Rural Sanitation Survey and Potential Technological Solutions for Improving Existing Sanitary Systems in India

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Abstract: Dealing with psycho-social aspects of rural groups for building toilets and make them utilize is a tedious task. The vivid aspects leading to open defecation and in order to find solutions for eradicating the same is being concentrated which is more likely prevailing in rural India. The survey was carried out in various villages of India to check the overall sanitation, hygiene habits, waste and wastewater discharge and most importantly, factors affecting the toilet adoption in the locality. The interaction with the officials of gram panchayat gave us an idea about methodologies and drawbacks of toilet construction. It also gave a comprehensive idea about assistance from the government in sanctioning the allocated funds and procedure adopted to construct toilets among rural population. A wide range of different income group was chosen and problems were noted. The solutions could be divergent depending on various parameters like population, terrain, economic conditions etc. The overall research is concentrated in monitoring and developing public health globally and attain success in rural sanitation.

Keywords: Public health, construct, toilets, gram panchayat, hygiene, sanitation.

Introduction

The term sanitation generally, refers to the provision of facilities and services for the safe disposal of human urine and faeces. Study suggests that problem is more prevalent in the rural areas. The most dangerous practice of open defecation is the highest in rural areas and is almost five times higher than urban areas. In this light, the dynamics of sanitation in the rural areas is discussed with major concern and to overcome the lack of approach. The main objective is to understand the overall sanitation, hygiene habits, waste and wastewater discharge and most importantly, factors affecting the toilet adoption in the rural locality. The psychological barrier of not using toilets and reason for practicing open defecation in rural area is the major concern of analysis. To assess the existing sanitary condition and provide an indigenous technological solution suited for improving the overall hygiene of the villages. The survey study showed that handling of solid and liquid waste is comparatively easier than that in urban areas owing to the fact that there no highly contaminated industrial wastes. In rural areas, most of the waste can be safely reused for beneficial purposes with limited resources. There are several technologies suitable for different socio-economic and geological conditions of rural areas, also there is less space constraint which allows application of natural treatment process which is economic with minimal maintenance requirement and more environmentally sustainable.

Literature Review

“Ref. [1]” O’Reilly 2010 has quoted in his study thatsanitation projects often ignore how family political relations (e.g., women’s lack of decision-making power) and variable access to resources (e.g., periodic water scarcity) impact toilet usage by all family members. “Ref. [2]” Many sanitation practitioners and researchers acknowledge that toilet interventions must move beyond building toilets, and instead focus on engaging the social and economic factors that will lead to toilet adoption. Scholars have highlighted that toilet adoption comes from providing the right kinds of toilet designs (Devine 2010), “Ref. [3]” community involvement (Kar and chambers 2008), “Ref. [4]” involvement of the state (Black and Fawcett, 2008), “Ref. [5]” finding locally specific solutions (Waterkeyn and Cairncross, 2005) and “Ref. [6], Ref. [7]” understanding people’s ideas and values around sanitation (Rheinlander et al., 2010;Drangert and Bahadar, 2011. “Ref. [8], Ref. [9]” The work of Robinson (2007) and Joshi et al. (2011) indicated that communities, even poor communities, know already about good hygiene behavior but lack the means and incentives to build or use facilities.

In many low-income communities installation of a sewerage system is unfeasible as it requires significant capital investment and a piped water supply. Therefore, on-site sanitation technologies such as pit latrines and pour-flush toilets, with disposal to a leach pit or septic tank are often the most appropriate solution. In fact, it was estimated that 1.77 billion people worldwide use pit latrines as their principal means of sanitation. However, on-site sanitation allows the focused leaching of high loads of human excreta directly into the subsurface within the built-up area. "Ref. [10]" On the other hand, open defecation generally results in excreta spread diffusely across open areas. Therefore, on-site sanitation may pose a greater threat to nearby groundwater-derived potable supplies through the introduction of enteric pathogens or elevated concentrations of nitrate (Dzwairo et al., 2006).
"Ref. [11]" In a study about about composting, the factors affecting the process of composting include water content, temperature, carbon to nitrogen ratio, pH, particle size, porosity, oxygen concentration. These parameters depend on the formulation of the compost mix. Composting based sanitation systems are known as composting toilets, dry toilets, bio-toilets or waterless toilets (Del Porto and Steinfeld, 2000).

Materials and Methodology

Study Area

A simple random sampling approach was adopted during survey. The survey covered approximately 75-80% of household in each village. Each household was visited door to door and the questions were asked to them and the respective responses were noted down. Three villages from each state were surveyed. The details of villages is mentioned in the table below.

