A Review of Package Treatment Options for Domestic Wastewater

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Abstract
Generation and acquisition of domestic wastewater is becoming a threat for health and environment in areas where sewerage network is absent. With haphazard growth of cities, existing sewerage system could be inadequate to manage generated wastewater. Therefore, it is necessary to take an overview probable management system for wastewater and to select appropriate alternative technologies so as to avoid health and environmental issues.
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Introduction:

With growing urbanization and increasing water demand, wastewater generation is increasing. Usually out of 70-80 % of total water supplied for domestic use gets generated as wastewater (CPHEEO). Normally, the domestic wastewater is expected to collect through sewerage network and treat the same at centralized sewage treatment plant. But in India domestic wastewater collection and treatment facilities are currently limited to hardly 40 % of geographical area (CPCB, 2004). The treatment methods applied are primary, secondary and tertiary. The primary treatment includes screening, grit removal and primary settling tank. Secondary treatment includes mainly biological processes such as activated sludge or trickling filter followed by secondary settling tank. (Manual on Sewage and Sewerage Treatment", 2nd edition, 1993). If necessary, tertiary treatment is provided such as activated carbon adsorption, etc. This treated wastewater is disposed off in nearby surface water bodies or applied for land irrigation.

Centralized wastewater treatment systems involve large quantities of wastewater. However, centralized collection and treatment of wastewater requires pumps, piping materials and energy, ultimately increasing the cost of the treatment system. Hence, constructing a centralized treatment system for small communities or peri-urban areas will result in burden for low income countries. Due to absence of required funding and technical assistance, untreated domestic wastewater finds direct access to water and land systems causing pollution. Therefore, it is necessary to think about adequate alternative technologies for domestic wastewater management.

Present Scenarios of Domestic Wastewater Treatment and Disposal

Nowadays, domestic wastewater is preferred to treat through on-site treatment system or Decentralised Wastewater Treatment System (DEWATS). There are several onsite wastewater treatment systems which if designed, constructed, operated and maintained properly will provide adequate treatment.

The most popularly known on-site wastewater treatment system is septic tank. Basically septic tank is sedimentation and digestion tank - consisting of one or more chambers in which sewage is held for one to three day depending upon the tank capacity. During this period the heavier suspended solids settle to the bottom of tank forming sludge. After the accumulation of sludge, digestion takes place anaerobically. Due to anaerobic digestion of sludge, gas is produced. However, there is continuous accumulation of sludge which needs periodic removal of it. The septic tank is capable of removing approximately 25-50 % of BOD (DEWATS, 1998).

The Imhoff tank is another primary treatment method but it is less common. The imhoff tank can accommodate higher flow rates and provides fresher effluent when de-sludged at designed intervals than the septic tank (DEWATS, 1998). Both systems are inexpensive and simple to operate and maintain. Many secondary treatment methods exist for on-site wastewater treatment. Most common secondary treatment is sand or media filters.

In areas with shallow, less permeable or highly permeable soils, more complicated onsite systems will be required. The conventional onsite wastewater treatment systems are not effective in removing nitrate and phosphorus compounds and reducing pathogenic organisms. As such, these systems cannot be used without further treatment and hence safe disposal. The popular septic tank system also does not serve as total treatment for domestic wastewater. The main cause of failure is partial digestion, inadequate capacity, the unsuitability of the soil and the site characteristic. The partially treated effluent flows to underground water table or nearby water bodies leading to deterioration of precious water resources. This unduly interferes with public health and reduces value of environment in general. Hence there is need to focus on innovative approaches to treat domestic wastewater, which has capability to substitute onsite treatment options such as septic tank.

Package Treatment Options for Domestic Wastewater

A few of the options discussed below will serve as better alternative for collecting, treating and disposing the domestic wastewater arising in area where conventional sewerage is not present.

The basic idea of decentralized approach is to treat wastewater by means of low-cost treatment systems one of such systems in combination of septic tank and anaerobic filter. The results from experiment on real wastewater treatment by baffled septic tank with anaerobic filter seems to be better option for wastewater treatment based on studies conducted at Vietnam. The anaerobic filters have more significant removal efficiency with dissolved organic matters rather than the solids. The data show that this system effectively treats black water, with average removal efficiency by COD 74.85 %, by BOD 71.47 % and by SS 71.14% (Anh, et al.,2002).

