Disinfection Devices: Field Experiences

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Introduction

Wastewater that is to be surface applied must first be disinfected to remove odors and disease-causing microorganisms. We are conducting a study, funded by an EPA 319 grant, determining the ability of subsurface flow constructed wetlands to treat wastewater on-site. When 10 of our 21 wetlands were installed with sprinklers for surface application, we got into the activity of effluent disinfection. Currently, there are two basic methods of disinfection for on-site wastewater treatment systems: chlorination and ultraviolet (UV) light disinfection. Both chlorination and UV disinfection have a dose and time relationship. The longer wastewater is exposed to chlorine or UV light, and/or the stronger the chlorine concentration or light intensity, the greater the potential of disinfection (White, 1999).

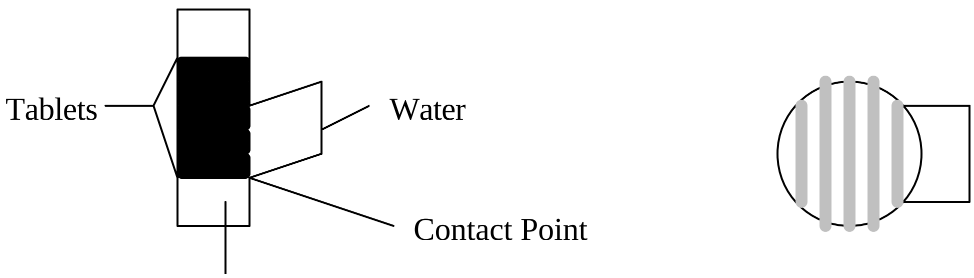
Optimal disinfection occurs with high quality effluent. Poor wastewater quality, water with total suspended solids (TSS) over 50 mg/L or turbidity over 12 NTU, can contribute to UV unit failure (Petrasek, *et al.*, 1980). Total suspended solids and turbidity are two wastewater parameters that quantify the presence of particles in wastewater. Both disinfection methods require the removal of large particles that may contain or shield microorganisms from the disinfectants (Johnson & Qualls, 1984). Organic matter and nitrogen compounds in effluent increase the amount of chlorine that must be added to achieve disinfection (White, 1999, Tchobanoglous & Burton, 1991).

Tablet Chlorinators

The first disinfection method we chose to use was classical tablet chlorination. Tablet chlorinators (see figure on following page) are comprised of:

- calcium hypochlorite tablets
- a tube that holds the tablets
- a contact device which assures contact between tablet and water and
- a storage reservoir where wastewater is stored before spraying.

Tablet Chlorinator



Side view **Top view (without tablets)**

In our situation, water exited the wetland through a pipe to the contact device. The contact device holds the tube where chlorine tablets are stacked. Only the bottom tablet is in contact with the water. When this bottom tablet erodes, gravity pulls the next tablet into place. Tablet life and degree of chlorination depend on the quality of effluent, the percentage of the water contacting the tablets, and how long the water stays in contact with tablets. A balance must be achieved with contact time: a long contact time results in over-chlorination and rapid consumption of the tablets while a short contact time may result in weakly-chlorinated water.

From past experiences, it has been discovered that tablet chlorinators have many pitfalls (Weaver & Lesikar, 2000). First, this delicate balance of chlorine tablet-wastewater contact time must be achieved through trial and error in adjusting the contact device position. Secondly, how much water hits the tablet is difficult to control. Without routine weekly or biweekly maintenance, chlorination becomes sporadic based on non-uniform dissolution of the tablets and/or buildup of residue in the chlorinator. Homeowners are inconsistent in adding chlorine tablets when needed and some who do add tablets use the wrong type. Only chlorine tablets approved for use in wastewater, those made from calcium hypochlorite, are acceptable. Homeowners often substitute chlorine tablets made for swimming pool chlorination. These tablets are often made from trichloroisocyanuric acid, which, if wetted repeatedly, can produce nitrogen chloride, which is explosive.

Third, storage of calcium hypochlorite tablets is problematic because they are a strong oxidant. Protection should be worn when handling chlorine tablets. Tablet containers should be stored away from metal products (chlorine gas can corrode metal) and should be opened only in well-ventilated areas. Finally, disinfection byproducts are generated when chlorine reacts with organic materials in wastewater. These byproducts, such as chloramines and trihalomethanes, are carcinogenic (White, 1999).

Texas regulations require wastewater to contain at least 0.1 mg of chlorine per liter of wastewater and have no more than 200 fecal coliforms per 100 ml of wastewater if surface application is to occur (TAC, 2001). Chlorine kits can determine chlorine concentration. A positive test for chlorine generally is accepted to indicate that fewer than 200 fecal coliforms per 100 ml of wastewater are present.

Tablet chlorinators were effective if:

- the chlorinator contained the correct chlorine tablets at all times (2-5 tablets)
- contact was made between tablets and wastewater
- regular maintenance was conducted weekly or biweekly to check for problems, blockage, etc.

