Disinfection for Onsite Wastewater Treatment Systems

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1. INTRODUCTION

The infiltration of partially treated wastewater effluent into the soil, a common practice for many onsite and decentralized wastewater management systems, has the potential to degrade groundwater quality. Of primary concern is the transfer of pathogenic constituents from infected individuals via wastewater to groundwater. While it has been observed that varying degrees of disinfection may occur as wastewater percolates through soil, it is apparent that most soil infiltration systems have not been designed to take advantage of this effect. Instead, soil infiltration systems traditionally have been designed to achieve the function of inexpensive wastewater disposal, which may not be adequately protective of public health. Decentralized treatment systems that include a disinfection process may serve to protect groundwater resources and public health.

Further, agencies responsible for the protection of human health require data on the application of technologies for the treatment and disinfection of wastewater, particularly in areas where traditional approaches to wastewater management may not be sufficient.

Problem Statement

Because of the dispersed nature of decentralized wastewater management systems, proper maintenance procedures are sometimes difficult to implement. It is possible that a given process will be required to operate reliably for a long period of time between maintenance activities. Most onsite and small flow applications do not utilize redundant systems to ensure performance; therefore, reliability is of special interest. In some decentralized wastewater applications, disinfection is of particular importance as a barrier against pathogens. Unfortunately, little information is available that can be used to determine the reliability and maintenance intervals required to keep a given small flow disinfection process performing to a high standard. Manufacturer recommendations may be of limited value given the degree of variability that exists in individual and small treatment facilities and other site-specific conditions. In addition, a range of disinfection units are available that may be applied for wastewater disinfection. Thus, research is needed to characterize the performance, reliability, constraints, maintenance needs, and other factors involved in the disinfection of small wastewater flows.

Objectives

The objective of this course is to evaluate commercially available disinfection units and determine the following for each process:

1. Disinfection performance
2. Reliability and constraints of the disinfection methodology
3. Maintenance requirements and frequency
3. Estimated cost of installation and operation

Disinfection performance was determined by measurement of MS2 coliphage, total coliform, and fecal coliform.

Organization

The course is organized into the following sections (1) an introduction to disinfection systems as they may be applied for the treatment of small wastewater flows, including some of the unique challenges encountered in small systems design; (2) the methodology used for evaluation of each disinfection unit, including the characteristics of the pretreatment system utilized; (3) an assessment of disinfection performance, reliability, maintenance, and cost; and (4) a summary of the primary conclusions.

2. BACKGROUND

Numerous disinfection units are available for wastewater treatment applications, including chlorination, ultraviolet (UV) light, and ozonation systems. However, the use of disinfection for onsite and small wastewater treatment systems has not been practiced commonly because, in part, it was perceived that land disposal of small wastewater flows would not significantly effect groundwater. Unfortunately, it has been determined that conventional onsite treatment systems do have the potential to impact groundwater (Ahmed et al., 2005, Nicosia et al., 2001; Arnade, 1999; Yates, 1985). Therefore, decentralized treatment processes that can be used to ensure safe discharge of wastewater effluents are desirable. As discussed below, the disinfection of wastewater from onsite and small wastewater systems presents special problems related to cost, reliability, and maintenance.

Disinfection Processes for Small Wastewater Flows

The disinfectants used most commonly for small treatment systems are sodium and calcium hypochlorite and UV light (U.S. EPA, 2002). A summary of disinfection processes that may be utilized for small wastewater flows is presented in Table 1. While the processes identified in Table 1 can be used to disinfect wastewater, each process has inherent constraints that may limit general application. For example, ozone is known to be a strong oxidant and has been used for water and wastewater disinfection applications; however, the cost of an effective ozonation system may be prohibitive for small treatment facilities. While effective, chlorine gas (Cl_2) and chlorine dioxide (ClO_2) are not considered for small facilities due to the hazards presented by storage, handling, and application of these chemicals. Other processes that are identified in Table 1 that have been applied for wastewater disinfection include biological filtration and peracetic acid. Membrane filtration and pasteurization, while identified in Table 1, are not discussed further as these processes are not currently feasible for small systems. Additional details on the operation and design of each of these technologies may be found in Crittenden et al. (2005), Tchobanoglous et al. (2003), U.S. EPA (2002), and Crites and Tchobanoglous (1998).

Table 1
Summary of disinfectants used for disinfection of small wastewater flows

Disinfectant	Formula	Form	Constraints or concerns for application to small flows
Sodium hypochlorite	NaOCl	Liquid	Corrosive, toxic, formation of carcinogenic by-products, requires chemical feed system, effectiveness may depend on water quality
Calcium hypochlorite	$Ca(OCl)_2$	Solid tablet	Corrosive, toxic, formation of carcinogenic by-products, requires tablet feed system, effectiveness may depend on water quality, non-uniform tablet erosion may affect dose
Ozone	O_3	Gas	Corrosive, toxic, requires a feed gas preparation unit and a pump for injection of ozone, effectiveness may depend on water quality, high output systems will require ozone off-gas destruction
Peracetic acid	CH_3CO_3H	Liquid	Corrosive, toxic, not commercially available, requires a chemical feed system, effectiveness may depend on water quality
Ultraviolet (UV) light	-	UV radiation	Requires periodic lamp maintenance and replacement, fouling can reduce effectiveness, performance sensitive to water quality
Biological filtration	-	Enzymatic activity, predation	Size of filter may be a limitation, expense of obtaining appropriate media, additional research needed to define design, operation, and reliability
Membrane filtration	-	Size exclusion	Dense membranes capable of excluding pathogens, e.g. reverse osmosis, require substantial wastewater pretreatment, energy and maintenance intensive
Pasteurization	-	Heat energy	Energy intensive and process not commercially available

Sodium hypochlorite

Sodium hypochlorite is an oxidizing agent that is able to disinfect water at high rates at relatively low concentrations. Sodium hypochlorite is available in solution concentration ranging from 1.5 to 15 percent and is the active ingredient in household bleach (3 to 6 percent) and in pool sanitizers (11 to 15 percent). At increased concentrations, the solution decomposes at a higher rate compared to low concentrations. In addition, NaOCl should be stored in a cool, dark area, and in a non-corrosive container.

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