ON-SITE SANITATION TECHNOLOGIES FOR REUSE

Prasanthi Hagare
Environmental Engineering Group, Faculty of Engineering, University of Technology, Sydney, Australia

Hagare B. Dharmappa
Environmental Engineering Program, Faculty of Engineering, University of Wollongong, Australia

Keywords: Domestic wastewater, treatment, Decentralized Systems, re-use, on-site, design, performance

Contents

Summary

Wastewater is now being considered more as a resource rather than a waste. Technologies are now available to treat wastewater to acceptable standards for reuse. In small communities or industries, small decentralized wastewater treatment systems can be used to treat and reuse water for purposes such as irrigation, industrial reuse, groundwater recharge or even potable water augmentation. In this article, a description of some of the technologies that can be adopted by small communities is given. Decentralized wastewater management is also becoming popular in single homes where the householder is responsible for treatment and discharge of wastewater on the

premises. Due to increased awareness even among lay people, technologies are now being used to treat and reuse domestic wastewater on-site for various purposes. In this article some of these technologies such as suspended growth aerated wastewater treatment systems (AWTS) and packed bed filters are described in detail. Irrigation, being the most common reuse option, techniques such as evapotranspiration, land treatment by drip irrigation and advanced FILTER techniques are also discussed.

1. Introduction

The issue of sustainable water use is a topic of great significance now, more than ever. It is becoming imperative that we reduce our day-to-day water use by efficient means or recycle and/or reuse water. Recycling water is not a new concept to us. The natural hydrological cycle ensures that the impurities in water are removed by the process of natural evaporation and pure water is recycled back to earth by precipitation. All water supplies on land originate from this natural precipitation (rain or snow) and find their way back to the oceans where they once again follow the hydrological cycle. Human beings are extracting water from the natural cycle at a much faster rate than Nature can cope. The centralized water and wastewater management trend, both in developed as well as developing countries is reducing the quantity of available fresh water on the planet. Wastewater from individual households, commercial units, industries and other community places is collected by an extensive network of pipes and treated at a common effluent treatment plant before discharging it to fresh waterways or oceans. This can be a valid option for urban areas where water supply is abundant. However, the increase in population, and the increase in industrial growth is rapidly increasing water pollution to such an extent that the amount of fresh water readily available is reducing very fast. In centralized sewage treatment systems approximately 200–300 L per person per day is treated and disposed. For a typical city in a developed country, such as Sydney, it amounts to about, 4 million people × 200–300 L/d = 800–1200 million L/d. This quantity of wastewater is either discharged into the waterways or oceans.

Wastewater treatment plants in urban areas are usually located very far away from potential users of treated water. Reuse within the city would require extensive treatment and also an expensive redistribution network. In some countries this is being adopted in spite of the cost, so as to save water and reuse it. Water repurification plants which combine treated wastewater and raw fresh water adopt the principle of resource recovery and sustainable water usage.

The uneven distribution of precipitation, continued population growth, contamination of both surface and groundwaters, and periodic droughts are increasing the need to search for new and reliable water sources. Hence, in areas where the available sources of water are limited or are unreliable, it is now recognized that wastewater represents a very reliable water source.

If wastewater from urban and near urban areas were reused locally for a variety of non-potable uses, the demand on the potable supply would be reduced and population growth could be sustained. As a result, in recent times, it has become very important that the focus of the field of wastewater management be changed from the construction of centralized sewage treatment systems to on-site or decentralized wastewater treatment systems.

More opportunities are available to reduce water usage when wastewater is managed by householders using the concept of decentralized waste management. Decentralized systems can provide an opportunity to treat wastewater on site to such a level that at least part of the wastewater can be reused for non-potable uses within the premises.

On-site treatment systems collect, treat and dispose or reuse all the wastewater within the boundaries of the premises. These systems can manage wastewater from individual houses, or isolated communities, industries, or institutional facilities at or near the point of waste generation. For small decentralized systems, the treatment processes can range from intermittent or recirculating granular medium filters to membrane processes. Residual solids removal is often needed for higher levels of reuse, prior to disinfection with either chlorine or ultraviolet (UV) radiation.

