United States Environmental Protection Agency

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Alternative Disinfection Methods Fact Sheet: Peracetic Acid

DESCRIPTION

Disinfection is considered to be the primary mechanism for the inactivation/destruction of pathogenic organisms to prevent the spread of waterborne diseases to downstream users and the environment. It is important that wastewater be adequately treated prior to disinfection in order for any disinfectant to be effective. Table 1 lists some common microorganisms found in domestic wastewater and the diseases associated with them.

Table 1: Infection Agents Potentially Present In Untreated Domestic Wastewater

ORGANISM	RELATED DISEASE
Bacteria:	
Escherchia coli	Gastroenteritis (enterotoxigenic)
Leptospira (spp.)	Leptospirosis
Salmonella (2,100 serotypes)	Salmonellosis
Salmonella typhi	Typhoid fever
Shigella (4Spp.)	Shigelloisis (bacillary dysentery)
Vibrio Cholerae	Cholera
Protozoa:	
Balantidium Coili	Balantidiasi
Cryptosporidium (Parvum)	Cryptosporidiosis
Entamoeba histolytica	Amebiasis (amoebic dysentery)
Giardia Lamblia	Giardiasis
Helminthes:	
Ascaris lumbricoides	Ascariasis
T. Solium	Taeniasis
Trichiura trichiura	Taeniasis
Viruses:	
Enteroviruses (72 types) e.g. Polio, Echo, Coxsackie	Gastroenteritis, heart abnormalities, meningitis
Hepatitis A	Infectious Hepatitis
Norwalk Virus	Gastroenteritis
Rotavirus	Gastroenteritis

Table 1: Continued

Source: Adapated from Crites and Tchobanoglous,1998

The effectiveness of a Peracetic Acid (PAA) disinfection system depends on the characteristics of the wastewater, the concentration of PAA, the amount of time the microorganisms are exposed to the PAA, and the reactor configuration. For any one treatment plant, disinfection success is directly related to the concentration of colloidal and particulate constituents in the wastewater. PAA is a strong oxidant and virucide.

The mechanisms of disinfection using PAA include:

- Direct oxidation/destruction of the cell wall with leakage of cellular constituents outside of the cell.

Choosing a suitable disinfectant for a treatment facility is dependent on the following criteria:

- Ability to penetrate and destroy infectious agents under normal operating conditions.
- Absence of toxic residuals and mutagenic or Carcinogenic compounds after disinfection.
- Safe and easy handling, storage, and shipping.

When PAA decomposes in water, the free radicals hydrogen peroxyl (HO_2) and hydroxyl (OH) that are formed have great oxidizing capacity and play an active role in the disinfection process. It is generally believed that the bacteria are destroyed because of protoplasmic oxidation resulting in cell wall disintegration (cell lysis). The effectiveness of disinfection depends on the susceptibility of the target organisms, the contact time, and the concentration of the PAA.

APPLICABILITY

To reach high levels of disinfection of wastewaters, the concern about the formation of halogenated disinfection byproducts (DBPs) has become more and more of an issue. The need for an economical and relatively simple retrofit to an existing wastewater treatment facility has become apparent. The use of peroxygen chemical compounds has been practiced for years in Europe, but in the last several years water treatment companies have been considering the use of peracetic acid (PAA) as an alternative to halogenated disinfection chemicals (such as chlorine based products).

Peracetic acid is an equilibrium mixture of acetic acid and hydrogen peroxide and water $CH_3COOH + H_2O_2 \leftrightarrow CH_3COOOH + H_2O$. Commercially available PAA has a stabilizer to increase its storage life. The problem is to demonstrate that the use of PAA is: An effective disinfection compound that does not generate harmful DBPs; A more rapid acting disinfectant than chlorine based disinfectants; That PAA can be economically retrofitted and/or work in series with an existing disinfection system; That PAA dissipates rapidly and does not generate harmful disinfectant byproducts even if overdosed.

RESULTS

Some of the results of the actual study using PAA as a disinfectant are shown in Table 2.

