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Integrated ozone microreactor technology for water treatment

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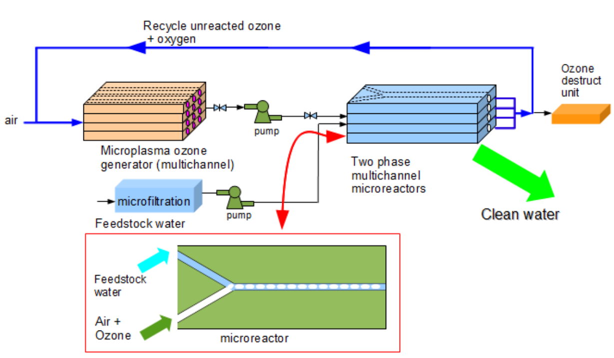
Safe and clean potable water is a basic primary need for daily living and the ability to process water using minimal expenditure of resources provides tremendous advantages. In this work, we present ozone process technology being developed at KWJ Engineering to decontaminate recovered potable water and greywater with a small energy footprint. The technology involves the in-situ local generation of ozone, a powerful broad spectrum disinfectant, generated from air. Unique microreactor technology integrated with a low power ozone source enables high efficiency mixing of water and ozone at high mass transfer rates for decontaminating a multitude of pathogens and chemical contaminants. The compactness and low power feature of microreactors and micro-ozone generators creates a portable and scalable system that can provide on the spot potable water in many situations such as disaster relief, rural communities, and space habitats.

The research was focused on two types of water a) recovered potable water and b) greywater. The demonstration includes a scalable and modular system using a reactor with millimeter size channels for enhanced mixing of ozone and water combined with a proprietary KWJ-designed microplasma ozone source. We achieved the integration of a micro-ozone generator [1] with a microchannel gas-liquid reactor, and have demonstrated the efficacy of bacterial destruction in a batch system using an ozone sparger. Further, organic chemical destruction was accomplished in the closed, continuous microreactor system. The greywater treatment showed a significant reduction of total suspended solids, fats/oils/grease, and turbidity (to < 25 NTU) by ozonation alone without any pre- or post-processing.

Several microreactor designs were tested to determine the optimum channel width and mixing length for water treatment applications. The microplasma ozone sources developed in this program were effective in batch experiments for the destruction of E.Coli in water. The E.Coli concentrations were reduced from 10^7 cfu/mL to 1 cfu/mL in less than 3 minutes under different ozone generator conditions which produced 70-100 ppm ozone.

The microreactor currently uses external mini-pumps and voltage controllers. Further miniaturization using micropumps and a modular microreactor design has been completed and testing is now leading us to an integrated structure capable of efficiently sanitizing water.

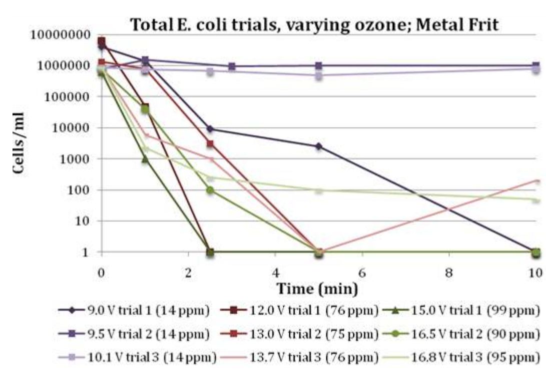


Conceptual schematic of water purification system

The system can be scaled up and adapted for autonomous or in-line operation and create a viable alternative or adjunct to current water purification technology. The system is intended to find applications in emergency kits for disaster relief equipment both small scale and medium scale, for point-of-use and point-of-entry applications such as the NASA space station, in local and remote situations, personal use such as campers, and possibly for municipal water management technologies due to its economical design, low resource footprint, and no need for consumable supplies other than ambient air.

The internal components include plastic “MEMS” structures that can be mass produced using lamination and coatings technology with low cost and weight. The new design results in a compact system that could be operated on solar-power or rechargeable batteries. A major advantage of microreactor technology is scalability which can make it possible to have a larger volume decontamination system made from thousands of microreactor channels to provide throughput of a few gallons per hour or higher. Municipal water systems are another application where the microbicidal and virucidal power to neutralize pathogens at the source of the water supply is important.

Environmental remediation of both groundwater and soils contaminated with industrial contaminants may also be possible with the proposed system. The statistics from the United Nations and the World Health Organization indicate that more than one in six people, or 894 million, do not have access to the 20-50 liters of safe freshwater required for daily human consumption. The microreactor system along with energy harvesting technology could function as a primary means of decontamination for small scale applications or can augment contemporary technologies along with filtration, to provide a comprehensive solution for larger scale water management. Mid-scale portable systems for military operations using water recycling technologies can also be realized using the micro-ozonation technology.



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1] Blanchard, William C. Distributed Plasma Ion Source (DPIS), assigned to KWJ Engineering. 7.157,721 B1 US, 2007.
2] NASA final report, September 2011, NNX11CH38P