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Waste Stabilization Ponds: A Technical Option for Liquid Waste Management in Rural Areas in Haryana under Swachh Bharat Mission- Gramin

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Abstract

Liquid waste disposal is one of very serious issues in rural areas of Haryana. The goal of rural sanitation fails miserably when both the solid and liquid waste management (LWM) aspects are not given proper attention in the villages. Around 80% of the Gram Panchayat doesn't have a sustainable and scientific liquid waste disposal system in the state. On an average around 15000 to 18000 million liter of liquid waste (grey water) is generated per day in rural areas in India. In rural areas this aspect is neglected due to lack of proper infrastructure, availability of funds, sustainable technologies at household or community level, lack of operation and maintenance (O&M) and awareness among common people. The standing water provides a good site for breeding for disease vectors. The liquid waste can also further contaminate the surface water as well as groundwater. There are several technologies suitable for LWM under different socioeconomic and geological condition of rural areas. There is an increasing concern on liquid waste management mainly on grey water generated in residents, institutions, common places and wash water from kitchen, bathroom, markets etc. The present paper seeks to analyze and discuss waste stabilization pond as a technical option for liquid waste management in rural areas in Haryana.

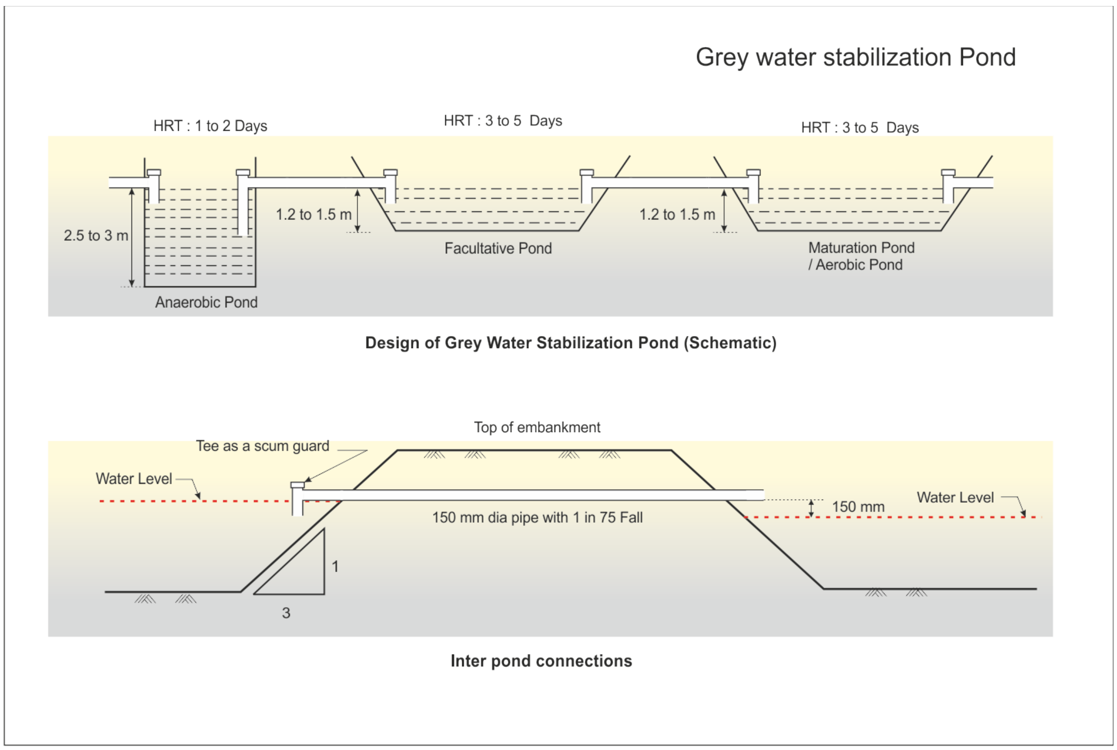
Introduction

The Prime Minister of India launched the Swachh Bharat Mission with two sub-missions, the Swachh Bharat Mission (Gramin) [SMB (G)] and the Swachh Bharat Mission (Urban) on 2nd October, 2014. The aim of the mission is to accelerate the efforts to achieve universal sanitation coverage and to put focus on sanitation by 2019, as an appropriate tribute to the 150th birth anniversary of Mahatma Gandhi, *Father of Nation*. In rural areas the mission focus on improving the levels of cleanliness in rural areas through solid and liquid waste management activities and making Gram Panchayats (GP) (village councils) open defecation free (ODF), clean and sanitized. The objective of SBM (G) is to bring about improvement in the cleanliness, hygiene and the general quality of life in rural areas. Solid and liquid waste management (SLWM) is one of the main components of the programme. The total assistance under SBM (G) for SLWM projects is based upon the total number of households in each GP, subject to a maximum of Rs.7 lakh, 12 lakh, 15 lakh and 20 lakh for GPs up to 150, 300, 500, and more than 500 households, respectively. The central and state government provides funding for SLWM project under SBM (G) in the ratio of 75:25 (MDWS, 2015). Any additional monetary requirement is to be met with funds from the state/gram panchayat, Finance Commission funding, corporate social responsibility (CSR), Swachh Bharat Khosh and through the public private partnership (PPP) model accordingly. There is a range of technological options for solid and liquid waste management. Selected technology should be sustainable, economically affordable, socially acceptable, technical feasible and environmental friendly.

