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Inactivation of phyto-pathogens in water by solar photocatalysis

ABSTRACT

The high stress over the Earth´s hydric resources by the human activity is due to the indiscriminate use of fresh water and also to the chemical and microbiological contamination of the water resources. For this reason the scientific community has recently been focused on developing research for water treatment and recycling. In water reclamation it is critical to perform an effective treatment to reduce the hazardous chemical compounds and pathogens. The traditional techniques for treatment and purification of water solve a part of the problem but present certain limitations. For this reason there are different technologies under research focused on overcoming the drawbacks of the traditional techniques. The Advanced Oxidation Processes (AOP) are based on the generation of hydroxyl radicals (OH) that allow the mineralization of a large variety of organic compounds due to the high oxidation potential and low specificity. The oxidative properties of the AOP can also be used for the inactivation of microorganisms as it has been proven by the number of scientific publications during the last 15 years. Especially interesting are AOP that use solar radiation as source of photons, as this could allow for development of methods for water treatment at low cost and environmentally friendly. The main objective of this work is to explore the capabilities of different photochemical solar techniques for water purification and reuse. This work studies the efficiency of the different photocatalytic solar treatments for the inactivation of Fusarium spp and Phytophthora capsici spores. Both types of fungi are responsible for severe contamination of water and soils in agriculture. These spores are very interesting for this research because of their resistance to conventional water purification treatments and to environmental factors. Therefore, these spores used as target for disinfection permit to analyse the effectiveness of the several solar AOP studied in this work observing gradients in efficiency between the different methods evaluated. One of the treatments studied is the heterogeneous photocatalysis with titanium dioxide (TiO_2). This semiconductor generates OH radicals in water when it is illuminated with photons of wavelength lower than 390 nm and there is oxygen available. This catalyst has been previously studied in literature showing promising results in water disinfection. Other photocatalytic technique under investigation for water disinfection here was photo-Fenton using also solar radiation. It is based on a cycle of catalytic reactions promoted by iron salts, H2O2 and solar photons with wavelength lower than 580 nm. In this area the scientific contributions remain low. A large part of this experimental work has been accomplished with this technique, i.e., photo-Fenton with sunlight. As organic chemicals are removed, the disinfection by photo-Fenton shows high efficiency in the inactivation of the spores under evaluation. A new solar treatment with H2O2 also has been investigated. This is the first time that this treatment has been demonstrated to be capable for fungi inactivation in water at small and large scale. This process cannot be considered photocatalytic, it generates photochemical and photobiological changes that damage the viability of the microorganisms. This is novel in water disinfection and, given the positive experiment results, it could be considered as a low cost alternative for the treatment and reuse of wastewater for

agriculture. An aspect that affects mainly the photocatalytic efficiency of these solar treatments is the presence of organic and inorganic compounds that are naturally found in water. For this reason the different solar treatments evaluated were tested with different types of water:

(i) distilled water, where there are no interferences in the formation of OH radicals as no chemicals compounds are present;

(ii) water from a natural well, characterised for a high concentration of carbonates/bicarbonates;

(iii) Water prepared on lab to simulate the output of a wastewater treatment plant (WWTP). This water is used as experimental model to avoid the typical fluctuations in the chemical composition of the real effluents from WWTP and;

(iv) Real effluent from a WWTP (El Bobar, Almeria, Spain) with the corresponding amounts of chemical compounds (organic and inorganic) and microorganisms. These solar processes were initially investigated with small water volumes using bottled reactors (200 mL) in all water types. At this small scale it was possible to obtain preliminary results and evidences of the behaviour and efficiency of each process. Then all the processes under study were also elavualted on a 60 L solar CPC reactor. The experimental results demonstrated the high efficiency of the CPC system for inactivation of fungi spores using the three solar processes evaluated and with different types of water. This shows as well that these technologies can be applied in n CPC reactors successfully and itis an appropriate choice to consider for a real scale implementation in the future.