Table 1. Details of Villages

	Village Name	GP Name	Block Name	District	Approx. No. of Households
Bihar	Guriyama	Itma	Mohanpur	Gaya	148
	Ghosta	Ghosta	Madanpur	Aurangabad	100
	Kazichak	Chand chaura	Chandauti	Gaya	93
Karnataka	Aldakatti	Aldakatti	Aldakatti	Haveri	200
	Dodanalli	Dodanalli	Sirsi	Uttara Kannada	63
	Sulla	Sulla	Sulla	Dharwad	1356
T.N	Kurumbakadu	Rethinakottai	Aranthangi	Pudukottai	40
	Vellayapuram	Vellayapuram	Aruppukottai	Virudhunagar	321
	Konnerikuppam	Kadhirempatti	Tiruppatur	Vellore	120

Height to Age Relationship

Height is an important marker of human capital. Children who are able to grow upto their height potential are also able to develop towards their cognitive and other human capital potential (Case and Paxon, 2008). In developing countries such as India especially where fulfilling basic human needs such as food, cloth and shelter is still a major concern, not much heed is paid in improving sanitary environment which is one of the largest threats to early-life growth. Much research and survey has been carried out to analyse the impact of sanitation and practices such as open defecation on growth of children. And it has been observed that children growth is stunted in regions with poor sanitation. Hence, we can say that height of children is an indicator of sanitary environment of a particular place. The height of children against their respective ages was plotted on z-score standard chart prescribed WHO to find out the z-score.

Sampling and Analysis

Majority of Indian population resides in rural area. Initially to begin with the survey, three villages from different parts of the three states were chosen. Generally questions were asked from 2 to 3 members per household. While in some cases a group of residents were asked question instead of individual interview. Responses from both male and female member were taken simultaneously. If any child (0-5 years of age) was present in the house, his/her height was also measured and noted. Apart from this, village mukhiya/sarpanchwas also interviewed regarding the same. More information regarding various activities such as construction of new latrine etc. was acquired by visiting gram panchayat office. Village anganwadi centre was also consulted for tabling height of children below five years of age. The Gram Panchayat office was visited to have a brief knowledge about the proceedings and existing policy. Having interacted with officials present there to know the existing condition of village, various demographic data were incurred like population of the villages, various schemes sanctioned till now, toilets built, amount sanctioned, literacy rate, schools and colleges in nearby vicinity etc. The documented records of recently built toilets in villages and how co-operative are the officials of panchayat in sanctioning amount to construct subsidized toilets was acquired. Women also spoke about the problems they incur in daily activities; how difficult it is for them to defecate in open. They also had to carry water from distant away for drinking purpose. The solid waste dumped in

the vicinity of the house also caused foul smell for some period of time. People from different sections of village were interviewed and tried to understand their lifestyle and everyday work. We went and checked into the nearby schools and anganwadi that how interested are the children towards education. The teachers were asked if there was any epidemics spread and do they have awareness regarding the same.