Waste stabilization ponds (WSPs) are large, shallow basins of varying depth (figure-1) where raw sewage is treated entirely by natural processes using both bacteria and algae. They are one of the most cost-effective, reliable and easily-operated methods for treating domestic and industrial wastewater in temperate and tropical climates (Abdullahi *et al;* 2014). Solar energy is the only requirement for its working. The temperature and duration of sunlight in tropical countries provides an excellent opportunity for high efficiency and performance for this type of water cleaning system. Further, it requires minimum supervision for daily operation, simply by cleaning the outlets and inlet works. Waste stabilization ponds are very effective in the removal of faecal coliform. They are well-suited for low-income tropical countries where conventional wastewater treatment cannot be achieved due to the lack of a reliable energy source. Many African countries in tropical climates use WSPs for wastewater treatment e.g., Botswana, Kenya, Malawi, Tanzania, Uganda, Zambia, and Zimbabwe (UNEP-IETC, 2014). In four successive summers of polar regions of Canadian Arctic WSPs were found to reduce more than 80% of total suspended solids (TSS) and carbonaceous biochemical oxygen demand ($CBOD_5$) (Ragush *et al;* 2015). In America the most common types of pond used are facultative pond having different names like oxidation pond, sewage lagoon and photosynthetic pond (Reed *et al;* 1995). Further, the advantage of these systems in terms of removal of pathogens is one of the most important reasons for its use. WSP are often thought of as being suitable in developing countries because of their simplicity, low cost and maintenance, low energy utilization, strength, and sustainability (Mara, 2003). The efficiencies of combined anaerobic, facultative and maturation ponds in treating municipal wastewater to reduce BOD, COD, TSS was found to be 50.65%, 48.95% and 44.3%, respectively (Ghazy *et al;* 2008).

Regarding the design, WSP systems consist of single or several series (in parallel) of anaerobic, facultative and maturation ponds. The anaerobic pond is deprived of oxygen and function like a open septic tank where the anaerobic digestion occur at the bottom converting organic load to CH_4 and CO_2 and releases some soluble products in water column. The anaerobic treatment is more suited to waste water with high BOD (UNEP-IETC, 2002). The chemical reactions occurring in anaerobic pond can be illustrated through following equation (Crites *et al;* 2006):-

$$5(CH_2O)x \rightarrow (CH_2O)x + 2CH_3COOH + Energy$$
$$2CH_3COOH + 2NH_4HC \rightarrow 2CH_3COONH_4 + 2H_2O + 2CO_2$$
$$2CH_3COONH_4 + 2H_2O \rightarrow 2CH_2 + 2NH_4HCO_3$$



Designed and drawn by: First Author Sandeep Kumar

Figure 1. Structure and design of waste stabilization pond

Around 60% of BOD removal at 20^{o}C can be secured through properly designed anaerobic pond. Hydraulic retention time of only one day is sufficient for waste water having BOD up to 300 ppm and temperature > 20^{o}C (UNEP-IETC, 2014). However, the hydraulic retention time depends on the volumetric BOD required (g/m^{3}d) (WEF, 2006). The high efficiency of BOD removal along with partial mineralization of organics investigated in an anaerobic pond and also reduces the space requirement (Mara *et al;* 2001).