In urban and rural areas which are currently not sewered, the trend is to use on-site or decentralized waste management systems to treat and dispose domestic wastewater. This is a very common practice in most of the developing countries and in rural or remote parts of developed countries. Some of the on-site systems are used to partially treat the domestic wastewater, before it is pumped and taken out to a sewage treatment plant. At times, the householder is responsible for treatment and disposal of wastewater on the premises. Conventional on-site sewage management systems include septic tanks followed by soil absorption systems. In these systems the treated wastewater is disposed on land without further use.

In the following sections, the reuse options and wastewater technologies available are discussed under two headings: (i) reuse options for small decentralized systems and (ii) reuse options for single households.

2. Options for Small Decentralized Systems

Small decentralized waste management systems are useful when new communities are developed away from a large urban area. These include a group of houses, industries and community centers. In planning a wastewater treatment system, the reuse application usually determines the technology to be adopted and the degree of reliability required for the treatment processes and operation. Specific reuse categories and treatment technologies that may be applicable will depend on the location and type of wastewater reuse opportunities. For small and decentralized wastewater systems, agricultural and landscape irrigation are the most common forms of water reuse.

2.4. Effluent Reuse Options

Types of effluent reuse includes:

- agricultural irrigation
- landscape irrigation
- industrial recycling and reuse

- recreational/environmental uses
- groundwater recharge
- habitat wetlands
- non-potable miscellaneous uses
- augmentation of potable supplies.

Some of the categories of municipal wastewater reuse and typical applications are given in Table 1 (Tchobanoglous, 1999).

Wastewater reuse categories	**Typical applications**
Agricultural irrigation	Crop irrigation, commercial nurseries.
Landscape irrigation	Parks, school yards, freeway median strips, golf courses, cemeteries, greenbelts, residential.
Industrial recycling and reuse	Cooling water, boiler feed, process water, heavy construction.
Groundwater recharge	Groundwater replenishment, salt water intrusion control, subsidence control.
Recreational/environment uses	Lakes and ponds, marsh enhancement, streamflow augmentation, fisheries, snowmaking.
Nonpotable urban uses	Toilet flushing, clothes washing, car washing, fire protection, air conditioning, etc.
Potable reuse	Blending highly purified water with existing water supply, pipe to pipe water supply.

Table 1. Categories of municipal wastewater reuse and typical applications (Tchobanoglous, 1999)

2.4.1. Agricultural Irrigation

Crop irrigation is one of the oldest and most common types of effluent reuse. The safe use of municipal wastewater for garden watering is highly desirable, particularly as a large portion of potable water supply is used for gardening (40–50% in a typical Australian household, Hodges, (1999)). The type of crops that can be grown include large canopy trees (15–20 m+), small to medium trees (6–15 m), small to medium shrubs (1.5–2 m) or ground/rockery/clumping plants (1 m).

2.4.2. Landscape Irrigation

Landscape irrigation, also referred to as urban reuse, includes irrigation of:

- parks
- playgrounds

- golf courses
- freeway medians
- landscape areas around commercial, office, and industrial developments
- landscape areas around residences.

Many landscape irrigation projects involve dual distribution systems—one distribution network for potable water and another for reclaimed water. The recycled water distribution system becomes the third water utility, after the wastewater and potable water systems, and is operated, maintained, and managed like the potable water systems.

2.4.3. Industrial Reuse

The principle uses that industry can make use of recycled water are cooling water, process water, boiler-feed water, and irrigation and maintenance of plant grounds. Cooling water, either for cooling towers or cooling ponds, creates the single largest demand for water in many industries and is the predominant industrial application (Crites and Tchobanoglous, 1998).