Results

Z-SCORE

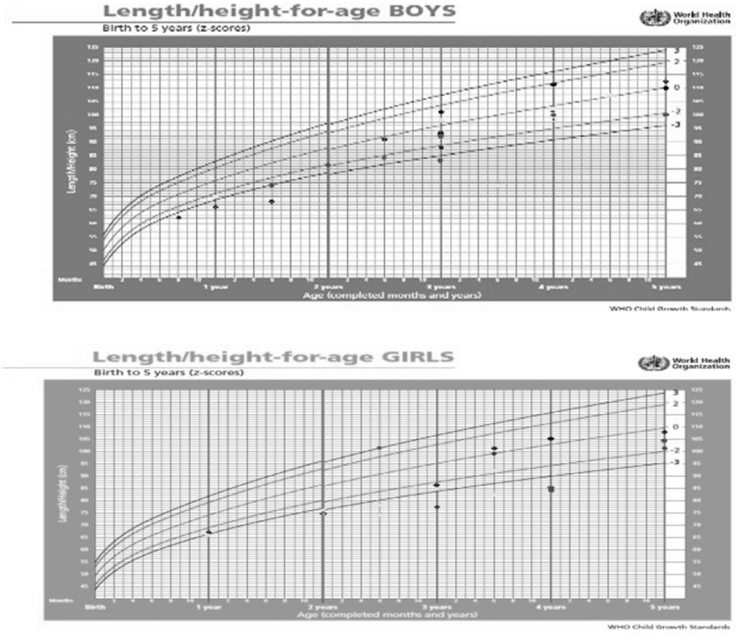

Figure 1. Average z-score observed in Bihar among boys and girls respectively

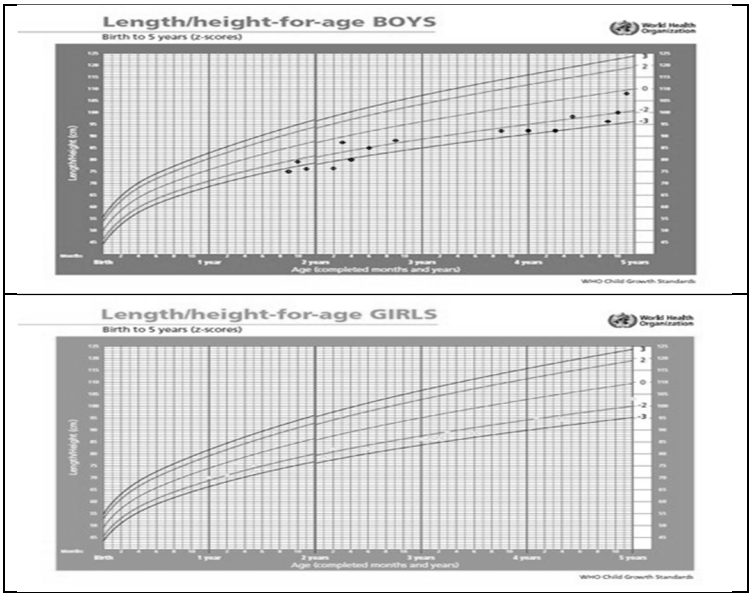

Figure 2. Average z-score observed in Karnataka among boys and girls respectively

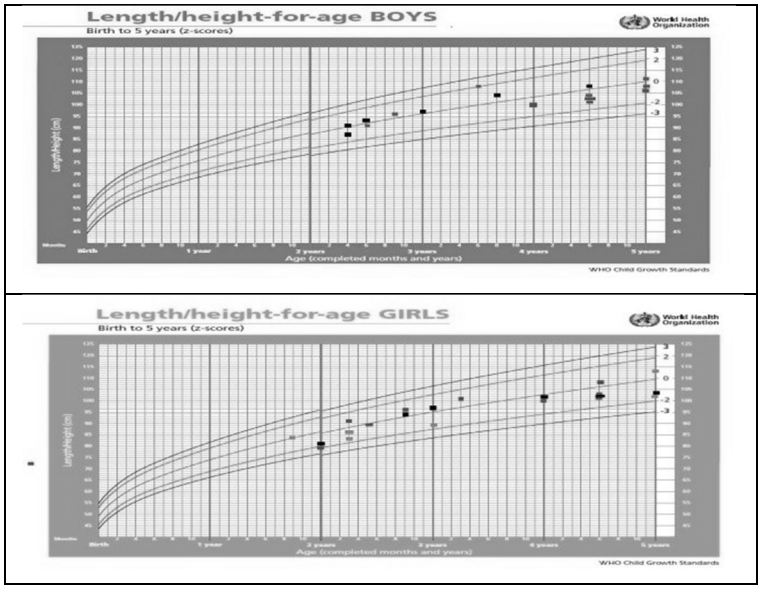

Figure 3. Average z-score observed in Tamilnadu among boys and girls respectively