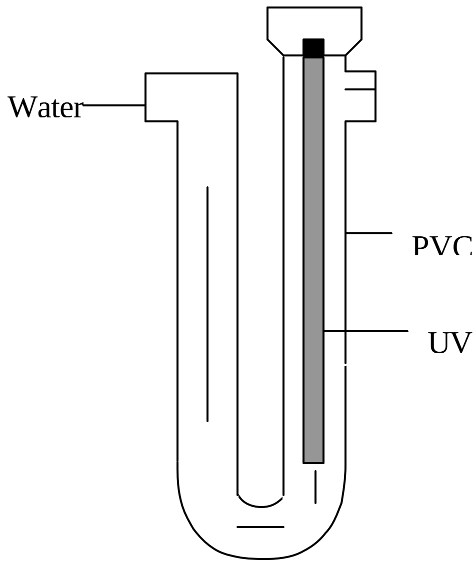
Tablet chlorinators can be an effective disinfection method, but in our experience, were not dependable without high maintenance.

<u>Ultraviolet Light Disinfection Units</u>

The second method of disinfection we employed was ultraviolet (UV) light. Ultraviolet light has been used in for disinfection on a large scale at wastewater treatment plants for disinfection. Small UV disinfectors are now available that may be used for individual on-site systems. Ultraviolet disinfection uses radiation within the range of 190 to 400 nm to penetrate cell walls and damage DNA and RNA. This genetic mutation either prevents replication of or kills the cell (Tchobanoglous & Burton, 1991). Disinfection efficiency is dependent on UV dose (light intensity and exposure time) and wastewater characteristics such as TSS and turbidity.

The UV units we used consisted of a 10 cm-diameter U-shaped PVC pipe containing a submersed UV bulb in a quartz glass sleeve (see figure on following page). The UV units were placed inside the storage tank where water is stored before surface application.

Ultraviolet Disinfection Unit



Two different types of bulbs were used with the UV units. One bulb was a low-pressure, 37-watt bulb that emitted light with a wavelength of 254 nm. The other was a medium-pressure, 57-watt bulb emitting a wavelength range of 190-400 nm. The low-pressure bulb was evaluated on 3 wetlands, and the medium-pressure bulb on 2 wetlands (one of which the low-pressure bulb was also evaluated on). Water was passed through the UV units at various flow rates to get a range of exposure times. Samples were collected at these flow rates and plated for the presence of fecal coliforms. Water quality data, including TSS and turbidity, were collected as well.

One of the four sites selected for UV disinfection had excellent results for a duration of at least 1 year without maintenance. The other three, however, did not provide consistent disinfection. Wastewater quality data, given in the table below, shows both TSS and turbidity below the previously mentioned 50 mg/L and 12 NTU, respectively, at wetlands A and C.

Water Quality Data

Wetland	BOD_5 (mg l^{-1})	TSS (mg l^{-1})	Turbidity (NTU)
A	5 ± 4	5 ± 3	6 ± 2
B	20 ± 7	14 ± 7	42 ± 22
C	9 ± 3	3 ± 1	5 ± 2
D	15 ± 4	9 ± 4	29 ± 21

The UV unit at wetland C was unsuccessful, even though water quality at wetland C was comparable to wetland A, where successful disinfection was achieved. The main reasoning for failure at wetland C was that the UV bulb became coated with a film. A slimy, dark film developed on several bulbs after 1-2 weeks of operation. This coating reduced the intensity of light reaching the wastewater. When the bulbs were wiped clean, they were again able to disinfect. Maintenance (wiping the bulb clean once a week) is not likely to be conducted by homeowners. A face shield, eye protection, gloves, and long sleeves should all be worn when handling a UV bulb to prevent burning.

<u>Liquid Chlorination</u>

The third and our present method of disinfection employed at our wetland sites is liquid chlorination. The liquid chlorinator we use is a 5-gallon tank that sits in the ground or aboveground filled with household bleach. When the timer-controlled pump turns on to spray water for surface application, an aspirator creates a vacuum that siphons bleach into the effluent tank.

Liquid chlorinators have some advantages over tablet chlorination. Homeowners are accustomed to using bleach for laundry and it is relatively inexpensive and available. Any household bleach can be used, so there is no opportunity for confusion about bleach type. Bleach can be purchased on an “as needed” basis, whereas chlorine tablets must be purchased in larger quantities. There is a greater cost for chlorine tablets at an initial time, while bleach has a lower, but periodic cost. Additionally, if bleach is purchased as it is needed, there are no storage issues to address. We have had some success with homeowners filling the chlorine reservoirs, but not at every site. Filling the tanks is the only maintenance required by the homeowner, thus, liquid chlorination is a low maintenance method of disinfection.

Another advantage liquid chlorinators provide over tablet chlorinators is more precise dosing. When the effluent tank contains a specified volume of wastewater, bleach is introduced into the tank and surface applied. Chlorination is not dependent on contact time with water and is more uniform than tablet chlorinators.

Some problems have been encountered with liquid chlorinators. Air leaks in the system and improper timer settings can lead to underchlorination or overchlorination. It may take some effort calibrate the pumping frequency so the water is properly chlorinated. Also, if the liquid chlorinator were to malfunction, its complexity hinders the average homeowner from making repairs. Overall, liquid chlorination has been a success in our experiences when the chlorinators are properly calibrated.

Conclusion

All methods for disinfection of wastewater effluent require maintenance. When functioning well, UV disinfection required the least maintenance and has great potential. The main problem with was biofilms forming on the bulb, reducing light intensity. Chlorination was highly effective in reducing odors and in disinfecting water. The method of chlorine delivery seems to favor liquid chlorination for controlling dosage, ease for the homeowner to purchase chlorine bleach, and having reduced maintenance.

References

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