Table 2: Residual PAA and Related Fecal Coliform Counts in the Contact Basins

Sample Point	Average PAA Residual (ppm)	Fecal Coliform (cfu/100ml)
Secondary Effluent	not applicable	48,000
1	0.9	13,680
2a	0.6	4,040
2b	0.5	3,620
3a	0.3	2,600
3b	0.2	2,340
4a	0.1	1,800
4b	0.1	1,480
5	0	580

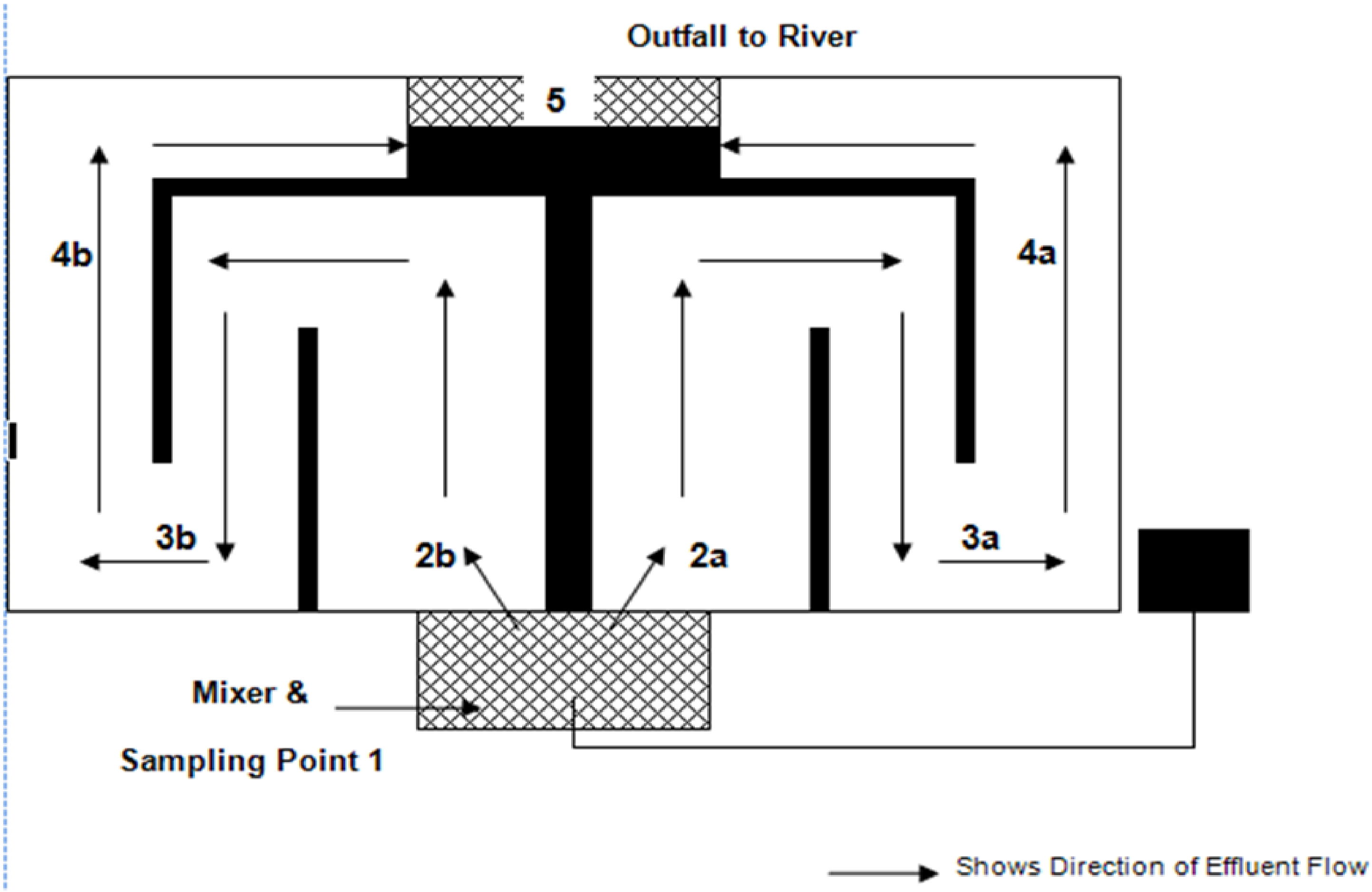

Figure 1: Disinfection Schematic

The results of these tests indicate that PAA is a fast acting disinfectant. As shown in Table 3, the initial fecal coliform counts were reduced 10 fold within the first 8-10 minutes estimated residence time after contact with the product (sample points 2a and 2b). Additionally, all PAA was consumed prior to discharge (sample point 5), demonstrating the lack of persistence of the PAA.

