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Onsite Waste Water Treatment System

T. Subramani[1], J. Akela[2]
[1]Professor & Dean, Department Of Civil Engineering, VMKV Engineering College, Vinayaka Missions University, Salem, India.
[2,] PG Student Of Environmental Engineering, Department Of Civil Engineering, VMKV Engineering College, Vinayaka Missions University, Salem

ABSTRACT
Onsite wastewater treatment systems (OWTSs) have evolved from the pit privies used widely throughout history to installations capable of producing a disinfected effluent that is fit for human consumption. Although achieving such a level of effluent quality is seldom necessary, the ability of onsite systems to remove settles able solids, floatable grease and scum, nutrients, and pathogens. From wastewater discharges defines their importance in protecting human health and environmental resources. In the modern era, the typical onsite system has consisted primarily of a septic tank and a soil absorption field, also known as a subsurface wastewater infiltration system, or SWIS. In this manual, such systems are referred to as conventional systems. Septic tanks remove most settle able and floatable material and function as an anaerobic bioreactor that promotes partial digestion of retained organic matter. Septic tank effluent, which contains significant concentrations of pathogens and nutrients, has traditionally been discharged to soil, sand, or other media absorption fields (SWISs) for further treatment through biological processes, adsorption, filtration, and infiltration into underlying soils. Conventional systems work well if they are installed in areas with appropriate soils and hydraulic capacities; designed to treat the incoming waste load to meet public health, ground water, and surface water performance standards; installed properly; and maintained to ensure long-term performance. These criteria, however, are often not met. Only about one-third of the land area in the United States has soils suited for conventional subsurface soil absorption fields. System densities in some areas exceed the capacity of even suitable soils to assimilate wastewater flows and retain and transform their contaminants. In addition, many systems are located too close to ground water or surface waters and others, particularly in rural areas with newly installed public water lines, are not designed to handle increasing wastewater flows.

KEYWORDS: Septic tank effluent, SWIS, Conventional systems, wastewater flows.

I. INTRODUCTION:

1.1 NITRATE CONTAMINATION OF GROUND WATER.

Conventional onsite system installations might not be adequate for minimizing nitrate contamination of ground water, removing phosphorus compounds, and attenuating pathogenic organisms (e.g., bacteria, viruses). Nitrates that leach into ground water used as a drinking water source can cause methemoglobinemia, or blue baby syndrome, and other health problems for pregnant women.

Nitrates and phosphorus discharged into surface waters directly or through subsurface flows can spur algal growth and lead to eutrophication and low dissolved oxygen in lakes, rivers, and coastal areas. In addition, pathogens reaching ground water or surface waters can cause human disease through direct consumption, recreational contact, or ingestion of contaminated shellfish. Sewage might also affect public health as it backs up into residences or commercial establishments because of OWTS failure.

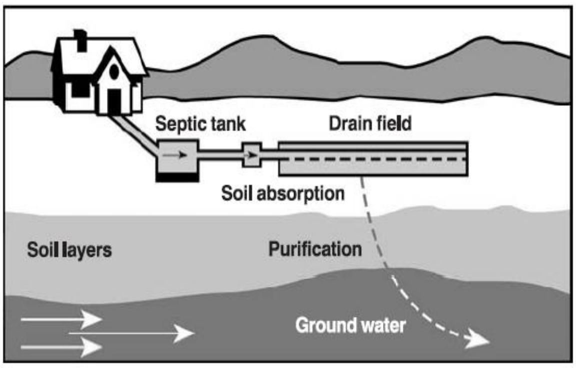

Figure 1-1. Conventional onsite wastewater treatment system

Nationally, states and tribes have reported in their 1998 Clean Water Act section 303(d) reports that designated uses (e.g., drinking water, aquatic habitat) are not being met for 5,281 water bodies because of pathogens and that 4,773 water bodies are impaired by nutrients. Onsite systems are one of many known contributors of pathogens and nutrients to surface and ground waters.

