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A REVIEW ON SUSTAINABLE AND COST-EFFECTIVE WASTEWATER TREATMENT SYSTEMS FOR RURAL AND PERI-URBAN COMMUNITIES UP TO 10,000 PE

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Abstract - *This study has been undertaken to develop Sustainable Waste Water treatment. Most of the river basins in India and elsewhere are closing or closed and experiencing moderate to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. Current and future fresh water demand could be met by enhancing water use efficiency and demand management. An estimated 38354 million liters per day (MLD) sewage is generated in major cities of India, but the sewage treatment capacity is only of 11786 MLD. Similarly, only 60% of industrial waste water, mostly large scale industries, is treated. . The scope of this paper is to provide some easy-to-understand guidance on taking decisions in wastewater management in settlements and towns (waste stabilization ponds, HSSF_CW, DEWATS) with up to 10,000 population equivalents (PE).*

Key Words: sustainable1, cost effective, waste stabilization 3, DEWATS 4, HASSF-CW 5, MLD6

1. INTRODUCTION

Sanitation including wastewater collection and treatment systems for small communities are a matter of concern to every country. The number of treatment plants in rural areas is very high but they are small in size. They are commonly subjected to high seasonal and even daily variations. When improving an existing and/or designing a new sanitation system, sustainability criteria related to the following aspects should be considered: Health and hygiene (2) Environment and natural resources (3) Technology and operation (4) Financial and economic (5) Socio-cultural and institutional aspects

1.1 Wastewater production and treatment:

As per CPHEEO estimates about 70-80% of total water supplied for domestic use gets generated as wastewater. The per capita wastewater generation by the class-I cities and class-II towns, representing 72% of urban population in India, has been estimated to be around 98 lpcd while that from the National Capital Territory-Delhi alone (discharging 3,663 mld of wastewaters, 61% of which is treated) is over 220 lpcd (CPCB, 1999).As per CPCB estimates, the total wastewater generation from Class I cities (498) and Class II (410) towns in the country is around 35,558 and 2,696 MLD respectively. While, the installed sewage treatment capacity is just 11,553 and 233 MLD, respectively (Figure 1) thereby leading to a gap of 26,468 MLD in sewage treatment capacity.

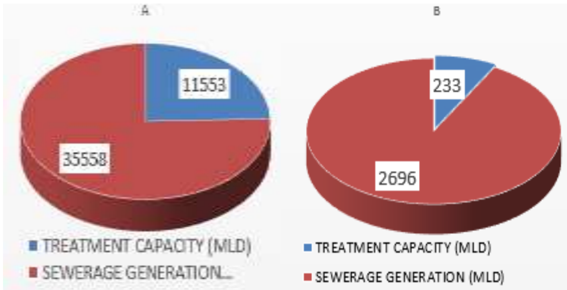

Figure 1: Sewage generation and treatment capacity in 498 Class I cities and 410 class II towns in India. (CPCB, 2009)

1.2 Waste water treatment process:

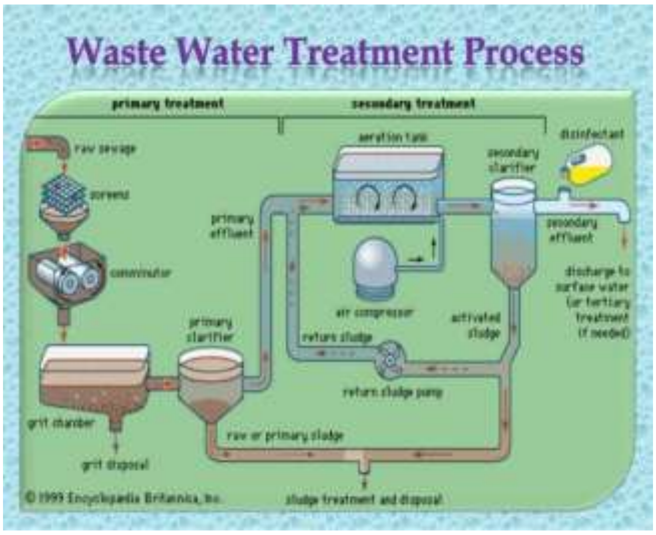

Figure 2: waste water Treatment Process

1.3 Wastewater Collection:

Type of collection system	Treatment options:
A)Centralized system, combined sewerage	Intensive wastewater system (e.g. activated sludge), extensive wastewater treatment (e.g pond)
B)Combined on-site and centralized system	Collection and pre-treatment of wastewater on-site in septic tanks combined with settled or simplified sewerage and intensive or extensive secondary treatment
C)Semi-centralized system	Number of smaller, semi-centralized treatment plants serve one agglomeration
D)Decentralized on-site system (no sewerage) household based	Intensive, extensive and innovative wastewater system possible