Facultative pond either primary or secondary receives settled waste water from anaerobic pond and designed for BOD removal at a temperature between 20°C and 25°C on the basis of low surface loading and development of healthy algal population. The process of oxidation of organic matter in primary or secondary facultative pond is usually dominant by aerobic bacteria and algal photosynthesis generates oxygen for BOD removal by pond bacteria (Mara and Pearson, 1998). It is estimated that about 30% of influent BOD in primary facultative pond leaves in the form of CH_4 gas (UNEP-IETC, 2002). In sunlight, the algal cells utilize CO_2 form waste water and release O_2 produced during photosynthesis. The oxygen produced during photosynthesis is used by aerobic and facultative bacteria to stabilize organic material in upper layer of water. At peak algal activity carbonate and bicarbonate ions react to provide CO_2 and leaves excess of hydroxyl ion (OH^-) which result in an increased pH of > 9 which kills fecal bacteria (Mara and Pearson, 1998). This also creates conditions favorable for ammonia removal and volatilization (US EPA, 2002).

Maturation pond is usually 1-1.5 meter deep and receives effluents from facultative pond. The primary function of this pond is to remove excreted pathogen along with small degree of BOD and nutrients. Time and temperature are the two principal parameters used in designing maturation pond. The death of faecal bacteria increases with both time and temperature (Feachem *et al;* 1983).

The pond system can be used alone but usually they are used in combination with each other (Kumar and Sharma, 2017). In many cases anaerobic ponds and facultative ponds are enough for wastewater treatment but depending on the nature of waste water the maturation ponds are provided for further polishing purposes. Maturation ponds are necessary when the treated wastewater is to be used for unrestricted irrigation and has to comply with the WHO guidelines (WHO, 2001) of <1000 faecal coliforms per 100 ml, and when stronger wastewaters of having BOD >150 mg/l are to be treated prior to surface water discharge (Mara and Pearson, 1998). In some cases facultative ponds are provided without anaerobic ponds.

The study was carried out with the objectives to discuss water supply access, use and disposal of liquid waste in rural areas of Haryana state. To compile the sources and type of waste water generated in rural areas with district wise liquid waste management projects (waste stabilization pond) sanctioned till March, 2018. To analyze the district wise progress in terms of status of completion and there after functional aspects of completed and sanctioned projects. To discuss various issues and challenges in implementation and thereafter operation of liquid waste management projects. The structure and design waste stabilization pond is given in figure 1.

Materials and Methods

State profile

Haryana a landlocked North Indian state stands 21st in terms of its area with about 44,212 km^2. It lies is between 27°39' to 30°35' N latitude and between 74°28' and 77°36' E longitude and altitude varies between 200-1200 metres above sea level. As of 2011 census of India, the state is inhabited by population of 25,353,081 and has a literacy rate of 76.64 %. Male literacy stands at 85.38 %, while female literacy is at 66.67 %. The state is divided into four divisions for administrative purposes i.e. Ambala, Rohtak, Gurgaon and Hisar. There are 21 districts, 62 sub-divisions, 83 tehsils, 47 sub-tehsils, 126 blocks, about 154 cities and towns and 6184 gram panchayats and 6,841 villages (PRI, 2016) in the state.

Data generation

The secondary data regarding detail of sanction and construction of project for liquid waste management, their functional status etc was taken with permission to use from the office of Haryana State Swachh Bharat Mission, Development & Panchayat Department, Chandigarh. Simple statistical tools have been applied for data analysis. The primary information on existing liquid waste disposal and management has been generated during field visit, focused group discussion during capacity building programme organized on campus as well as off campus. The issues of liquid waste disposal were also raised and mentioned in performa's filled during organizing of capacity building programme of newly elected members of PRIs i.e. Sarpanches (village head), member Panchayat Smitis (block councils) and Zila Parishads (district councils) by Haryana Institute of Rural Development (HIRD), Nilikheri, district Karnal (Haryana), a nodal agency for capacity building for PRI's in the state.