Onsite wastewater systems have also contributed to an overabundance of nutrients in ponds, lakes, and coastal estuaries, leading to overgrowth of algae and other nuisance aquatic plants. Threats to public health and water resources underscore the importance of instituting management programs with the authority and resources to oversee the full range of onsite system activities planning, sitting, design, installation, operation, monitoring, and maintenance. EPA has issued draft Guidelines for Management of Onsite/ Decentralized Wastewater Systems to improve overall management of OWTSs. (Fig.1.1)

1.2 History of onsite wastewater treatment systems

King Minos installed the first known water closet with a flushing device in the Knossos Palace in Crete in 1700 BC. In the intervening 3,700 years, societies and the governments that serve them have sought to improve both the removal of human wastes from indoor areas and the treatment of that waste to reduce threats to public health and ecological resources.

The Greeks, Romans, British, and French achieved considerable progress in waste removal during the period from 800 BC to AD 1850, but removal often meant discharge to surface waters; severe contamination of lakes, rivers, streams, and coastal areas; and frequent outbreaks of diseases like cholera and typhoid fever.

By the late 1800s, the Massachusetts State Board of Health and other state health agencies had documented links between disease and poorly treated sewage and recommended treatment of wastewater through intermittent sand filtration and land application of the resulting sludge. The past century has witnessed an explosion in sewage treatment technology and widespread adoption of centralized wastewater collection and treatment services in the United States and throughout the world.

All of the alternative treatment technologies in current use require more intensive management and monitoring than conventional OWTSs because of mechanical components, additional residuals generated, and process sensitivities (e.g., to wastewater strength or hydraulic loading). Replacing gravity-flow subsurface soil infiltration beds with better-performing alternative distribution technologies can require float switched pumps and/ or valves. As noted, specialized excavation or structures might be required to house some treatment system components, including the disinfection devices (e.g., chlorinators, ultraviolet lamps) used by some systems.

1.3 Regulation of onsite wastewater treatment systems

Public health departments were charged with enforcing the first onsite wastewater “disposal” laws, which were mostly based on soil percolation tests, local practices, and past experience. Early codes did not consider the complex interrelationships among soil conditions, wastewater characteristics, biological mechanisms, and climate and prescribed standard designs sometimes copied from jurisdictions in vastly different geoclimatic regions.

In addition, these laws often depended on minimally trained personnel to oversee design, permitting, and installation and mostly untrained, uninformed homeowners to operate and maintain the systems. During the 1950s states began to adopt laws upgrading onsite system design and installation practices to ensure proper functioning and eliminate the threats posed by waterborne pathogens (Kreissl, 1982). Despite these improvements, many regulations have not considered cumulative ground water and surface water impacts, especially in areas with high system densities and significant wastewater discharges.

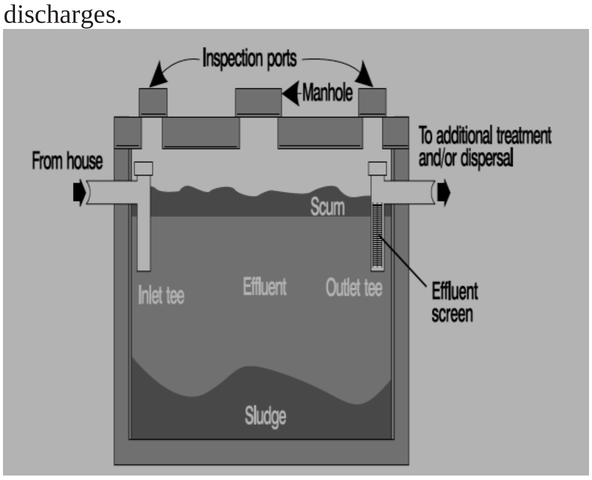

Figure 1-2. Typical single-compartment septic tank with at-grade inspection ports and effluent screen

Kreissl (1982) and Plews (1977) examined changes in state onsite wastewater treatment regulations prompted by the publication of the first INDIA Public Health Service Manual of Septic-Tank Practice in 1959. Plews found significant code revisions under way by the late 1970s, mostly because of local experience, new research information, and the need to accommodate housing in areas not suited for conventional soil infiltration systems.

