Contribution ID: **14** Type: **Invited Oral**

Inactivation of water-transmissible viruses by combining advanced oxidation techniques

Tuesday, 19 September 2023 15:00 (30 minutes)

Water scarcity is among the most pressing problems of the modern world. Water usage estimates vary, but about 70% of worldwide water is used for irrigation for growing crops [1]. With the latest advancements in climate change and shortage of food, pressing issues with water scarcity will only escalate. Stated facts point to minimizing agricultural water usage, which can be achieved by expanding the network of closed-loop irrigation systems and innovative water management. Thanks to already improving irrigation management and practices, FAO estimates that the amount of water used by agriculture in developing countries will increase by only 14%. [1]. Using closed systems for water irrigation exposes several problems, like agrochemical residues, the balance of ions in the nutrient solution, and pathogens'spread. The latter is particularly pressing in closed-loop irrigation systems, as one single plant can release pathogens (bacteria, moulds, viruses) through the root system into the circulating water, infecting other plants. Some closed-loop irrigation systems use UV disinfection, which is economical but quite susceptible to water turbidity and requires several filters, while others, to a smaller extent, use membrane filtration, which is prone to constant filter cleaning. To address the spread of pathogens in closed-loop and semi-closed-loop irrigation systems, we have researched the possibility of joining two advanced oxidation methods: hydrodynamic cavitation and gaseous plasma. In this sense, we have designed a device that exploits the effect of hydrodynamic cavitation called the "supercavitation regime"that enables a formation of a single stable water bubble filled with water vapour [2]. In this way, we created conditions to ignite a gaseous plasma in water vapour and hence generate oxidizing species and, to a smaller extent, UV radiation. We built and tested two systems, small and medium scale, each with different characteristics for the inactivation of plant viruses. Systematic measurements were performed with MS2 bacteriophage, a surrogate for human enteric viruses, with both systems'best-achieved inactivation rate of 5-log. The method proved to be non-cytotoxic and efficient in inactivating (or even destroying) MS2 bacteriophage and is thus considered an environmentally friendly disinfection method as it uses no chemicals.

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Session Classification: Water Treatment

Track Classification: Water Treatment