Result and Discussion

Water supply access, use and disposal of liquid waste in rural areas: Haryana has the distinction of providing piped water supply to all villages in the state, though, the quantity and hours of supply varies across villages. The Public Health Engineering Department (PHED) had installed deep and high capacity tube wells to meet the drinking water needs of the villages. Beside meeting a part of the essential drinking water needs of the villagers it was pointed out by almost all the PRIs member during the training programme of newly elected PRIs conducted by HIRD as given in that it associated with a number of problems (Table 1).

For instance the pumps run only when there is power supply, which is irregular and unsure, as a result the pump operator is unable to maintain any fixed schedule. Usually the pumps run for the entire period during power supply causing over supplies the water, which causes water wastage. Moreover the pipelines laid to connect the household in these schemes were of lower quality and thus often causes leaking and wastage of water.

Table 1. Training Programme of Newly Elected Members of PRIs during 2016-2017

Name of Training Programme	Numbers of Training Programme Conducted	Number of Participants attended	Male/ Female		General	Schedule Caste	Backward Caste
			M	F			
Five DayTraining Programme for Newly Elected Sarpanches	142	5407	3568	1829	2693	1276	1438
Two-Day Training programme of Member Zila Parishad	10	226	141	85	112	53	61
Two-Day Training programme of Member Panchayat Smitis	66	2110	1343	767	957	577	576

Source: Kumar and Sharma, 2017

The panchayats have installed the submersible pumps from their own funds as well as from the funds availed from Panchayat Smitis and Zila Parishad. There are 7,37,000 tube wells / pump sets in the state which translates to about a tube well / pump set for every 15 households (Department of Economic and Statistical Analysis, Govt. of Haryana, 2013). The indiscriminate sinking of tube wells and their over exploitation needs to be curtailed from the perspective of water conservation and wastewater that needs to be treated. The liquid waste both grey water and black water are disposed through a network of constructed drains finally into a pond if pond is not available the wastewater is disposed into open areas.

Sources and Type of Waste Water generated: In rural areas waste water is generated from domestic use i.e. from kitchen, bathroom, toilet, cloth washing, animal care activities, from community like small scale industries, commercial and business activities, institutions, healthcare facilities, market places, farming, animal husbandry activities etc. The wastewater generated can be categorized into two types as below:

Grey water is wastewater from kitchen, bathroom, and cloth washing. Based on its use, this water requires less treatment than black water and generally contains lesser pathogens. After treatment it can be reused in kitchen gardening and fodder raising.

Black water is water that has been mixed with waste from the toilet and requires chemical or biological treatment and disinfection before re-use. The table 2 given below can be used as to cross-check the estimate of wastewater quantity. It is revealed from the analysis of sources of wastewater and its type that more than 90% of waste water generated as grey water. Therefore grey water management is major challenge in rural areas.

Table 2. Sources of wastewater and its type quantity from different source

Sr. No.	Sources	Type of Waste Water	Quantity/ Day/ Person
1.	Toilet	Black Water	3 liter
2.	Bathing	Grey Water	20-30 liter
3.	Kitchen	Grey Water	5-10 liter
4.	Cloth Washing	Grey Water	15-20 liter

Source: UNICEF, 2010.

Detail of district wise liquid waste management project (waste stabilization pond) sanctioned: The waste stabilization pond in the form of three pond/ five pond have been constructed under the guidelines of Swachh Bharat Mission- Gramin as a component of solid and liquid waste management in rural areas. The composite project of solid and liquid waste management was developed after the estimation and calculation of amount of liquid waste generated in the gram panchayat area through a well designed survey format. As per data analysis a total number of 1289 projects have been sanctioned out of 1360 villages taken under solid and liquid waste management in 22 districts from the year 2014 to till now (Table 3). The maximum numbers of 121 projects were sanctioned in Kaithal district followed by district Jhajjar and Yamunanagar, respectively and least number of projects have been sanctioned in the district Palwal, Mahendragarh and Mewat, respectively. Out of the total sanctioned projects 28.23 % have been completed, 43.75 % are in progress of construction and 29.40 % are not started yet in the state. It further analyzed that out of the total 364 completed projects 85.16 % are functional and rest not functional due to various reasons like faulty construction, flooding etc.