Kreissl found that states were gradually increasing required septic tank and drainfield sizes but also noted that 32 states were still specifying use of the percolation test in system sizing in 1980, despite its proven shortcomings.(Fig.1.2)

Other differences noted among state codes included separation distances between the infiltration trench bottom and seasonal ground water tables, minimum trench widths, horizontal setbacks to potable water supplies, and maximum allowable land slopes (Kreissl, 1982). Although state lawmakers have continued to revise onsite system codes, most revisions have failed to address the fundamental issue of system performance in the context of risk management for both a site and the region in which it is located. Prescribed system designs require that site conditions fit system capabilities rather than the reverse and are sometimes incorrectly based on the assumption that centralized wastewater collection and treatment services will be available in the future. Codes that emphasize prescriptive standards based on empirical relationships and hydraulic performance do not necessarily protect ground water and surface water resources from public health threats. Devising a new regime for protecting public health and the environment in a cost-effective manner will require increased focus on system performance, pollutant transport and fate and resulting environmental impacts, and integration of the planning, design, sitting, installation, maintenance, and management functions to achieve public health and environmental objectives.

1.4 Onsite wastewater treatment system use, distribution, and failure rate

According to the INDIA Census Bureau (1999), approximately 23 percent of the estimated 115 million occupied homes in the United States are served by onsite systems, a proportion that has changed little since 1970. As shown in figure1.3 and table, the distribution and density of homes with OWTSs vary widely by state, with a high of about 55 percent in Vermont and a low of around 10 percent in Salem (INDIA Census Bureau, 1990). New England states have the highest proportion of homes served by onsite systems:

New Hampshire and Maine both report that about half of all homes are served by individual wastewater treatment systems. More than a third of the homes in the south eastern states depend on these systems, including approximately 48 percent in Salem and about 40 percent in both Namkkal and Krishnagiri. More than 60 million people depend on decentralized systems, including the residents of about one-third of new homes and more than half of all mobile homes nationwide (INDIAC ensus Bureau, 1999). Some communities rely completely on OWTSs.

A number of systems relying on outdated and underperforming technologies (e.g., cesspools, drywells) still exist, and many of them are listed among failed systems. Moreover, about half of the occupied homes with onsite treatment systems are more than 30 years old (INDIA Census Bureau, 1997), and a significant number report system problems.

A survey conducted by the INDIA Census Bureau (1997) estimated that 403,000 homes experienced septic system breakdowns within a 3-month period during 1997; 31,000 reported four or more breakdowns at the same home. Studies reviewed by USEPA cite failure rates ranging from 10 to 20 percent . System failure surveys typically do not include systems that might be contaminating surface or ground water, a situation that often is detectable only through site level monitoring.

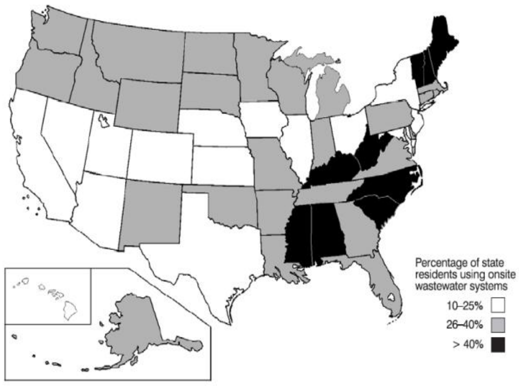

Figure: **1.3. On site treatment**. **system distribution**

Comprehensive data to measure the true extent of septic system failure are not currently collected by any single organization. Although estimates of system failure rates have been collected from 28 states, no state had directly measured its own failure rate and definitions of failure vary (Nelson et al., 1999). Most available data are the result of incidents that directly affect public health or are obtained from homeowners' applications for permits to replace or repair failing systems.

The 20 percent failure rate from the Massachusetts time-of transfer inspection program is based on an inspection of each septic system prior to home sale, which is a comprehensive data collection effort. However, the Massachusetts program only identifies failures according to code and does not track ground water contamination that may result from onsite system failures. In addition to failures due to age and hydraulic overloading, OWTSs can fail because of design, installation, and maintenance problems.

Hydraulically functioning systems can create health and ecological risks when multiple treatment units are installed at densities that exceed the capacity of local soils to assimilate pollutant loads. System owners are not likely to repair or replace aging or otherwise failing systems unless sewage backup, septage pooling on lawns, or targeted monitoring that identifies health risks occur. Because ground and surface water contamination by onsite systems has rarely been confirmed through targeted monitoring, total failure rates and onsite system impacts over time are likely to be significantly higher than historical statistics indicate.

