DEFINING THE MAXIMUM ALLOWABLE DISCHARGE LIMIT OF VIGOROX® WWT II (PERACETIC ACID) IN WASTEWATER EFFLUENT

VigorOx® WWT II Wastewater Disinfection Technology

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This edition of Disinfection Digest discusses the discharge limit of peracetic acid (PAA) into the environment and the incorporation of dilution factors in the assessment of a site-specific, risk-based residual PAA concentration in wastewater effluents.

HISTORICAL PERSPECTIVE ON PAA DISCHARGE LIMITS

The US EPA's approval of VIGOROX® WWT II as a wastewater and sewage effluent disinfectant in public and private treatment facilities set a maximum amount of PAA that can be discharged from a facility at 1 mg / L (ppm). However, the environmental risk and fate assessment of PAA by the US EPA did not provide a rationale as to how this value was set.

Likewise, many state regulatory agencies have set a maximum PAA discharge limit in the effluent at 1 ppm, without providing an environmental risk rationale associated with the selection of this concentration.

REVISED UA EPA APPROVAL OF VIGOROX® WWT II TREATED EFFLUENT

Subsequent to this initial effluent limit, the US EPA has approved the discharge of VIGOROX® WWT II in a wastewater effluent to be set in a site-specific manner, utilizing a dilution factor determined from the receiving water body flow and plant effluent discharge flow[1].

The selection of a site-specific, dilution-factor-based discharge limit is critical in insuring that the peracetic acid is properly dosed to meet the target microbial kill for a given wastewater water flow, while maintaining the established effluent limit. The residual peracetic acid concentration at the outflow of the plant is dependent upon several factors, including the concentration of PAA applied at the head of the disinfection chamber, the water quality oxidant demand on the PAA, and the contact time within the disinfection chamber:

Equation 1

$$[PAA]_{residual} = f([PAA]_{dosed}, [PAA]_{demand}, t)$$

Where [PAA] is the concentration of PAA in mg/L and t is the contact time in minutes.

As a result of Equation 1, setting a residual limit, without considering the conditions specific to the wastewater treatment plant, may arbitrarily establish a PAA application rate that exceeds the residual limit. Thus, for situations with short contact times, the allowable PAA concentration dosed may result in poor overall microbial kill. As a result, the required PAA dosage needed to meet a plant's microbial kill requirements may lead to a PAA residual in excess of the allowable 1 ppm limit, especially if the contact time is short and the water quality is high (little PAA demand).

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DILUTION FACTORS

Under a site-specific, dilution-factor-based residual limit, the maximum concentration that a treatment plant discharges can be calculated as:

Equation 2

$$[PAA]_{effluent} = f([PAA]_{receiving\ stream})(DF)$$

Where DF = dilution factor and $[PAA]_{receiving\ stream}$ is the PAA concentration in the receiving stream protective of sensitive aquatic species (see below).

The dilution factor for a specific location is determined as:

Equation 3

$$DF = \frac{plant\ effluent\ discharge + receiving\ stream\ 7Q10}{plant\ effluent\ discharge}$$

where the receiving stream 7Q10 is defined as the lowest seven--day average stream flow over a ten year period.

The 7Q10 value is common for environmental engineering design work[2]. The 7Q10 value also is often a part of the plant's NPDES permit, and as a result is available for many POTWs. It is a measure of low flow conditions and is a conservative value for use in determining dilution factors. As an example, a plant discharging 10 MGD into a receiving stream with a 7Q10 flow of 40 MGD would have a dilution factor of 5.

For an understanding of actual, real world dilution factors across the United States, the E-FAST3 database was evaluated to determine the dilution factors for POTWs (listed as standard industrial code 4952 in the database). The database is not complete for the over 19,000 POTWs listed, with only 9,026 records containing both the plant discharge rate data and 7Q10 flow rate data.

The distribution of dilution factors for these nine thousand POTWs are shown in Table 1.

