace amounts of nitrogen oxide and ammonia. Biogas is stored inside plant through liquid displacement chamber. Biogas plant is made up of Reinforcement Concrete Cement (R.C.C.); therefore, no recurring expenditure is required for its maintenance.

Produced biogas is used for cooking, lighting though mantle lamps, and electricity generation. Cooking is the most convenient use of biogas. Biogas burner at reasonable price is available in the market that consumes about 25 cft of biogas per hour. Mantle consumes 2-3 cft biogas per hour that gives illumination equivalent to 40-watt bulb at 220 volt. Electricity generation is through dual fuel engine coupled with alternator that runs on 80% biogas and 20% diesel. Consumption of biogas is 15cft/BHP/hr. Based on `Sulabh Model' design, 140 number of biogas plants of 35 to 60 cum per day gas production capacity have been constructed by Sulabh in different states of the country so far.

2.2 BET (Biogas plant Effluent Treatment) System for reuse of effluent

During biogas generation there is remarkable reduction (up to 85%) of BOD of effluent of biogas plant in comparison to its affluent value. In absolute term the BOD of effluent is around 125 mg/l. Similarly, pathogen count is still higher than the permissible limit of discharge in any water body. Such effluent contains good percentage of nitrogen, potash, phosphate and other micronutrients for plants, but its aesthetically bad odor, yellowish color, high BOD and pathogen contents limit its reuse for agriculture/horticulture or safe discharge in water body.

In a public toilet linked with biogas plant, used by 1000 users per day, maximum 5000 lts of wastewater is generated per day. For a continuous flow from the treatment system a flow rate of 5-6 LPM (Liter Per Minute) will solve the purpose.

After a series of experiments under a R&D project[7] funded by the MNES, the author has developed a simple and convenient technology named as BET (Biogas plant Effluent Treatment) to treat such effluent. The technology is based on sedimentation and filtration of effluent through sand and activated charcoal followed by ultraviolet rays. The system consists of an overhead sedimentation tank of 2000 lts capacity with bottom conical shape fitted with valve. Effluent from outlet chamber of biogas plant is lifted to this tank and left for one and half hours to settle. It is passed through the sand filter column through Liquid Flow Meter at the rate of 6 LPM. From sand column it flows upward through an activated carbon column where carbon contact time is maintained for 5-6 minutes. Sand and carbon columns are made up of mild steel. From carbon column effluent passes through a U-V channel where retention time is kept for 30 seconds that helps eliminate bacteria and other pathogens. The treated effluent is colorless, odorless, pathogen free having BOD less than 10mg/l-quite safe for aquaculture, agriculture/horticulture purposes or discharge into any water body without causing pollution. It can also be used for floor cleaning of public toilets in water scarcity areas.

Recurring expenditure: The system requires 1 H.P. of electric motor to lift effluent to the overhead tank for maximum 3 hours a day i.e., 2.5 units of power a day is required. For operation of 3 nos. of UV (15 watts each) about one unit of power will be consumed per day. Such low consumption of electricity can easily be obtained through biogas. Expenditure incurred on the periodical replacement of activated carbon is very low that can easily out of the user's charges of the toilet complex.

One such system is under operation with a Sulabh public toilet complex with 13 WCs. (8 for gents and 5 for ladies) at Mahavir Enclave, New Delhi that is being used by around 600 users per day. Produced biogas is being used for cooking in a kitchen, lighting mantle lamps inside toilet complex and electricity generation. Treated effluent is being used for irrigating the lawn and horticulture.
Based on this new technology 3 Nos. of plants have been implemented in Ranchi – the capital town of Jharkhand State where there is no sewer system and disposal of waste from public toilets is a major challenge. One such toilet complex at Birsa Chowk with 20 WCs (12 for gents and 8 for ladies) is used by over 700 users a day. Produced biogas is being used for cooking, lighting, and electricity generation. A part of the treated effluent from public toilet linked biogas plant is being used for cleaning of floors of public toilet. Rest of it is discharged in the drain. 35 Nos. of public toilets are being implemented in the State with BET technology.

Implementation of two public toilets with such system in Kabul, Afghanistan is under way, on the invitation of the Government of Afghanistan and with the financial support from the Government of India (official communication). Since the area is completely unsewered with severe water scarcity and people use water for ablution, such technology will help a lot in conservation of water and maintaining good sanitation and public toilets clean.

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