1.5 Problems with existing onsite wastewater management programs

Under a typical conventional system management approach, untrained and often uninformed system owners assume responsibility for operating and maintaining their relatively simple, gravity-based systems. Performance results under this approach can vary significantly, with operation and maintenance functions driven mostly by complaints or failures.

In fact, many conventional system failures have been linked to operation and maintenance failures. Typical causes of failure include unpumped and sludge-filled tanks, which result in clogged absorption fields, and hydraulic overloading caused by increased occupancy and greater water use following the installation of new water lines to replace wells and cisterns. Full-time or high use of vacation homes served by systems installed under outdated practices or designed for part-time occupancy can cause water quality problems in lakes, coastal bays, and estuaries.

- Failure to adequately consider site-specific environmental conditions.
- Codes that thwart adaptation to difficult local site conditions and are unable to accommodate effective innovative and alternative technologies.
- Ineffective or nonexistent public education and training programs.
- Failure to include conservation and potential reuse of water.
- Ineffective controls on operation and maintenance of systems, including residuals (septage, sludge).
- Failure to consider the special characteristics and requirements of commercial, industrial, and large residential systems.
- Weak compliance and enforcement programs.
- These problems can be grouped into three primary areas: (1) insufficient funding and public involvement; (2) inappropriate system design and selection processes; and (3) poor inspection, monitoring, and program evaluation components. Management programs that do not address these problems can directly and indirectly contribute to significant human health risks and environmental degradation.

Irrigated agriculture will play a major role in determining the future food security of most Asian countries, and it will also be the major contributor to the additional food production required as world population expands (Svendsen and Rosegrant 1994). Therefore, it is important to raise the agricultural performance of low productivity irrigation systems, while sustaining the performance of more productive systems. In many countries, and particularly in India, accurate evaluation of irrigation system performance and sustainability is hampered by lack of adequate, reliable, and timely irrigation statistics.

Usually, performance indicators such as yield, cropping intensity, and irrigation intensity are measured at an aggregated level, often at the state or national levels. Data at project level are rarely collected. If collected, they frequently are unreliable or not easily accessible (Murray- Rust and Merrey 1994). It is in this context that IWMI, as part of its ongoing research program on the use of emerging technologies in irrigation management, applied remote sensing and geographic information system (GIS) techniques to study the Cauvery Irrigation System and to analyze agricultural performance issues.

The diagnostic analysis of the operation of the Cauvery canal command area in northwest India reported here was the result of collaborative research by the National Remote Sensing Agency, Hyderabad, India, the Haryana State Irrigation and Water Resources Department, Chandigarh, India, and the International Water Management Institute

Hydrologic analysis based on ground data was carried out, aided by GIS and supplemented with output data from a distributed computer model that simulates the spatiotemporal behaviour of canal water, soil water, and groundwater. The salient findings from this research are reported here and in Remote Sensing and Hydrologic Models for Performance Assessment in Sirsa Irrigation Circle, India (Bastiaanssen et al. 1998).

The Cauvery Irrigation System is above average in agricultural performance compared with other irrigation systems in Haryana (Economic and Statistical Organization 1995). Currently, Cauvery contributes about 40 percent of Haryana’s wheat production and 6 percent of national production. Through its warabandi principle (see box) of rigid rotational water distribution, Cauvery is designed to deliver water equitably to farmers over an extended area. But farmers’ success in growing a high proportion of wheat and reaching high production levels is being achieved by pumping groundwater.

These two studies demonstrate the potential of remote sensing and GIS for evaluating the performance of irrigation systems under two of India’s major food crops. Multispectral satellite data can be used to derive information on cropped area, cropping pattern and calendar, and crop productivity in irrigation systems (Thiruvengadachari and Sakthivadivel 1997).

Specific objectives of the Cauvery system study were, first, to generate disaggregated data on total irrigated area, area under major crops, and wheat productivity and, second, to integrate satellite-derived data with ground-measured data to identify factors that constrain agricultural performance and threaten the sustainability of the agricultural production system. A critical issue that this research addresses is whether present practices for allocating and distributing canal water supplies can continue without detriment to agricultural production and the groundwater regime.