District wise progress in terms status of completion and functional aspects of completed and sanctioned projects: There exist a lot of inter district variation in terms of total number of projects sanctioned, completion of sanctioned projects, functional status of completed project, initiation of work in terms of in progress of the sanctioned project and the project not started at all. As per the data available given the table 2 and represented in the figure 2 below showed that only two district namely Jhajjar and Palwal have completed more than 50 % of sanctioned projects and less than 10 % of sanctioned projects have been completed in district Jind and Sonipat. The pace of completion of sanctioned is least and below 5 % in district Karnal and Mewat.

The waste stabilization constructed completely out of total sanctioned projects are fully functional in the District Hisar, Jhajjar, Kurukshetra, Mewat, Mahendragarh, Palwal, Panchkula, Sirsa, and Sonipat while in the districts Fatehabad, Gurugram, Kaithal, Rewari, Rohtak and Sonipat > 50% projects are functional. The functional projects in the district Jind, Karnal, Panipat, Yamunanagar are < 50 percent. More than 50% of waste stabilization ponds sanctioned in the districts namely Ambala, Faridabad, Fatehabad, Gurugram, Karnal, Mewat, Mahendragarh, Panchkula, Panipat and Rewari are under construction or in progress phase and the progress of construction is below 50 % in rest of the districts. In district Jind, Kaithal and Kurukshtra the work of construction has not started in more than 50% of total sanctioned projects while in the districts Ambala, Fatehabad, Faridabad, Hisar, Mahendragarh, Panchkula, and Rewari have only less than 10% of sanctioned projects are left without any starting of work.

Table 3. Detail of Liquid Waste Management Projects from 2014–2017 in Haryana

Progress of Liquid Waste Management Projects								
Sr. No.	**District**	**Total Villages taken up**	**No. of Works**					
			Sanctioned	**Completed**			**In Prog.**	**Not started**
				Func.	**Non-Func.**	**Total**		
1	Ambala	41	41	7	8	15	25	1
2	Bhiwani	71	52	19	0	19	21	12
3	Charkhi Dadri	31	18	8	0	8	7	3
4	Faridabad	33	33	6	3	9	17	7
5	Fatehabad	50	50	16	1	17	30	3
6	Gurugram	56	56	8	3	11	40	5
7	Hisar	93	92	36	0	36	33	23
8	Jhajjar	120	112	63	0	63	46	3
9	Jind	101	96	8	16	24	18	54
10	Kaithal	121	121	31	0	31	23	67
11	Karnal	71	71	2	5	7	41	23
12	Kurukshetra	55	55	19	0	19	6	30
13	Mewat	24	24	1	0	1	15	8
14	Mahendragarh	17	17	2	0	2	14	1
15	Palwal	15	15	8	0	8	7	0
16	Panchkula	31	22	5	0	5	16	1
17	Panipat	35	34	9	4	13	17	4
18	Rewari	64	51	5	1	6	40	5
19	Rohtak	50	49	12	2	14	18	17
20	Sirsa	82	81	31	0	31	30	20
21	Sonipat	91	91	7	0	7	44	40
22	Yamuna Nagar	108	108	7	11	18	38	52
Total		**1360**	**1289**	**310**	**54**	**364**	**546**	**379**

Source: With permission from Haryana State Swachh Bharat Mission, Chandigarh (2014-17)

