College of Engineering
Department of Civil & Environmental Engineering
Water and Energy Technology Center

University of Massachusetts Amherst

Water - Energy Nexus

Evaluation Vortex Process Technology (VPT)

Evaluation of VPT on Oxidation Technology Performance for Drinking Water Treatment

Background

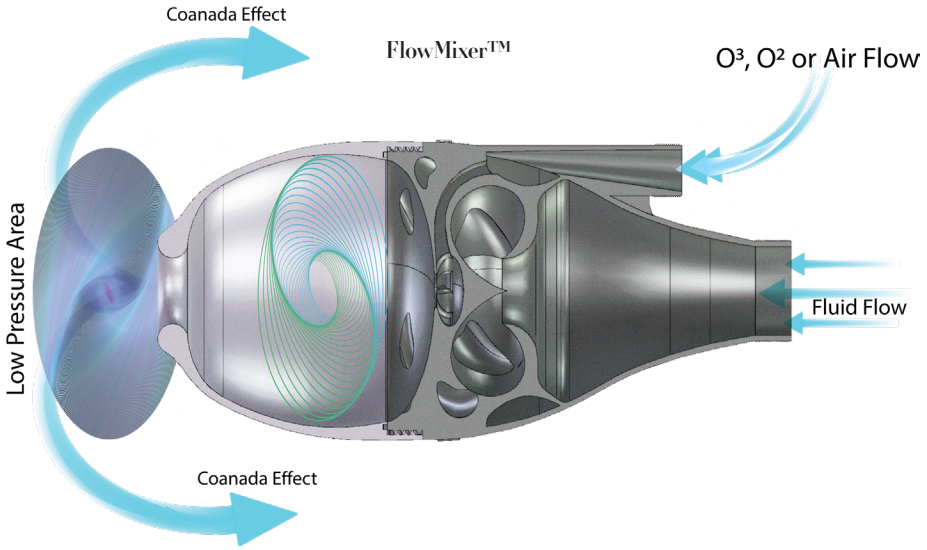
The Watreco Vortex Process Technology (**VPT**) was evaluated by the UMass Amherst Water Energy and Technology Center to determine its ability to improve the performance of modern water treatment oxidation technologies including ozone injection and LED-UV disinfection. The Watreco VPT includes two models: The Industrial Vortex Generator (**IVG**) model is designed to be installed in-line, under pressurized flow, and the FlowMixer™ (**FM**) model is designed to be installed in an open atmosphere tank or reactor. The FM promotes enhanced aeration and dissolution of gaseous chemicals by forming high concentrations of nano and microbubbles. The **IVG** creates a high strength cavitation, vortexed water that effectively decreases water viscosity and removes undissolved air bubbles.

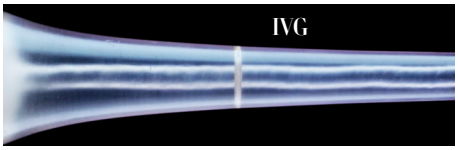
The UMass Amherst study titled, "Evaluation of VPT on Oxidation Technology Performance for Drinking Water Treatment," consisted of the following areas of performance evaluation:

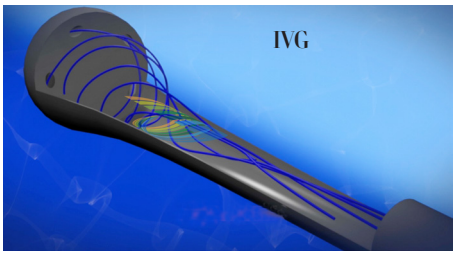
1. *Ozone dissolution and transfer efficiency and pre-ozonation performance compared to conventional chemical dosing systems*

2. *Removal of emerging drinking water contaminants coupled with the advanced oxidation technologies.*

3. *Evaluation of the VPT's ability to inactive or destroy biological contaminants such as Total coliform and E. Coli using LED-UV.*