2.4.4. Recreational/Environmental Uses

Recreational impoundments may serve a variety of functions from aesthetic, non-contact uses, to boating and fishing, to swimming. The required level of treatment will vary with the intended use of the water and the degree of public contact. The appearance of the recycled water is also of concern because the nutrients in the recycled water will stimulate the growth of algae and aquatic weeds. Removal of phosphorus and possibly nitrogen is usually needed to prevent algae growth in recreational reservoirs. Recycled water impoundments can be incorporated into urban landscape developments.

2.4.5. Groundwater Recharge

Groundwater recharge helps provide a loss of identity between recycled water and groundwater. The loss of identity has an important positive psychological impact where reuse is planned. Restrictions and reluctance to use recycled water can be overcome by groundwater recharge and subsequent recovery and use of the groundwater. Groundwater recharge can be accomplished by either surface spreading or by injection.

2.4.6. Habitat Wetlands

Natural or created habitat wetlands can make beneficial use of recycled water. Wetlands provide many valuable functions, including food attenuation, wildlife and waterfowl habitat, productivity to support food chains, aquifer recharge, and water quality improvement. The distribution between a "constructed" wetland and a "created" wetland is that the constructed wetland is intended as a treatment unit that can be modified or abandoned after its useful life has been completed. A created wetland, on the other hand, becomes a wetland area to be maintained and protected for its wildlife benefits in perpetuity.

Reclaimed water has been applied to wetlands for a variety of reasons, including:

- creation, restoration, and enhancement of habitat;
- provision for additional treatment prior to discharge to receiving water;
- provision for a wet-weather disposal alternative for recycled water.

2.4.7. Miscellaneous Uses

A variety of miscellaneous uses have been made of reclaimed water:

- flushing of toilets;
- supply for public or commercial laundries;
- fire fighting;
- construction water;
- flushing of sanitary sewers;
- washing aggregate and making concrete.

2.4.8. Augmentation of Potable Supplies

Potable supplies can be augmented with reclaimed water; however, for small systems, the prospects are usually limited. Indirect potable reuse has been practiced in some parts of the United States (Crites and Tchobanoglous, 1998).

2.5. Guidelines for Wastewater Reuse

The suggested USEPA guidelines are given in Table 2.

Level of treatment	Types of reuse	Reclaimed water quality	Reclaimed water monitoring	Setback distances
1. Disinfection tertiary[+]	Urban reuse[++] Food crop irrigation Recreational impoundments	pH= 6–9 BOD ≤10 mg/L Turb. ≤ 2 NTU coli = none Res. Cl_2 ≥ 1 mg/L	pH = weekly BOD = weekly Turb. = cont. coli = daily Res. Cl_2 =cont.	50 ft (15 m) to potable water supply wells[@]
Disinfected secondary	Restricted access area irrigation Food crop irrigation (commercially processed) Nonfood crop irrigation Landscape impoundments (restricted access) Construction Wetlands habitat	pH= 6–9 BOD ≤ 30 mg/L TSS = 30 mg/L coli = 200/100 mL Res. Cl_2 ≥ 1 mg/L	pH = weekly BOD = weekly Tss = daily coli = daily Res. Cl_2 =cont.	100 ft (30 m) to areas accessible to the public (if spray irrigation) 300 ft (90 m) to potable water supply well

[+] Filtration of secondary effluent.

[++] Uses include landscape irrigation, vehicle washing, toilet flushing, use in fire protection, and commercial air conditioners.
[@] Setback increases to 150 m if impoundment bottom is not sealed.

Table 2. Summary of EPA suggested guidelines for water reuse (Crites and Tchobanoglous, 1998))

-
-
-

Bibliography

Anda M., Ho G., and Harris C. (1999). Evapotranspiration systems for domestic wastewater reuse in remote aboriginal communities. *Proceedings of On-site '99*, Armidale, NSW, Australia, July.

AS1547 (1994). *Disposal Systems for Effluent from Domestic Premises.* Standards Australia, North Sydney, NSW. [Provides the details of codes and standards which must be considered while designing and operating an onsite effluent disposal systems.]

