ON-SITE SANITATION TECHNOLOGIES FOR COLD AND TEMPERATE CLIMATES

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Summary

On-site wastewater management systems are preferred by urban planners when the communities to be served are sparsely populated. A variety of on-site wastewater management technologies are available. Not all of them are suitable for all geographic locations and climatic conditions. In temperate and cold climates, performance of on-site systems are affected due to slow microbial waste degrading activities, and frosty soil conditions. Therefore, on-site wastewater management systems for cold and temperate regions need to consider the peculiar discharge conditions. Several on-site treatment and disposal technologies have been developed that specifically cater to the conditions of these regions. They can be broadly classified into soil absorption systems and treatment systems. In cold and temperate climates, the soil absorption systems have to be designed so that they can also impart treatment to wastewater to improve the quality, and to effectively dissipate during cold periods. On-site treatment technologies also have been developed for geographic locations where soil absorption systems may not function satisfactorily.

1. Introduction

The concept of on-site sanitation involves either full or partial treatment of sewage at the point of generation. On-site technologies are generally preferred by urban planners when the communities to be served are sparsely populated thereby making reticulated sewage collection an expensive affair. On-site sanitation systems are not merely cheap alternatives to conventional sewer systems because poorly planned and poorly maintained on-site systems will only increase the potential for health hazards and become diffuse pollution sources that contaminate land, groundwater and streams. A variety of technologies are available for on-site sanitation. Not all of them are suitable for all geographic locations and circumstances. The climatic conditions of a region have bearings on all stages of technology selection, planning, design, construction, and operation and maintenance. Hence, planning for on-site systems in regions with cold and temperate climates require various additional considerations that may not normally be required for warm and tropical climates since practically all aspects of wastewater collection, treatment and disposal are affected by temperature. This article describes some of such on-site disposal systems that are more suitable under cold and temperate conditions.

2. Problems of On-site Sanitation Systems in Cold and Temperate Climates

In temperate and cold climatic regions of developed countries, in order to prevent disruption of wastewater house connections, households let hot water run for long periods during winter. For the same reason, public sewers are insulated and encased. Major problems that affect the performance of on-site systems in cold climates are:

(i) Inadequate degradation and removal of organics and nutrients from sewage in septic tanks due to biological inactivity; for example, in tropical climates, waste stabilization ponds are designed for a hydraulic retention time of 20–30 days, whereas they are designed for 180 days in cold and temperate climates. The reason is that, during the winter period, the biological processes in the ponds practically stop and hence no discharges from these ponds are allowed. They act merely as storage ponds during this period.

(ii) Failure of soil absorption systems that are adopted for disposal of overflows from septic tanks, due to frosty soil conditions.

3. Appropriate On-site Sanitation Systems

On-site sanitation systems for cold and temperate regions therefore, need to consider the peculiar discharge conditions and should be able to provide adequate levels of treatment. Developments in this direction are mainly towards planning and design of more efficient soil absorption systems. In conventional soil absorption systems, the overflow from septic tanks flows into sand/gravel filled trenches through open-jointed or perforated pipes to soak and seep to eventually reach groundwater and surface water or to evaporate. Tropical climate designs for such soil absorption systems adequately consider the level of treatment to be achieved before the effluent reaches the ultimate environmental sink. In cold and temperate climates, the soil absorption systems have to be designed so that they can act as secondary treatment systems to improve the quality of wastewater as also to dissipate it effectively to achieve adequate dispersal during cold periods. Some of the prominent soil absorption systems that meet the above criteria are:

- mound absorption system;
- ‘at-grade’ system;
- low-pressure pipe system;
- ‘in-drain’ system;
- contour trench system.

There are also a few treatment systems developed for overflow from on-site sanitation systems. They include,

- recirculating sand filter with rock storage filter;
- the ‘ruck’ system;
- peat treatment system.

4. Soil Absorption Systems

4.6. Mound Absorption System

The mound absorption system, as the name implies, has a mound of sandy soil over and under the sand/gravel fill through which septic tank effluent is uniformly distributed by perforated infiltration pipes (Figure 1). This system is also called ‘elevated tile system’, ‘evapotranspiration mound’, ‘sand mound’ or ‘above-ground absorption system’. The fill is normally comprised of textured sand, sandy loams, soil mixtures, bottom ash or slag from boilers.