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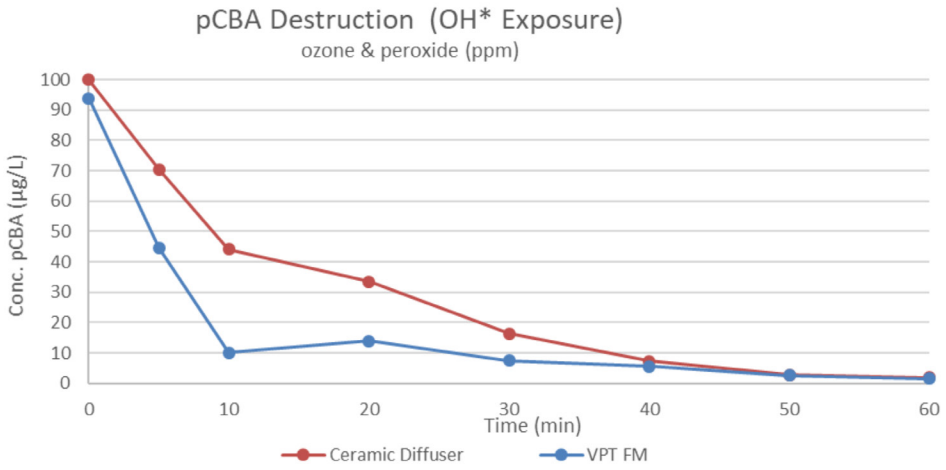
Discussion

Cavitation is used in numerous chemical processing industries, including drinking water treatment. The Watreco Vortex Technology (VPT) displays a higher degree of cavitation and observable vortex pathlength which improves upon conventional cavitation methods. The VPT should be considered as an optional treatment method to improve oxidation and/or advanced oxidation processes (AOPs) when adding or replacing existing cavitation methods. Para-chlorobenzoic acid (pCBA) was used as a model pollutant and probe compound to observe hydroxyl radical exposure in solution. The VPT demonstrated improved hydroxyl radical exposure to contaminants of interest compared to conventional contact reactors (e.g. simple feed pump or gaseous stone diffuser) (Figure 1). This indicates improved reactions between dosed oxidants and contaminants of interest.

The VPT IVG showed improved contaminate destruction of recalcitrant emerging contaminants Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonate (PFOS) when combined with advanced oxidation processes (AOPs) including ozone-peroxide and UV-peroxide. The maximum observed improvement was approximately 18%. Further research is being conducted to further develop treatment schemes which combine the VPT and advanced oxidative processes to achieve PFAS concentrations below the USEPA health advisory guidelines standards (≤ 70 ppt) and other State Regulations.

Figure 1 Destruction of pCBA by ozone oxidation with and without VPT FM device



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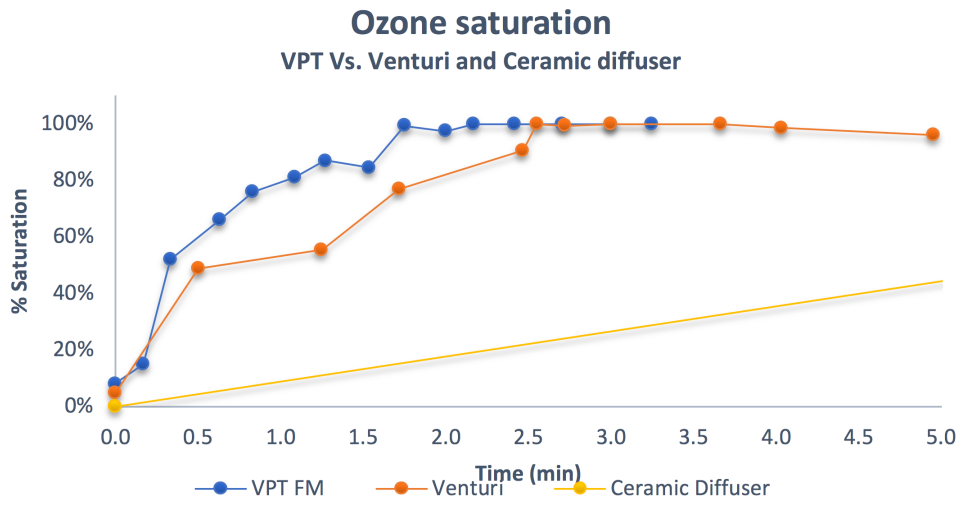
When coupled with ozone and hydrogen peroxide, the VPT FM also demonstrated a higher exposure of hydroxyl radicals than a conventional stone diffuser.

An increased transfer efficiency was observed for the dissolution of ozone to an open atmosphere ozone contactor when compared to a ceramic diffuser or common venturi. The VPT FM was able to complete ozone saturation at a rate outperforming the standard venturi by 40% in laboratory conditions and resulted in less ozone being wasted to atmosphere (Figure 2).