Biswas T., Jayawardane N. S., Blackwell J., Christen W. W., and Cook F. J. (1999). The 'FILTER' technique for year round treatment of wastewater. *Proceedings of On-site' 99*, Armidale, NSW, Australia, July.

Crites R., and Tchobanoglous G. (1998). *Small and Decentralized Wastewater Management Systems*, WEB McGraw-Hill Publications, NY. [This book provides a comprehensive summary of various small and onsite waste treatment and disposal systems used around the world.]

Dharmappa H. B., and Khalife M. A. (1998). Design of aerated wastewater treatment systems for on-site waste disposal, *Water Journal*, Australian Water and Wastewater Association, **25**(4), 28.

Hagare P., and Dharmappa H. B. (1999). Process analysis and design of on-site aerated wastewater treatment systems. *Proceedings of On-site '99*, Armidale, NSW, Australia, July.

Khalifé M. A. (1995). Septic tanks design and their applications in Australia, ME (Hons) Thesis, Dept. of Civil and Mining Engineering, University of Wollongong, NSW. [This thesis presents an Australian case study on characteristics of wastewater and performance of existing septic tanks. The thesis also provides the details of new designs.]

Khalifé M. A., and Dharmappa, H. B. (1996). Performance evaluation of aerated wastewater treatment systems (AWTS). *Water Journal*, Australian Water and Wastewater Association, **23(**5), 25–28.

Khalifé M. A., Dharmappa H. B., and Sivakumar M. (1997). Performance evaluation of conventional septic tank systems in rural communities. *IAWQ Asian Regional Conference on Water Quality and Pollution Control*, 20–22 May, Seoul, South Korea, 1779–1791.

Metcalf and Eddy Inc. (1991). *Wastewater Engineering: Treatment Disposal Reuse*, 3rd Edition. McGraw-Hill Inc., New York. [This book provides a comprehensive analysis of various treatment techniques, which can be used for treating domestic wastewater. It also discusses various disposal options.]

SAHC (1995). *Standard for the Construction, Installation and Operation of Septic Tank Systems in South Australia.* Public and Environmental Health Branch, South Australian Health Commission, Adelaide. [This code of practice provides design, construction and operation details for septic tanks which are useful in practice.]

Spooner A. (1994). Personal communication. Health and Building Department, Campbelltown City Council, Campbelltown, NSW.

THS (1996). *Code of Practice for Small On-Site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent.* Environmental Health Program Directorate, Territory Health Services, Department of Housing and Local Government, Darwin NT. [This code of practice provides useful information on the design and construction of on-site wastewater treatment system. This code also provides details on the disposal and reuse of treated effluent.]

Tchobanoglous G. (1999). Decententralised systems for wastewater management and sustainable development, *Proceedings of On-site '99,* Armidale, NSW, Australia, July.

Venhuizen D. (1998). Sand filter/drip irrigation systems solve water resources problems, *Proccedings of the Eighth National Symposium on Individual and Small Community Sewage Systems: "On-site Wastewater Treatment"*, Florida, March 8–10, 1998, USA.

Biographical Sketches

Prasanthi Hagare is currently a Lecturer in the Environmental Engineering Group in the Faculty of Engineering, University of Technology, Sydney, Australia. She has been working in the field of water and wastewater treatment since 1989 and so far has published over 40 technical articles. Dr. Hagare has worked with well-regarded researchers in the field and has established contacts with several leading research teams both in Australia and overseas. Her experience with design, operation and maintenance of wastewater collection and treatment systems is well recognized. She is an active researcher in the fields of Environmental Engineering and has been successful in obtaining funding from government and private organizations in Australia.

Hagare Dharmappa is a Senior Lecturer in Environmental Engineering Program at University of Wollongong, Australia. He has been working in the area of Environmental Engineering for the last 15 years. Currently, he is involved in teaching, research and consultancy in the area of Environmental Engineering. His current areas of active research include industrial waste management and on-site waste disposal. Dr. Dharmappa has published over 70 articles in the areas of cleaner production, process design and optimization, waste management and engineering education.