Table 2. Questionnaire responses and their analysis of various villages

		BIHAR	KARNATAKA	TAMIL NADU
Drinking Water	Main source of drinking water	Ground Water	Common borewell/openwell/water cans	Ground Water / Purchasing filtered water
	Method for tapping drinking water	Hand-pump/ Motor-pump/ well	Motor pumps/ water cans/ openwells.	Hand Pump
	Depth of GWT	12m - 20m	10m-30m	10-15m
	Taste	Not detectable	Not detectable	Not detectable
	Odour	Not detectable	Not detectable	Not detectable
	Turbidity	No visible turbidity	No visible turbidity	No visible turbidity
	Hardness	Soft	Soft/Hard	Soft
	History of any disease	No	No	No
	Pretreatment	No/ occasional boiling for use of infants	No/ occasional boiling for use of infants	No/ occasional boiling for use of infants
Toilet Facilities	% age Household with toilet	30-40	50-60	30-40
	Public/Community toilet	No	No/ if yes they are non-functional	Yes but not in working condition
	Other means of toilet	Open Defecation	Open Defecation	Open Defecation
	Types of Toilet	Squatting pan with pour/automatic flush	Squatting pan with pour/automatic flush	Squatting pan with pour/automatic flush
	Drainage Facility	Soak Pit	Soak Pit	Soak Pit
	Acceptability for new toilet construction	Low to moderate	Low to moderate	Low to moderate
	Reason for not constructing toilet	Construction and maintenance cost,Space constraint,Unawareness, Habituated to OD and Migration to town and cites	No willingness to use/ Unawareness/construction and maintenance cost/ uneven distribution of land/ space constraint	Money, space constraint, and lack of awareness and knowledge.
Waste (Grey) Water	Disposal of grey water	In backyard of houses or into ponds and ditches through sewers	Infront of the houses/backyard of the house/To plants/ponds or ditches through sewers	In backyard of houses or ditches through sewers
	Condition of sewer and drains	Sewers are mostly clogged because of silting and dumping of trash. Drains –	Sewers are mostly clogged because of silting and dumping of trash	Sewers – mostly clogged because of silting and dumping of trash

		in dry condition filled with solid wastes.		Drains – in dry condition filled with solid wastes.
	Grey water related concerns and problems	Pollution of ponds, stagnation leads to rise of mosquitoes and other disease vectors. Backflow and inundation during rainy seasons	Stagnation infront of the house leads to rise of mosquitos and other unhygiene condition. Pollution of ponds, clogging of sewers.	Pollution of ponds, stagnation leads to rise of mosquitoes and other disease vectors. Backflow and inundation during rainy seasons
Solid Waste Management	Availability of trash bins	No	No	No
	Dumping site	In ditches or self-made dumping sites	In ditches or self-made dumping sites nearby houses	In ditches or self-made dumping sites
	Cleaning frequency and method of cleaning	Unknown Kitchen waste dumped with cow dung for making manure Burning of rubbish	Once in a fortnight or once in a month. Kitchen wastes dumped with cowdung for manure. Burning of rubbish.	Unknown Kitchen waste dumped with cow dung for making manure. Burning of rubbish or collected by GP
	Other application	Cow dung cakes are used as fuel for cooking	Cow dung cakes are used as fuel for cooking and also sold if available in large quantity	Cow dung cakes are used as fuel for cooking
	Nuisance	Clogging of sewers, burning of trash causes pollution, fly and odour problem.	Clogging of sewers, fly and odour problems. Excessive burning of wastes causes pollution.	Clogging of sewers, burning of trash causes pollution, fly and odour problem.
Z-Score (0-5yr)	-3≤ (extreme malnutrition)–M	24%	33%	0%
	-3>-<-2 (moderate malnutrition)-M	20%	40%	0%
	-2≥ (normal)-M	56%	27%	100%
	-3≤ (extreme malnutrition)-FM	48%	0%	0%
	-3>-<-2 (moderate malnutrition)-FM	14%	37%	0%
	-2≥ (normal)-FM	38%	63%	100%

Table 3.Potential Solutions suggested and technical validations

	Major Concerns	Solution Suggested	Validations
Bihar	Unhygienic condition of hand-pumps	Repairing and disinfection borewells and hand pumps. Providing sanitary seal and well apron.	Hand pumps are widely used in villages. Many wells were found in unhygienic condition making it prone to water contamination.
	Clogging of sewers	Removing garbage and silt from sewers. Flushing and cleaning using High Strength Calcium Hypochlorite. Providing covers to the sewers and small silting tank for individual/group of house.	Sewers are essential for proper functioning of a central treatment facility. The village sewers were in mostly clogged and stagnant which leads to flies and mosquitoes nuisance.
	Discharge of waste water(grey water)	Providing a centralized collection system. Construction of Oxidation Pond and percolation pond.	Oxidation pond is low construction and maintenance setup. It's ideal for small community, its effluent doesn't need disinfection and villages have less space constraint than urban areas.
	Open defecation	Repairing of existing toilets Construction of new individual/public or community toilet.	OD leads to spread of diseases such as diarrhea, intestinal infection, typhoid etc. It hampers in child growth and poses threat to women security.
	Solid waste nuisance	Creating awareness regarding various solid waste and their hazards. Devising a locally self-maintained solid waste management scheme.	Mindless dumping of solid wastes has led to clogging of sewers and unhygienic condition in and around village and its water bodies. Villagers have no less awareness regarding their ill effects and it can be beneficially handled.
K	Unhygienic condition of	Repairing and disinfection borewells and	Many wells were found in non-hygienic condition