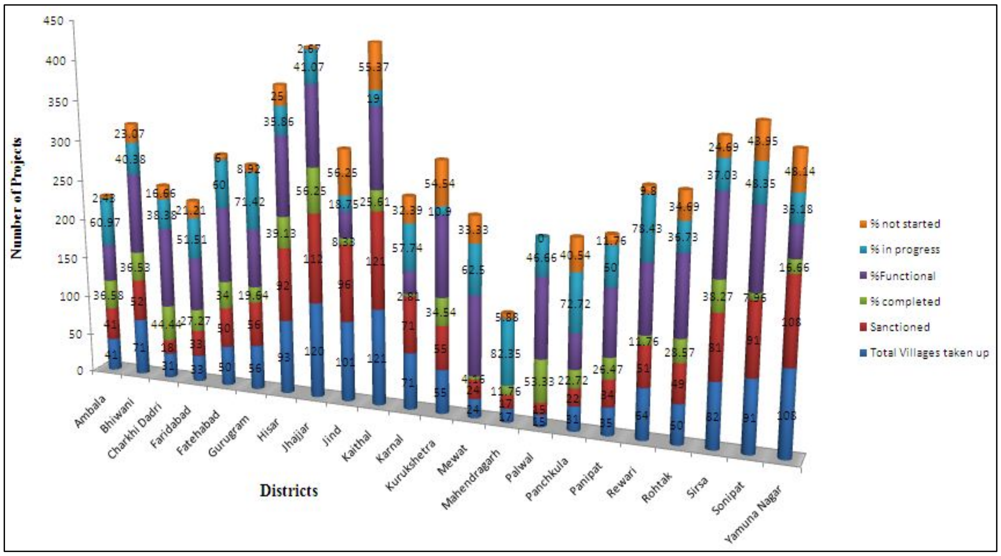


Figure 2. Progress of LWM projects in the districts during 2014- 2017

Issues and challenges in implementation and thereafter operation of liquid waste management projects: The Department of Development & Panchayat, Government of Haryana sanction the liquid waste management projects as a composite project of SLWM. The sole project of liquid waste management cannot be sanctioned under SBM-G scheme moreover there is a cap of funds depending upon the number of households in the Gram Panchayat as discussed above. The estimated cost of the project can vary and exceeds in most of the projects than prescribed funds in guidelines of SBM-G due to different ground condition like length of drains to be constructed to channelize the waste water into the pond, disposal of stagnant water from the existing pond, removal of sludge etc. In some cases it was observed that the estimated cost was revised and exceeded to double than the original in various gram panchayats i.e. Khasa Kheri, Chandana, Bhalang, Atela, hence the projects could not taken up for further action. In case the project cost exceed the prescribed cap the provision of funds made from Center Finance Commission or State Finance Commission or both. In both the cases the construction of project delays due to non-availability of funds on time.

Secondly the work of excavation of pond has to be carried out from Mahatma Gandhi National Rojgar Guarantee Scheme (MGNREGS) as per the direction of State Government, Haryana and this cost of excavation of pond is not included in the estimate of project cost. The manual work of excavation of pond takes a lot of time and delays the work. In addition of taking time in MGNREGS, there are issues of delay of payment of wages of the workers they are not easily willing to work under this scheme.

In many projects there are also site related issues selected for the construction of pond like encroachment and habitation etc. There are also the cases of faulty construction observed in many projects due to improper survey and estimation of liquid waste generated from all sources and households etc. The complaints were also received from different villages of district Sonipat due to flooding and overflow of WSP at Directorate office, Chandigarh. It has also been observed that the required depth of different prescribed ponds also vary which disturbs the treatment process. A case of faulty construction is seen in the village Bukhapuri of block Nilokheri of district Karnal. The most important issues in almost every project is the utilization and final disposal of treated water of maturation pond and due to lack of this provision this ultimately causes accumulation and flooding of pond and hence defeats the whole purpose.

Conclusion and Recommendation

The scientific and sustainable liquid waste disposal and management is need of hour in all the rural areas. The sustainable waste management technologies will bring about a positive change in sanitation and hygiene behavior among rural people. Waste stabilization ponds (WSP) are very effective technology subjected to properly designed and construction of the project. This is very expensive in comparison to other technologies and also require proper operation and maintenance which otherwise lacking due to lack of funds and ownership. In place of WSP other cost effective decentralized technologies like leech pit, soakage pit at household level or community level must be used wherever possible. The scientific treatment of liquid waste will help in income generation through fish culture and water can be reused for irrigation. There is also a need of proper and effective training for all the officer/official as well as PRI's members dealing with implementation of SLWM projects. It is also recommended that the Gram Panchayat should place the system of solid waste management before the implementation of liquid waste management projects for their effective management and sustainability.

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