2. Different Types of Waste Water Treatment Systems Used In India Peri Urban And Rural Area

2.1 WASTE STABILIZATION PONDS

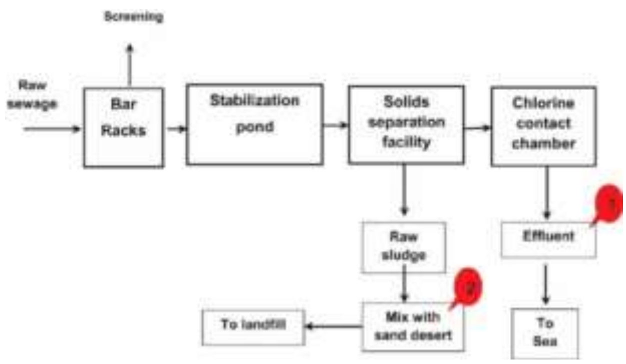

Figure 3: Process of treatment in waste stabilization ponds

In a first pond (anaerobic pond), solids and settleable organics settles to the bottom forming a sludge, which is, digested anaerobic by microorganism. In a second pond (facultative pond), algae growing on the surface provide the water with oxygen leading to both anaerobic digestion and aerobic oxidation of the organic pollutants. Due to the algal activity, pH rises leading to inactivation of some pathogens and volatilisation of ammonia. The last ponds serves for the retention of stabilised solids and the inactivation of pathogenic microorganisms via heating rise of pH and solar disinfection.in this pond 90% BOD and TSS; high pathogen reduction and relatively high removal of ammonia and phosphorus; Total HRT: 20 to 60 days. Its operation and maintenance is as shown on figure 3.

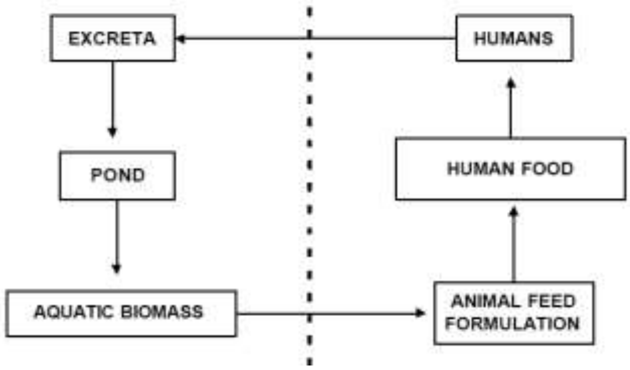

Figure 4: Operation and Maintenance of waste stabilization ponds

This method has been successfully implemented in city of Mathura in Uttar Pradesh. A detailed case study has been made on this implementation .Figure 5 represents an overview of the implementation of the project.

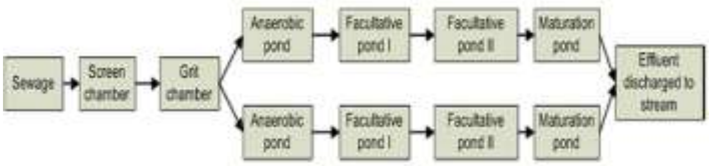

Figure 5: Waste stabilization pond in Mathura City

The results of case study done on city of mathura are as follows

Intended benefit/purpose	Fulfilled yes/no	comments
Treatment of waste water according to	not available	No monitoring results are available

indian standards		
Reuse of treated waste water	Not applicable	Reuse is not possible as no agriculture is practiced
No energy requirements	yes	Treatment plant does not need any enregy but some energy is required for transporting waste water to the plant
No skills required for operation and management	yes	The operations are from local community need