	hand-pumps	hand pumps.	making it water contaminated.
	Clogging of sewers	Removing garbage and silt from sewers. Providing covers to the sewers and small silting tank for individual/group of house.	Sewers are essential for proper functioning of a central treatment facility. The village sewers were in mostly clogged and stagnant which leads to flies and mosquitoes nuisance.
	Discharge of waste water(grey water)	Providing a centralized collection system. Construction of Oxidation Pond and percolation pond. Also providing phytorid technology for highly populated village.	Oxidation pond is low construction and maintenance setup. Its ideal for small community whereas for large population phytorid is efficient technology.
	Open defecation	Repairing of existing toilets Construction of new individual/public or community toilet.	OD leads to spread of diseases such as diarrhea, intestinal infection, typhoid etc. It hampers in child growth and poses threat to women security
	Solid waste nuisance	Creating awareness regarding various solid waste and their hazards. Devising a locally self-maintained solid waste management scheme. Providing different coloured sanitary bins.	Vermicomposting can be carried out which is cost efficient as well as multi-functional.
Tamil Nadu	Unhygienic condition of hand-pumps	Repairing and disinfection borewells and hand pumps. Providing sanitary seal and well apron	Hand pumps are widely used in villages. Many wells were found in unhygienic condition making it prone to water contamination.
	Clogging of sewers	Removing garbage and silt from sewers. Flushing and cleaning using HSCH. Providing covers to the sewers and small silting tank for individual/group of house.	Sewers are essential for proper functioning of a central treatment facility. The village sewers were in mostly clogged and stagnant which leads to flies and mosquitoes nuisance.
	Discharge of waste water(grey water)	Providing a centralized collection system. Construction of Phytorid Bed and percolation pond.	It is suitable for all rural areas. No need of skilled operator. It is very cost effective. No mechanical or electrical equipment, hence, maintenance cost is very less. There is no reject or by-products and no odour while treating the sewage.
	Open defecation	Repairing of existing toilets Construction of new individual/public or community toilet.	OD leads to spread of diseases such as diarrhea, intestinal infection, typhoid etc. It hampers in child growth and poses threat to women security.
	Solid waste nuisance	Creating awareness regarding various solid waste and their hazards. Devising a locally self-maintained solid waste management scheme.	Mindless dumping of solid wastes has led to clogging of sewers and unhygienic condition in and around village and its water bodies. Villagers have no less awareness regarding their ill effects and it can be beneficially handled.

Table 4: Treatment schemes for different villages

Village/ Waste water	Grey Water	Black Water
Guriyama (BR1)	OP	SP
Ghosta (BR2)	OP	SP
Kazichak (BR3)	OP	SP
Aladakatti (KN 1)	PS	SP
Dodnalli (KN 2)	OP	SP
Sulla (KN 3)	PS	SP
Kurumbakkadu (TN 1)	PS	SP
Velleyapuram (TN 2)	PS	SP
Konnerikuppam (TN 3)	PS	SP

OP - Oxidation Pond; PS - Phytorid System
STP - Sewage treatment plant; SP – Soakpit

Oxidation Pond

Suitability and advantages

1. The waste water in the villages eventually end up in small ditches and ponds which can be converted and designed to form an engineered oxidation pond.

2. The region lies near the tropic of cancer and receives plenty of sunshine with sparse population which is ideal for operation of an oxidation pond
3. BOD, faecal coliform and helminth removal is higher than by other treatment methods such as ASP, RBC etc.
4. Low cost, Low maintenance and easy to construct.
5. Effluent doesn't require disinfection.

Table 5: Sample design values for a typical OP in villages of Bihar

Parameter	Values
Population	550
Water demand	100 lpcd
Sewage discharge	44000 *l*/d
Peaking factor	1.5
Design discharge	66000 *l*/d
Latitude	24^{o}
organic loading	225 kg/hac/day
Influent BOD	150 mg/*l*
Surface area	1 hac
units	2 @ 0.5 hac each
Depth	0.8 m + 0.2 m free board
Detention time	2 weeks
L/B ratio	2