II. STUDY AREA

2.1 MANAGEMENT OF ONSITE WASTEWATER TREATMENT SYSTEMS

Effective management is the key to ensuring that the requisite level of environmental and public health protection for any given community is achieved. It is the single most important factor in any comprehensive wastewater management program. Without effective management, even the most costly and advanced technologies will not be able to meet the goals of the community. Numerous technologies are currently available to meet a broad range of wastewater treatment needs. Without proper management, however, these treatment technologies will fail to perform as designed and efforts to protect public health and the environment will be compromised. The literature on OWTSs is replete with case studies showing that adequate management is critical to ensuring that OWTSs are sited, designed, installed, and operated properly.

Decentralized Wastewater Treatment Systems (1997), "Few communities have developed organizational structures for managing decentralized wastewater systems, although such programs are required for centralized wastewater facilities and for other services (e.g., electric, telephone, water, etc)." Good planning and management are inseparable. The capacity of the community to manage any given technology should be factored into the decision-making process leading to the planning and selection of a system or set of systems appropriate for the community.

As Kreissl and Otis noted in New Markets for Your Municipal Wastewater Services: Looking beyond the Boundaries (1999), appropriate technologies should be selected based on whether they are affordable, operable, and reliable. The selection of individual unit processes and systems should, at a minimum, be based on those three factors.

III. MANAGING OWTSS

Although managing OWTSs is obviously far more complicated than assessing whether the systems are affordable, operable and reliable, an initial screening using these criteria is a critical element of good planning. Historically, the selection and sitting of OWTSs has been an inconsistent process. Conventional septic tank and leach field systems were installed based on economic factors, the availability of adequate land area, and simple health-based measures aimed only at preventing direct public contact with untreated Wastewater.

Little analysis was devoted to understanding the dynamics of OWTSs and the potential impacts on ground water and surface waters. Only recently has there been an understanding of the issues and potential problems associated with failing to manage OWTSs in a comprehensive, holistic manner. Many case studies and reports from across the country provide documentation that a significant number of OWTSs lack adequate management oversight, which results in inadequate pollutant treatment.

The lack of system inventories in many communities makes the task of system management even more challenging. As a result of the perception that onsite/decentralized systems are inferior, old-fashioned, less technologically advanced, and not as safe as centralized wastewater treatment systems from both an environmental and public health perspective, many communities have pursued the construction of centralized systems (collection systems and sewage treatment plants). Centralized wastewater collection and treatment systems, however, are not the most cost-effective or environmentally sound option for all situations (e.g., sewage treatment plants can discharge high point source loadings of pollutants into receiving waters).

3.1 Elements of a successful program

The success or failure of an onsite wastewater management program depends significantly on public acceptance and local political support; adequate funding; capable and trained technical and field staff; and clear and concise legal authority, regulations, and enforcement mechanisms (Ciotoli and Wiswall, 1982). Management programs should include the following critical elements:

Clear and specific program goals

- Public education and outreach
- Technical guidelines for site evaluation, design, construction, and operation/maintenance
- Regular system inspections, maintenance, and monitoring
- Licensing or certification of all service providers
- Adequate legal authority, effective enforcement mechanisms, and compliance incentives
- Funding mechanisms
- Adequate record management
- Periodic program evaluations and revisions

Although all of these elements should be present in a successful management program, the responsibility for administering the various elements might fall on a number of agencies or entities. Regardless of the size or complexity of the program, its components must be publicly accepted, politically feasible, fiscally viable, measurable, and enforceable.

Many of the program elements discussed in this chapter are described in more detail in the other chapters of this manual. The elements described in detail in this chapter are those essential to the selection and adoption of a management program.

3.1.1 Clear and specific program goals

Developing and meeting program goals is critical to program success. Management programs typically focus on two goals—protection of public health and protection of the environment. Each onsite system must be sited, designed, and managed to achieve these goals. Public health protection goals usually focus on preventing or severely limiting the discharge of pathogens, nutrients, and toxic chemicals to ground water. Surface water bodies, including rivers, lakes, streams, estuaries, and wetlands, can also be adversely affected by OWTSs. Program goals should be established to protect both surface and ground water resources.