2.2 HORIZONTAL SUBSURFACE FLOW CONSTRUCTED WET LANDS [HSSF-CW]

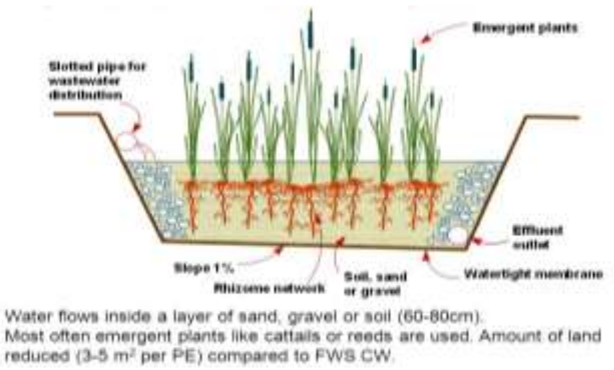

Figure 6: Process of treatment of waste by HSSF-CW method

Pre-treated grey or black water flows continuously and horizontally through a planted filter bed. Plants provide appropriate environments for microbiological attachment, growths and transfer of oxygen to the root zone. Organic matter and suspended solids are removed by filtration and microbiological degradation in aerobic anoxic and anaerobic conditions (MOREL and DIENER 2006).

BOD = 80 to 90 %; TSS = 80 to 95 %; TN = 15 to 40 %; TP = 30 to 45 %; FC $\leq$ 2 to 3 log; LAS > 90 %.Its operation and maintenance is emptying of pre-settled sludge, removal of unwanted vegetation, cleaning of inlet/outlet systems. This method has been successfully implemented in Katchpura slum, city of Agra, state of Uttar Pradesh. A detailed case study has been made on this implementation .Figure 7 represents an overview of the implementation of the project.

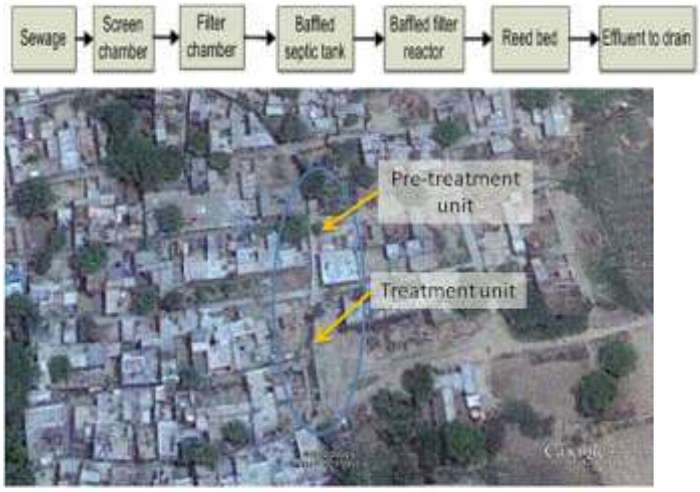

Figure 7: HSSF-CW in Katchpura slum, city of Agra

The results of case study done on city of Katchpura slum, city are as follows:

Intended benefit/purpose	Fulfilled yes/no	comments
Treatment of waste water according to indian standards	yes	
Reuse of treated waste water	yes	Treated water water is reused for gardening
No energy requirements	yes	no energy is required for

		treatment process
No skills required for operation and management	partly	operators recieve special training from NGO
Improvement of environmental situation	yes	environmental situation has been improved