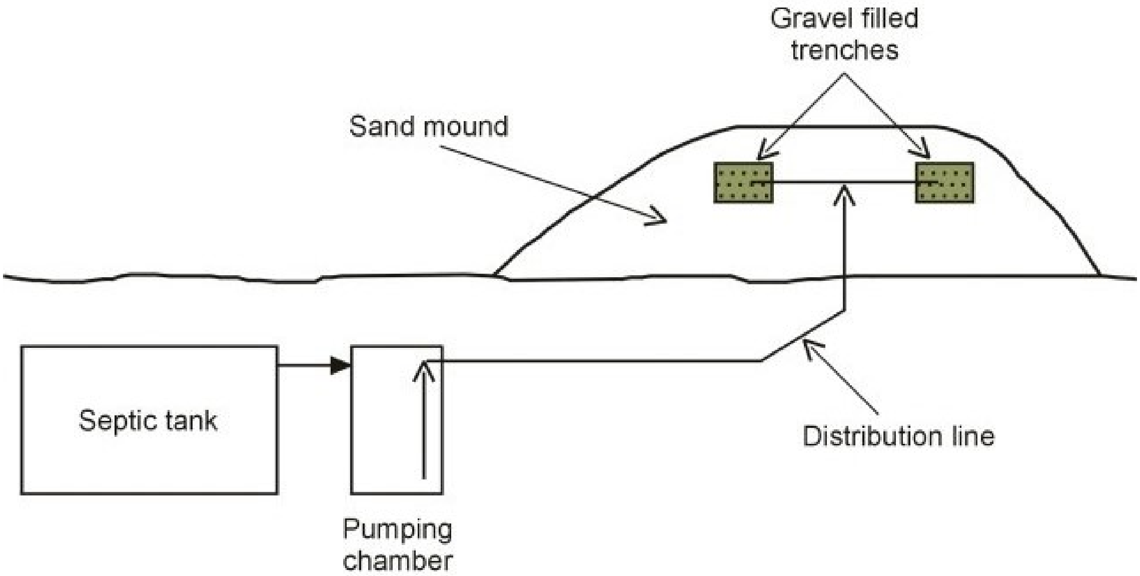

Figure 1. Mound absorption system

At the upper zone of the mound (the gravel/sand fill), unsaturated flow is established by the growth of biomass and some treatment occurs in this layer. This layer also functions to distribute the effluent over the entire base area of the mound so that it can infiltrate to more permeable topsoil, upon which the mound is constructed. The topsoil, in turn, further treats the effluent and distributes it over a still wider area before it enters the subsoil. Vegetative growths on the mound help evaporation of wastewater and also reduce visual impact of the mound.

Mounds are one of the most widely used alternatives for limiting soil conditions. However, they have been reported to have a high malfunctioning rate primarily due to improper design and installation.

Advantages

- This system can be used in areas where problematic conditions exist for common below-ground level soil absorption systems.
- Appropriate for locations with high groundwater table, low permeability soils or inadequate soil depths.
- Effectively removes organics and pathogens and substantially improves effluent quality.
- Construction and maintenance costs are low.

Disadvantages

- This system requires trained construction personnel to properly install the system to avoid failures.
- Occupies more space than the conventional sub-surface disposal system and reduces the land-use amenities of the property.
- Could create aesthetic problems.
- Often requires pumping to distribute effluent through the mound and hence energy costs.
- Not suitable for installation on steep slopes.

4.7. “At-grade” System

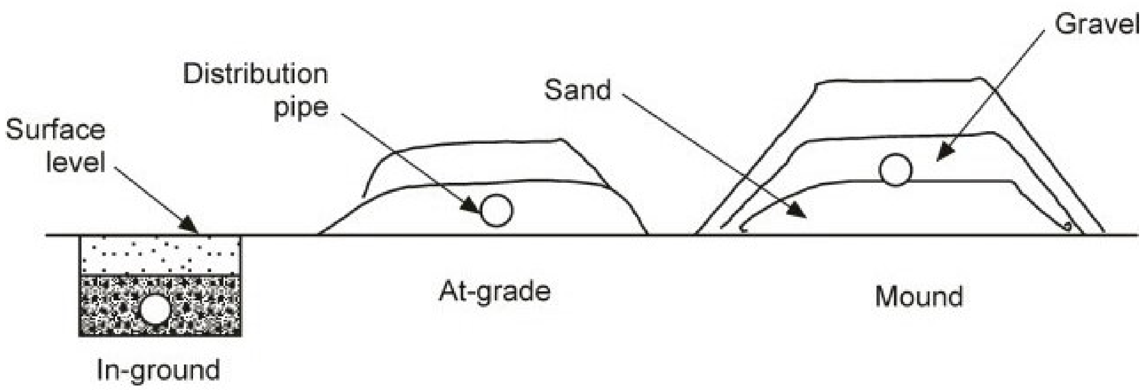

Figure 2. Comparison of different soil absorption systems in relation to ground level

The “at-grade” soil absorption systems differ from conventional sub-surface absorption systems in that they do not require any trenches and the sand/gravel bed through which the effluent seeps is placed on the tilled top soil. The effluent distribution pipe is placed on this bed and is covered again with aggregates. The top aggregate layer is synthetic fabric and soil. In contrast to a sand mound, this system does not have any sand bed between the top soil and sand/gravel bed. Figure 2 compares the conventional (sub-surface), sand mound (above-surface) and at-grade schemes of soil absorption systems.

At-grade systems are recommended for adoption at locations where the minimum depth of high water table or the bedrock is 0.9 m or less from surface level. The distribution network can be designed for either gravity or by pumping.

Advantages

- Construction and installation is comparatively easier.
- Can be used as an alternative to conventional system at locations with problem soil conditions.

Disadvantages

- As the distribution network is above ground level, it is susceptible to cold climates.
- The raised ground level reduces the use of property area.
- Long-term experience is not available about this system.

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Biographical Sketches

S. Vigneswaran is currently a Professor and a Head of Environmental Engineering Group in the Faculty of Engineering, University of Technology, Sydney, Australia. He has been working on water and wastewater research since 1976. He has published over 175 technical papers and authored two books (both through CRC press, USA). He has established research links with the leading laboratories in France, Korea, Thailand and the USA. Also, he has been involved in number of consulting activities in this field in Australia, Indonesia, France, Korea and Thailand through various national and international agencies. Presently, Dr. Vigneswaran he is coordinating the university key research strengths on “water and waste management in small communities,” one of the six key research centers funded by the university on competitive basis. His research in solid liquid separation processes in water and wastewater treatment namely filtration, adsorption is recognized internationally and widely referred.

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