IV. ESTABLISHING TREATMENT SYSTEM PERFORMANCE REQUIREMENTS

4.1 CHARACTERIZING WASTEWATER FLOW

This chapter outlines essential steps for characterizing wastewater flow and composition and provides a framework for establishing and measuring performance requirements. provides information on conventional and alternative systems, including technology types, pollutant removal effectiveness, basic design parameters, operation and maintenance, and estimated costs. describes treatment system design and selection processes, failure analysis, and corrective measures.

This chapter also describes methods for establishing and ensuring compliance with wastewater treatment performance requirements that protect human health, surface waters, and ground water resources. The chapter describes the characteristics of typical domestic and commercial wastewaters and discusses approaches for estimating wastewater quantity and quality for residential dwellings and commercial establishments.

Pollutants of concern in wastewaters are identified, and the fate and transport of these pollutants in the receiving environment are discussed. Technical approaches for establishing performance requirements for onsite systems, based on risk and environmental sensitivity assessments, are then presented. Finally, the chapter discusses performance monitoring to ensure sustained protection of public health and water resources.

4.2 Estimating wastewater characteristics

Accurate characterization of raw wastewater, including daily volumes, rates of flow, and associated pollutant load, is critical for effective treatment system design. Determination treatment system performance requirements, selecting appropriate treatment processes, designing the treatment system, and operating the system depends on an accurate assessment of the wastewater to be treated. There are basically two types of onsite system wastewaters residential and nonresidential. Single-family households, condominiums, apartment houses, multifamily households, cottages, and resort residences all fall under the category of residential dwellings.

Discharges from these dwellings consist of a number of individual waste streams generated by water-using activities from a variety of plumbing fixtures and appliances. Wastewater flow and quality are influenced by the type of plumbing fixtures and appliances, their extent and frequency of use, and other factors such as the characteristics of the residing family, geographic location, and water supply (Anderson and Siegrist, 1989; Crites and Tchobanoglous, 1998; Siegrist, 1983). A wide variety of institutional (e.g., schools), commercial (e.g., restaurants), and industrial establishments and facilities fall into the non residential wastewater category.

Waste water generating activities in some non residential establishments are similar to those of residential dwellings. Often, however, the wastewater from non residential establishments is quite different from that from of residential dwellings and should be characterized carefully before Onsite Wastewater Treatment System (OWTS) design.

The characteristics of wastewater generated in some types of non residential establishments might prohibit the use of conventional systems without changing wastewater loadings through advanced pre treatment or accommodating elevated organic loads by increasing the size of the subsurface wastewater infiltration system (SWIS). Permitting agencies should note that some commercial and large-capacity septic systems (systems serving 20 or more people, systems serving commercial facilities such as automotive repair shops) might be regulated under USEPA's Class V Underground Injection Control Program.

4.3 Estimating wastewater flow

The required hydraulic capacity for an OWTS is determined initially from the estimated wastewater flow. Reliable data on existing and projected flows Should be used if onsite systems are to be designed properly and cost-effectively. In situations where onsite wastewater flow data are limited or unavailable, estimates should be developed from water consumption records or other information.

When using water meter readings or other water use records, outdoor water use should be subtracted to develop wastewater flow estimates. Estimates of outdoor water use can be derived from discussions with residents on car washing, irrigation, and other outdoor uses during the metered period under review, and studies conducted by local water utilities, which will likely take into account climatic and other factors that affect local outdoor use.

Accurate wastewater characterization data and appropriate factors of safety to minimize the possibility of system failure are required elements of a successful design. System design varies considerably and is based largely on the type of establishment under consideration.

For example, daily flows and pollutant contributions are usually expressed on a per person basis for residential dwellings. Applying these data to characterize residential wastewater therefore requires that a second parameter, the number of persons living in the residence, be considered. Residential occupancy is typically 1.0 to 1.5 persons per bedroom; recent census data indicate that the average household size is 2.7 people (INDIA Census Bureau, 1998).

Local census data can be used to improve the accuracy of design assumptions. The current onsite code practice is to assume that maximum occupancy is 2 persons per bedroom, which provides an estimate that might be too conservative if additional factors of safety are incorporated into the design. For non residential establishments, wastewater flows are expressed in a variety of ways.

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V. TREATMENT PROCESSES AND SYSTEMS

This chapter contains information on individual onsite/decentralized treatment technologies or unit processes. Information on typical application, design, construction, operation, maintenance, cost, and pollutant removal effectiveness is provided for most classes of treatment units and their related processes. This information is intended to be used in the preliminary selection of a system of treatment unit processes that can be assembled to achieve predetermined pollutant discharge concentrations or other specific performance requirements.