2.3 Decentralized Waste Surface level picture of a Inside a DEWATS

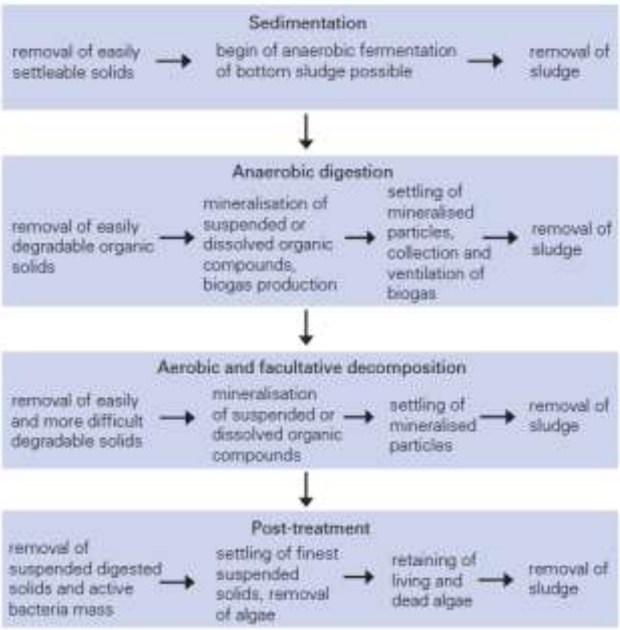

Figure 8: Process of treatment of waste by DEWATS method

This process has 80% Lower O&M costs than comparable technologies. No electricity is required. No chemicals added .Minimal maintenance Integrated with landscaping. Produces biogas and nutrient-rich water that are re-usable. Capacity 1,000 - 1 Million Liters per day (1-1,000 KLPD)..This method has been successfully implemented in Ullalu Upanagara, Bangalore, India.A detailed case study has been made on this implementation .Figure 9 represents an overview of the implementation of the project.

Figure 9-DEWATS in Ullalu Upanagara, Bangalore

Grama Swaraj Samithi (GSS), a local NGO, has been working in Ullalu Upanagara in the field of preventive health care since the 1990s. Since 2001, GSS has been promoting Community-Based Sanitation within the community. In close collaboration with the residents and local authorities, the construction of two sanitation centers was decided on. The implementation process was carried out as a pilot programmed, to test the application of participatory, administrative and technical instruments of the Community-Based Sanitation programmed for the area.

The participatory planning process resulted in the following layout of the overall complex:

• 2 separate sections – one for women, one for men
• 11 toilets and 1 bathing unit per section
• 12 laundry facilities – 8 for women, 4 for men
• fresh-water consumption:
– 11.5m^3 per day
– water connection and supply assured by Zilla Panchayat
- use of rainwater harvesting tank during the rainy season
• source and quantity of effluent:
– toilet and bathing wastewater: 7.5m^3 per day
– laundry wastewater: 4.0m^3 per day
• low maintenance:
– no piped water in toilets and bathing units
– minimum electrical devices
• security
– female and male sections visibly separated
– entrance area for control and collection of service charges

A comparative study of all the three process and their respective deeper case studies have been done in this paper.Figure 10 shows the comparative study of all the three processes

WSP	HSSF	DEWATS
Total area required is 400 sq.yd	Total area required is 109.86 sq.yd	Total area required is 0.5sq.m per cubic meter of water total area required is 95
90% BOD and TSS; high pathogen reduction and relatively high removal of ammonia and phosphorus; Total HRT: 20 to 60 days	BOD = 80 to 90 %; TSS = 80 to 95 %; TN = 15 to 40 %; TP = 30 to 45 %; FC ≤ 2 to 3 log; LAS > 90 %	wastewater treated 90% TSS = 95 %; TN = 40 %; TP = 30 to 45 %
It takes to treat: 20 to 60 days.Large surface areas required and needs to be protected to prevent contact with human or animals	it takes 30 days to treat Permanent space required; risk of clogging if wastewater is not well pre-treated, high quality filter material is not always available and expensive; expertise required for design, construction and monitoring	It takes 2 weeks treatment
Capacity/Adequacy Almost all wastewaters (including heavily loaded industrial wastewater) can be treated, but as higher the organic load, as higher the required surface. In the case of high salt content, the use of the water for irrigation is not recommended	It can be applied for single households or small communities as a secondary or tertiary treatment facility of grey- or blackwater. Effluent can be reused for irrigation or is discharged into surface water	Suitable for irrigation. Suitable for small and community level, Capacity:1,000 - 500,000 litres
The O&M of the WSP has been outsourced to a private company at a cost of 400,000 INR per year (≈5,000 EUR)1 according to the operators. The salary of the operators was reported as 32,000 INR per year	Total construction cost is land value operation and maintenance charges are 40,000 per year	Total construction cost is 18-20 lakhs,maintanace charges are operation and maintance charges 10,000 per year

Figure 10: comparative study of all the three processes of WSP, HSSF, DEWATS.

3. CONCLUSION

The results showed the overall sustainability of a wastewater treatment technology is a function of economic, environmental and social dimensions. Selection of best method and implicating that technology for rural areas and less populated areas reduces the cost as well as the

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