The below mentioned study presents an innovative way to improve the treatment efficiency of septic tank. The Improved Septic Tank, also known as Baffled Septic Tank (BAST) and one provided with Anaerobic Filter as BASTAF. The systems were developed and studied at the Centre for Environmental Engineering of Towns and Industrial areas (CEETIA), Hanoi University of Civil Engineering, Vietnam. The results of laboratory- and pilot-scale research on BAST and BASTAF systems show that at a hydraulic retention time (HRT) of 2 days, the BASTAF significantly increased the removal efficiencies in terms of BOD, COD and TSS compared with a conventional septic tank without any significant increase in construction expenses. The results indicated that a reactor combining sedimentation/equalizing chamber followed by two up-flow chambers could efficiently treat domestic wastewater. Average treatment efficiencies of 80–90% in terms of BOD, COD and TSS could be achieved. The addition of an anaerobic filtration chamber filled with charcoal or local-made recycled plastic balls could further increase removal efficiencies by 10% and prevent sludge wash out. The BASTAF system was not able to reach the strict wastewater discharge standards of Vietnam. Therefore a second study was conducted aiming at investigating post-treatment of BASTAF effluent with a vertical-flow constructed wetland. The study showed that treatment of BASTAF effluent in 2-stage vertical flow constructed wetland planted with locally available macrophytes, viz. *Typha orientalis*, *Phragmites communis*, and *Dracaena fragrans* allowed achievement of level A, Vietnamese standard for wastewater in terms of COD, BOD5, TSS, TN, NH4-N and TP (Anh, et al., 2007)

A new concept for a low-cost modified septic tank, named Up-flow Septic Tank/Baffled Reactor (USBR), was constructed and tested in a small village in Egypt. During almost one year of continuous operation and monitoring, this system was found to have very satisfactory removal results, where the average results of COD, BOD, and TSS removal efficiencies were 84%, 81%, and 89%, respectively, and the results of the experiment proved that the second compartment of Anaerobic Baffled Reactor was the main treatment unit in removing the pollutants during the start-up period and at the very early steady-state stage. However, after this period and during the steady-state operation conditions, the second compartment served as a polishing step. Also, it was observed that the USBR system was not affected by the imposed shock loads at the peak flow and organic periods. The results showed that the system is slightly influenced by the drop in the temperature. Decrease in BOD and COD removal by factor of 9% was observed, when temperature decreases from the average of 35 æ%C in summer time (for the first 127 days) to the average of 22 æ%C in winter time (between day 252 and day 280) (Sabry, 2010).

A pilot-scale setup was designed and constructed at a wastewater treatment plant in Giza, Egypt which fulfil the requirements and at the same time is simple and cost-effective. It consists of an up-flow anaerobic reactor; down-flow anaerobic packed-bed baffled reactor; a passive aeration and a biological filter system followed by a sedimentation tank. The biological filter is packed with plastic media. The system was operated at a hydraulic retention time of 24 hours in the anaerobic stages. To monitor the performance of the system, wastewater samples were collected from the influent and effluent of each treatment step along the pilot-scale setup. Available data indicated that the integration of the passive aeration and the biological filter system improved the effluent quality of the two-stage anaerobic system. The results show that the use of passive aeration after the anaerobic phases of the treatment increases the dissolved oxygen contents of the anaerobic effluent. The added oxygen will activate the aerobic attached-growth microorganisms which play the main role of wastewater treatment in the biological filter system. The treated final effluent has a quality acceptable for disposal in agricultural drains to meet with disposal standards. In addition, average overall removal efficiencies up to 85%, 69%, 88%, 91% and 89% were achieved for COD Total, COD Soluble, BOD_5, TSS and VSS, respectively (Sabry, et al., 2012).

Zero-M aims at concepts and technologies to achieve optimised close-loop usage of all water flows in small municipalities or settlements (e.g. tourism facilities) not connected to a central wastewater treatment - the Zero Outflow Municipality (Zero-M). A key idea in Zero-M is wastewater shall be treated specifically for the planned reuse purpose. All resources contained in the wastewater, namely water and nutrients, shall be reused. The aim is to introduce "low tech - high concept" solutions developed for small communities. The pilot scale plants have been installed at Technological Demonstration Centres (TDC) at four locations. The various configurations of treatment units implemented at four different locations are listed in (Table No. 1).