Complete design specifications for unit processes and complete systems are not included in the manual because of the number of processes and process combinations and the wide variability in their application and operation under various site conditions. Designers and others who require more detailed technical information are referred to such sources. Chapter 4 is presented in two main sections. The first section contains information about conventional (soil-based or subsurface wastewater infiltration) systems, referred to as SWISs in this document. Both gravity-driven and mechanized SWISs are covered in this section of chapter 4.

5.1 GENERAL INTRODUCTION TO SAND FILTERS

The second section contains a general introduction to sand filters (including other media), and a series of fact sheets on treatment technologies, alternative systems (e.g., fixed-film and suspended growth systems, evapo transpiration systems, and other applications), and special issues pertaining to the design, operation, and maintenance of onsite wastewater treatment systems (OWTSs).

This approach was used because the conventional system is the most economical and practical system type that can meet performance requirements in many applications. The first section is further organized to provide information about the major components of a conventional system.

Given the emphasis in this manual on the design bounder (performance based) approach to system design, this section was structured to lead the reader through a discussion of system components by working backwards from the point of discharge to the receiving environment to the point of discharge from the home or other facility served by the onsite system.

Under this approach, soil infiltration issues are discussed first, the distribution piping to the infiltration system including grave less systems is addressed next, and matters related to the most common preliminary treatment device, the septic tank, are covered last. The fact sheets in the second section of this chapter describe treatment technologies and discuss special issues that might affect system design, performance, operation, and maintenance.

5.2 Conventional systems and treatment options

The three primary components of a conventional system (figure 4-1) are the soil, the subsurface wastewater infiltration system (SWIS; also called a leach field or infiltration trench), and the septic tank. The SWIS is the interface between the engineered system components and the receiving ground water environment.

It is important to note that the performance of conventional systems relies primarily on treatment of the wastewater effluent in the soil horizon(s) below the dispersal and infiltration components of the SWIS. Information on SWIS sitting, hydraulic and mass loadings, design and geometry, distribution methods, and construction considerations is included in this chapter. The other major component of a conventional system, the septic tank, is characterized by describing its many functions in an OWTS.

Treatment options include physical, chemical, and biological processes. Use of these options is determined by site-specific needs. Table 4-1 lists common onsite treatment processes and methods that may be used alone or in combination to assemble a treatment train capable of meeting established performance requirements.

Special issues that might need to be addressed in OWTS design include treatment of high-strength wastes (e.g., biochemical oxygen demand and grease from schools and restaurants), mitigation of impacts from home water softeners and garbage disposals, management of holding tanks, and additives (see related fact sheets).

5.3 Subsurface wastewater infiltration

Subsurface wastewater infiltration systems (SWISs) are the most commonly used systems for the treatment and dispersal of onsite wastewater. Infiltrative surfaces are located in permeable, unsaturated natural soil or imported fill material so wastewater can infiltrate and percolate through the underlying soil to the ground water.

As the wastewater infiltrates and percolates through the soil, it is treated through a variety of physical, chemical, and biochemical processes and reactions. Many different designs and configurations are used, but all incorporate soil infiltrative surfaces that are located in buried excavations. The primary infiltrative surface is the bottom of the excavation, but the sidewalls also may be used for infiltration. Perforated pipe is installed to distribute the wastewater over the infiltration surface.(Fig.5.1)

A porous medium, typically gravel or crushed rock, is placed in the excavation below and around the distribution piping to support the pipe and spread the localized flow from the distribution pipes across the excavation cavity. Other gravelless or "aggregate-free" system components may be substituted.