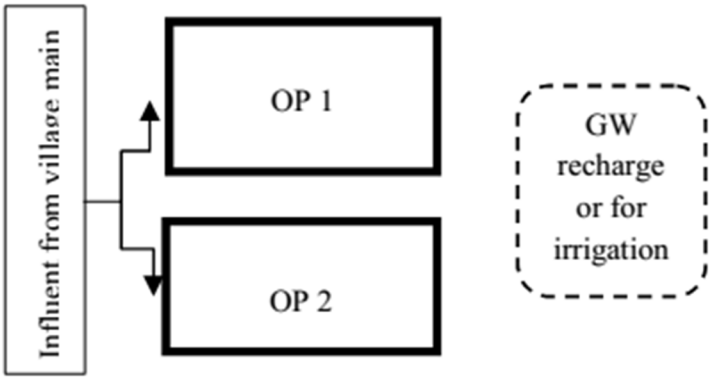

Figure 4: Schematic layout of OP

Phytorid System

Suitability and advantages

1. It is an indigenous technology with performance BOD removal efficiency of 80-95% especially developed to meet the requirements of small communities and villages in India.
2. The village KN 1, KN 3, TN 1, TN 2 and TN 3 have small population and hence construction of any other conventional treatment unit might not be feasible.
3. The effluent from phytorid system can be used for irrigation or ground water recharge as the technology genereates negligible sludge.
4. It doesn't affect the local eco-system and is aesthetically pleasing.
5. There is no odour problem and fly nuisance.
6. Very economical to construct as equipment cost is least where the waste water flows through gravity and is also energy efficient.

Table 6: Sample design values for a typical Phytorid system

Parameters	Values	
Population	800	
Water demand	100 lpcd	
Sewage discharge	64000 *l*/d	
Factor of safety	1.5	
Design discharge	100 m^3/d	
	Dia/Dimension	Depth
Sewage collection tank	10 m	1.5 m
Settling tank	6 m x 1.5 m	1.5 m
Phytorid bed	10 m x 20m	0.6 m
Storage tank	10 m	1.5 m

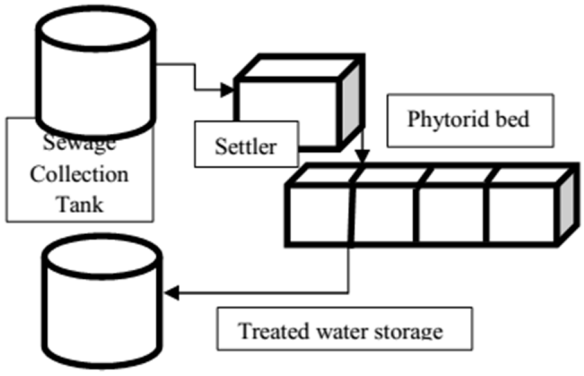

Figure 5: Schematic layout of PS

SOAK PIT

Suitability and advantages

1. Ground Water table in all the villages is fairly low (>10 m), hence deep excavated soak pits can be provided without risk of any ground water contamination.
2. Cost of construction is very less and it can be easily constructed with the help of locally available materials.
3. No or negligible maintenance is required and useful life of deep soak pit is round 10-15 years.
4. These areas are not prone to regular flooding or very cold temperature, hence ideal for soak pits.
5. Houses with already built toilets are using soak pit for waste water disposal without any difficulties.

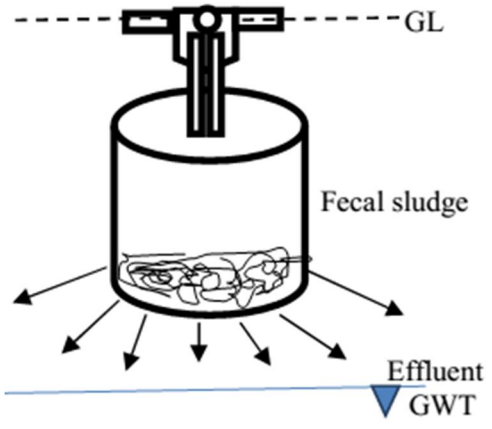

Figure 6: A Soak pit (single pit)

Conclusion

- The chief finding was that the most of rural India still practises open defecation to a major extent. Main reason being generation long habit, difficulties in maintenance, migration to urban areas and lack of will.
- Average z-score comparison for boys and girls depicts highest case of mal-nutrition among children in Bihar followed by Karnataka. No case of malnutrition was observed among children in Tamil Nadu, though sample size was relatively small but gives an indication of overall child health and hygiene in these states
- This finding suggests that the government initiatives are slightly to be modified to meet demands of those under below poverty line.
- More impetus should be given to indigenous technologies rather than importing new one.

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