Sr. No.	Site Location	Treatment Combinations	Wastewater Reuse Alternatives	Reference Figure
1.	Egypt	CW, SBR, MBR	Landscaping	1
2.	Morocco	AD, SBR, MBR, CW, HRAP	Landscaping, flushing	2
3.	Tunisia	AD, MBR, CW	Flushing	3
4.	Turkey	CW, SBR, MBR, AD, UV	Flushing, Landscaping, Irrigation	4

Table No. 1: Treatment Combination Details, Source: http://www.zer0-m.org

AD = anaerobic digester– Biological wastewater treatment unit
MBR = Membrane Bio-Reactor – Biological wastewater treatment unit
HRAP = high rate algal pond
SBR = Sequential Batch Reactor - Biological wastewater treatment unit
UV = ultra violet type disinfection unit
CW = constructed wetland – low cost wastewater treatment system

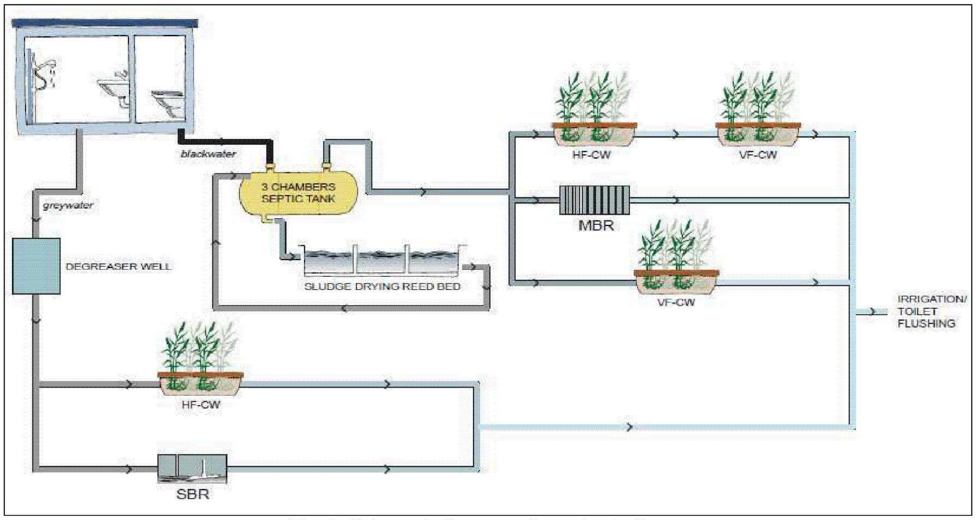

Fig. 1: Schematic Layout at Location in Egypt

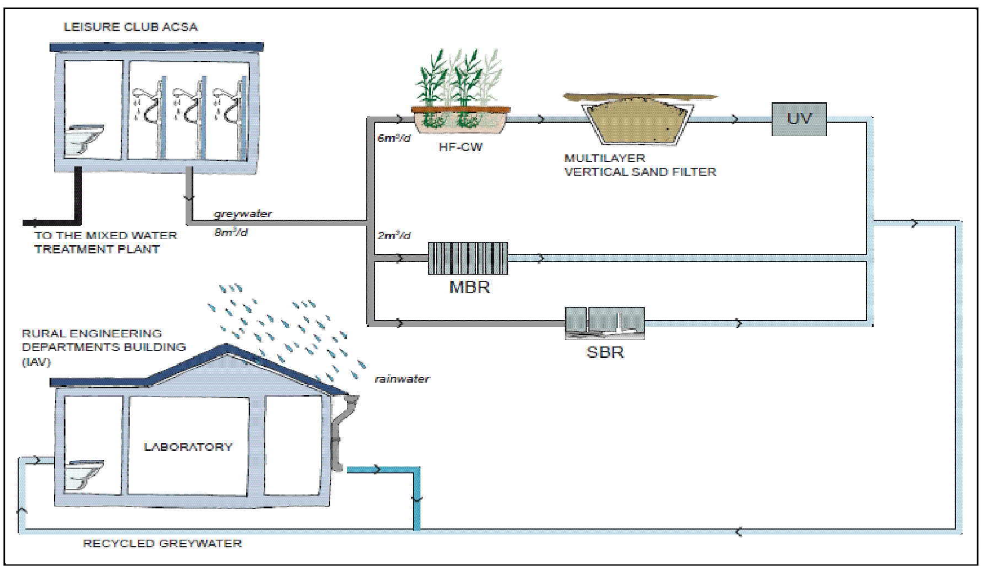

Fig. 2: Schematic Layout at Location in Morocco

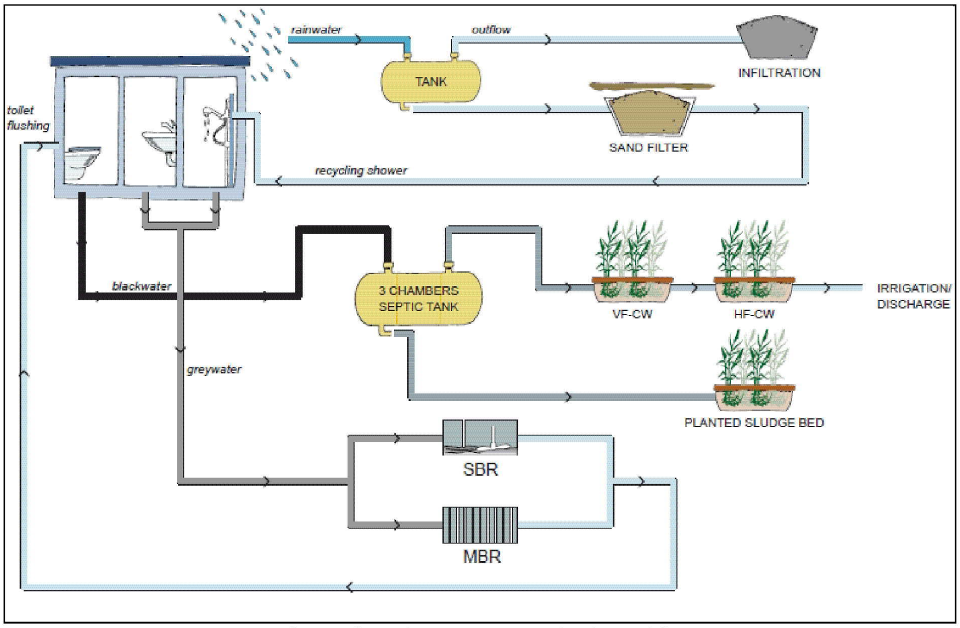

Fig.3: Schematic Layout at Location in Tunisia

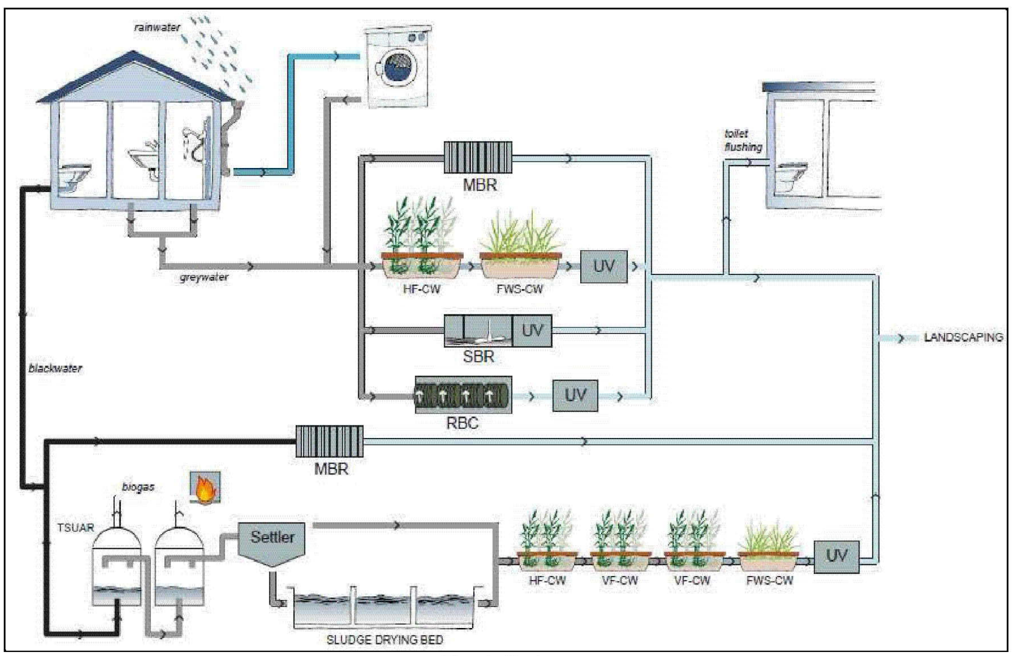

Fig. 4: Turkey

Summary

On-site treatment systems are provided to overcome the problems arising due to lack of provision of centralized wastewater collection, treatment and disposal system. The septic tank is one of the most popular on-site treatment systems but does not perform satisfactorily. It is necessary to devise alternative on-site treatment methods suitable for various locations. The alternatives discussed under the scope of this study seem to be sound however their actual performance in Indian conditions will strengthen the objectives of this study. In India at some places conventional on-site treatment options are used but they are not providing full treatment options and do not have potential to give the effluent quality suitable to reuse. Modified treatment options need to be used with minimum energy and cost intensive material.

The baffled septic tank followed by anaerobic filter, Up-flow Septic Tank/Baffled Reactor (USBR) followed by constructed wetland system are better treatment options. Though anaerobic system provides good results, the aerobic treatment is required to remove odor problems hence passive aeration needs to be incorporated. Constructed wetland as polishing treatment could be applied where the land is available. This treatment gives better quality effluent suitable for flushing and gardening purpose. Based on various studies reviewed here the need is emphasized to study various alternatives meeting with site requirements instead of relying on black box of septic tank.

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