Figure 2 Ozone saturation performance by the VPT FM Vs. Venturi



The VPT IVG showed a moderate ability to kill bacterial contaminants including total coliform and E. Coli without any chemical addition, demonstrating the power of the device's cavitation. When a modern LED-UV was used both with and without the VPT IVG in a batch setting, improved bacterial destruction was observed throughout testing. After ~200 minutes of reaction time, the water treated with the VPT IVG and LED-UV resulted in an additional 2-log removal of total coliform (Figure 4). This is suspected to be a result of continuous bombardment of the coliforms by the cavitation and UV radiation over time. Since LED-UV is still considered an early stage technology compared to mercury-based UV, eventual improvements in LED-UV technology will hopefully lead to a significant reduction in required treatment time and operational costs, especially if coupled with the VPT IVG.

Figure 3 E. coli inactivation vs. time with no chemical addition using VPT IVG

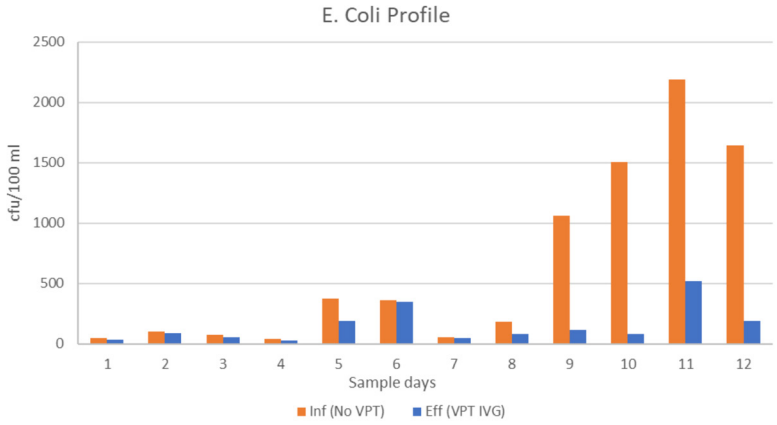
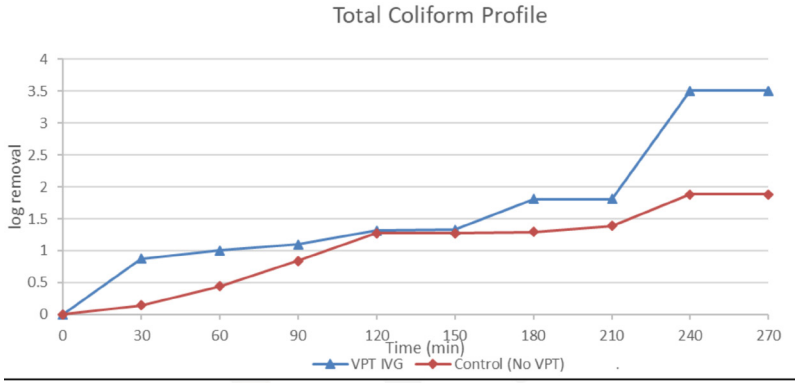


Figure 4 Total coliform inactivation vs. time for Canopus LED UV (Canopus Water Technologies, NY,NY) with and without VPT IVG.



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Recommendations

- Create pilot application assessment for mitigation of algae bloom events. The observed benefits of using the Flowmixer™ or IVG should have a positive impact on reducing total microcystins in ponds and lakes more cost effectively than traditional methods. The combination of improved oxidation by injection of ozone, hydrogen peroxide, oxygen from aeration and cavitation should be assessed in a scaled field application. Based on prior results at U Mass and other filed installations there is a high expectation of a positive return of investment for entities seeking to reduce the negative impacts of algae blooms.

- Create pilot application assessment for point of use or small scale potable water treatment. The goal is to scale up the testing conducted at U Mass that demonstrated improved contaminate destruction of PFOA, PFOS using the IVG/FLowmixer™ technology with advanced oxidation processes.

- Combining the VPT IVG with a conventional treatment method, such as UV or ozone, can improve the treatment performance depending on contaminant types and treatment goals. The combination of the LED UV unit and the VPT IVG showed improvement over the LED-UV treatment alone. The unique design of the LED reactor allowed for a cavitation to occur while being directly exposed to UV radiation. However, LED UV is a new technology and in need of further developments to achieve effectively achieve advanced oxidation processes. It is suggested that the VPT IVG be used to further test the VPT IVG combined with LED UV

- The VPT IVG demonstrated an improved inactivation efficiency of total coliform and E. Coli using the Canopus UV LED (Canopus Water Technologies, NY,NY). The IVG also showed some ability to inactive TC/EC as a stand-alone treatment device. However, the device is best suited to be coupled with an oxidation technology to improve bacterial inactivation. Further inactivation studies using chlorine, ozone, PAA, and peroxide may show improved TC/EC inactivation with less chemical use.

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