Table 1

Distribution of Dilution Factors and PAA Discharge Limits Resulting in a Concentration of 0.09 ppm PAA in the Receiving Water Body

Percentile	Dilution Factor	PAA Effluent Discharge Limit (ppb)
Minimum	<12	1.0*
5th		
10th		
20th		
25th		
30th		
40th	12	1.06
50th	25	2.26
60th	55	4.94
70th	125	11.3
75th	204	18.4
80th	347	31.2
90th	1592	143
95th	6440	580

*Per the VIGOROX® WWT II label, for DF's less than 12, PAA effluent discharge limit is set to 1.0 ppm.

As can be seen from Table 1, the spread of dilution factors across POTWs in the US is broad. As a result, the determination of the allowable PAA concentration in the effluent should be based on specific site flow conditions, as approved by the EPA specific to VIGOROX® WWT II.

PROTECTION OF SENSITIVE AQUATIC ORGANISMS

Green algae is one of the most sensitive aquatic organisms to peracetic acid, with an EC50 (dose at which 50% of the population test is incapacitated) of 0.18 mg/L and a no observable effects concentration (NOEC) of 0.12 mg/L, based on laboratory studies. To be consistent with the US EPA risk assessment policy for acute exposure, a target risk quotient (or margin of safety) of 2 is needed. Thus, a target PAA concentration of 0.09 ppm was calculated to protect the most sensitive organisms in the receiving water body. This value, coupled with the dilution factor based on the 7Q10 flow, determines the target residual peracetic acid concentrations at the outflow. These values, based on various 7Q10 flows, are shown in Table 1. Table 1 indicates that fifty percent of the POTWs within the US, based on the available records in E-FAST, would have an allowable PAA residual at the outfall in excess of 2.3 mg/L or higher.

In addition, based on a theoretical study was conducted using the CORMIX4 modeling system to model the fate of VIGOROX® WWT II in three hypothetical receiving streams (river, lake and ocean), under a variety of effluent and receiving body flow rates and conditions. The study demonstrated that the PAA discharged into the receiving water body dissipates within relatively short distances, within tens of meters downstream of the discharge point in all cases. Thus, due to decomposition and dilution, peracetic acid concentrations drop steeply once entering the receiving stream, and as a result have little impact of the environment.

DEFINING THE MAXIMUM PAA EFFLUENT CONCENTRATION ON THE VIGOROX® WWT II LABEL

The US EPA approved revised labeling for VIGOROX® WWT II, which considers the need to protect sensitive aquatic life and site--specific dilution factors, with the following allowable discharge concentration:

a. 0.09 ppm * DF where DF ≥ 12

b. 1.0 ppm where DF < 12 or the 7Q10 receiving stream flow is not known

From Table 1, 60% of the wastewater treatment plants fall into the case of having a DF in excess of 12.

In conclusion, setting a site--specific, dilution--factor--weighted peracetic acid residual balances the protection of the most sensitive aquatic species with the ability to meet target microbial pathogen reduction. The dilution--factor--adjusted residual levels are conservative in nature, being based on the 7Q10 receiving body flow, which itself is a very conservative, low flow value, and a PAA concentration based on the most sensitive aquatic organism to PAA with a high margin of safety. In addition, the rapid decomposition of peracetic acid leads to a lack of persistence in the environment, coupled with PAA's formation of non--harmful byproducts (acetic acid and water), suggests that a set limit of 1 ppm as a residual concentration is not appropriate for all wastewater treatment plant effluents. Many wastewater treatment plants across the US may discharge PAA in concentrations above 1 ppm and still maintain low environmental impact on aquatic life.

REFERENCES

(1) Peroxychem VIGOROX® WWT II label, EPA registration No. 65402--8

(2) Thomann, R.V. and J.A. Mueller. Principles of Surface Water Quality Modeling and Control (Harper and Row, 1987).

(3) The US EPA program that provides screening – level estimates of the concentration of chemicals released ot the air, surface water and landfills. See www.epa.gov/oppt.exposure/pubs/efast.htm.

(4) CORnell MIXing Zone Expert System, developed by Cornell University. See Doneker, R.L and G.H.Jirka, "CORMIX User Manual: A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters", EPA-823-K-07-001, Dec 2007.

PeroxyChem LLC
2005 Market Street,
Suite 3200,
Philadelphia, PA 19103
United States

+1 267 422 2400
www.active-oxygens.com

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