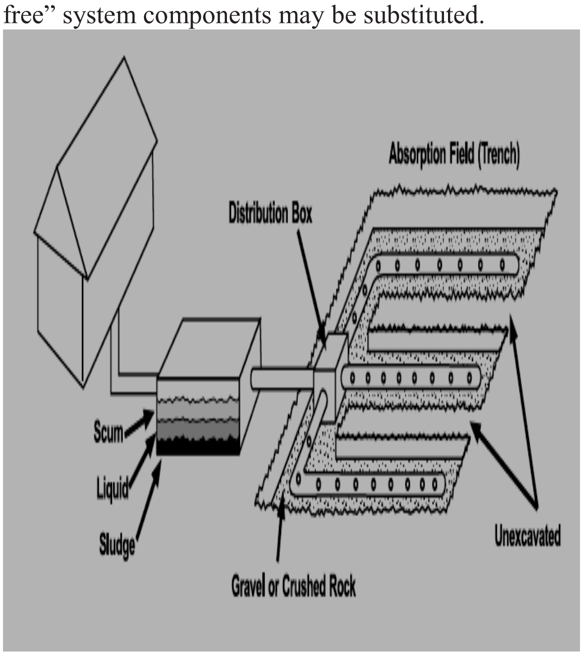

Figure 5-1. Conventional subsurface wastewater infiltration system

Subsurface wastewater infiltration systems provide both dispersal and treatment of the applied wastewater. Wastewater is transported from the infiltration system through three zones. Two of these zones, the infiltration zone and vadose zone, act as fixed-film bioreactors. The infiltration zone, which is only a few centimeters thick, is the most biologically active zone and is often referred to as the "biomat." Carbonaceous material in the wastewater is quickly degraded in this zone,

Free or combined forms of oxygen in the soil must satisfy the oxygen demand generated by the microorganisms degrading the materials. If sufficient oxygen is not present, the metabolic processes of the microorganisms can be reduced or halted and both treatment and infiltration of the wastewater will be adversely affected (Otis, 1985). The vadose (unsaturated) zone provides a significant pathway for oxygen diffusion to reaerate the infiltration zone (Otis, 1997, Siegrist et al., 1986).

Also, it is the zone where most sorption reactions occur because the negative moisture potential in the unsaturated zone causes percolating water to flow into the finer pores of the soil, resulting in greater contact with the soil surfaces. Finally, much of the phosphorus and pathogen removal occurs in this zone.

VI. CONCLUSION

Onsite systems serve **10%** of the housing units in the state. The survey results demonstrate that this 10% rate has been maintained for new housing units since the 1990 Census. All indications are that this trend will continue in the future. Onsite sewage treatment systems are a necessary and practical method to handle sewage treatment needs for many locations in Salem. These systems can be sited, designed, installed, monitored, and maintained to provide effective sewage treatment to protect public health and water quality. New innovations and technology that provide improved treatment are now available and will continue to be developed.

These systems need to be evaluated and used appropriately. The challenge is to change attitudes and practices to reflect the new reality that the function of systems is treatment and that the systems are permanent. The survey results demonstrate a significant variation in allowable practices and policies among state and local regulatory agencies. This inconsistency has perpetuated an atmosphere of uncertainty and confusion among all the stakeholders, wastewater treatment professionals and the general public alike.

The pending state wide regulations should remedy this situation by establishing baseline standards for all jurisdictions that have responsibility for onsite systems. Strong leadership is needed in areas where there are shared objectives, for example, professional certification. Collection and distribution of treatment results, from various components in different hydro geologic settings, is needed so that technology can be used appropriately to address treatment objectives. Any necessary changes can then be based on informed decisions.

A key to further developing the onsite/decentralized concept to met infrastructure needs is educating and informing all of the stakeholders. This includes not only the practitioners but also the policy and decision makers and the general public. Salem's growth and development needs require effective utilization of onsite/decentralized wastewater treatment systems as part of an integrated water management program.

Using onsite/decentralized systems is in many situations the appropriate and cost effective method of sewage treatment. Several issues remain to be addressed. Notably: 1) Salem needs to develop a comprehensive septage management strategy to meet future needs. Local government, the Regional Water Quality Control Boards and the State Water Resources Control Board need to develop strategies to ensure that the septage treatment and disposal facilities are adequate to meet the demand. 2) Salem needs to develop an effective training and certification program to ensure that systems are sited, designed, installed, inspected, operated, and maintained properly.

This survey found that obtaining accurate statistical information remains a problem. There is no data collection requirement or central data collection for this information. The pending regulations will require establishing management programs that include a minimum data collection element and this should enable more accurate and complete information in the future. The survey information presented should, however, provide reasonably accurate statistical information. This information can be used to gain a clearer picture of onsite sewage treatment system practices in Salem.

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