Table 3: Residual PAA in contact tanks and river outfall at a 5 ppm dose rate

Sample Point	Average PAA Residual (ppm)
1	n/a
2a	1.26
2b	1.21
3a	
3b	
4a	
4b	
5	
Outfall at River	.42

During the 5 ppm dose test, the flow rate of the effluent increased to 5678 m^3 / day which decreased the residence time to one hour. The PAA dose rate was verified to give a dose rate of 5 ppm; however, the highest number recorded during this test was 1.26 ppm. A sample at the mixer could not be obtained. The PAA decomposed rapidly with 0.42 ppm detected at the outfall. The purpose of the 5 ppm test was for river water testing; therefore no intermediate samples were taken. The final test was a repeat of the 1 ppm test that was performed in 2002. The results of this 1 ppm dose are shown in the Table 4 below:

Table 4: Residual PAA in contact tanks and river outfall at a 1 ppm dose rate

Sample Point	Average PAA Residual (ppm)
1	n/a
2a	0.8
2b	0.9
3a	0.3
3b	0.4
4a	0.25
4b	0.25
5	0
Outfall at River	0

During the 1 ppm dose study, the flow rate of the effluent varied from 2271 to 4542 m^3/day. This gave a residence time of between 67 and 133 minutes. All of the PAA was consumed before the wastewater reached the Huron River. These results are similar to the ones from the same test performed in 2002.

CASE STUDY: Frankfort, KY

The Frankfort, KY wastewater treatment plant evaluated PAA for use as a temporary disinfectant during an upgrade of their existing wastewater disinfection system (ozone). In 1980 the Frankfort wastewater treatment plant converted from chlorine gas to ozone for disinfection.

The plant was then upgraded from a 6.6 MGD plant to its current capacity of 9.9 MGD. In 2005 the decision was made to build a new higher capacity ozone generator in response to the higher capacity of the plant. Replacing the ozone generator necessitated a temporary disinfection technology during the 6 months between shut-down of the old generator and start-up of the new one.

After evaluating several disinfection technologies, including sodium hypochlorite and sodium bisulfite, the city went out to bid for a disinfection technology and PAA was chosen. This was the first commercial use of PAA for wastewater disinfection in the United States.

- The wastewater traveled through a static mixer and a disinfection chamber with a 26 minute contact time at permit flow. (See Figure 1).
- The target dose rate was automatically held constant based on the final effluent flow.
- Peracetic acid residuals at the discharge point were determined via a Chemetrics K-7905 test kit by Frankfort laboratory personnel.
- Bacterial analyses were performed daily by Frankfort laboratory personnel via the filtration method.
- BOD and pH analyses were taken daily by Frankfort laboratory personnel.

RESULTS OF THE CASE STUDY

- Within design flow conditions PAA 12% peracetic acid solution was effective at controlling fecal coliforms and E. coli. at a target dose of 0.7 ppm

- Effluent treated with PAA passed acute toxicity tests for Ceriodaphnia dubia.

- Treatments costs with PAA were competitive to disinfection with sodium hypochlorite and sodium bisulfite.

- Residual PAA in the wastewater at discharge was less than 1 ppm thereby eliminating the need of a neutralization step.

- No measurable effect was observed by Frankfort laboratory personnel on pH and BOD by the use of PAA for disinfection.

COSTS

Peracetic acid is applied to the wastewater process from a bulk or intermediate storage vessel directly into the wastewater. Typically a pump is used to transfer the PAA from the storage vessel into the secondary effluent. Good dispersion/mixing can improve the effectiveness of the amount of PAA added. The injection rate is controlled by proportional flow control from a 4-20 mA signal sent from the wastewater utility effluent flow measurement. Most systems in the USA receive PAA in containers not larger than 300 gallon one-way disposable totes. The single most expensive item (for tote systems) is a flow paced pump skid that cost less than $50,000 for a 50 MGD facility at 4 ppm PAA.

REFFERENCES

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