Photocatalytic mineralization of simulated medical wastewater. Oxidation kinetics, toxicity evaluation, phytotoxicity assessment.

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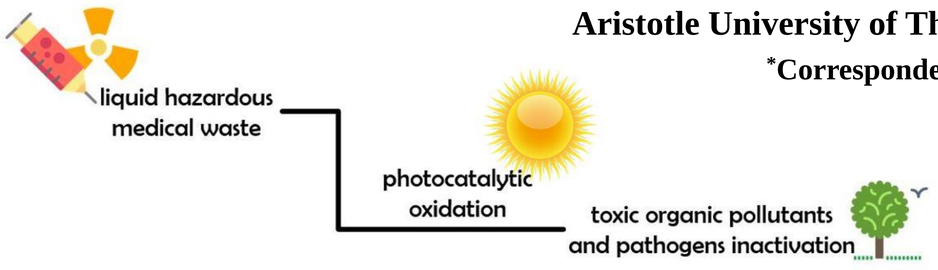
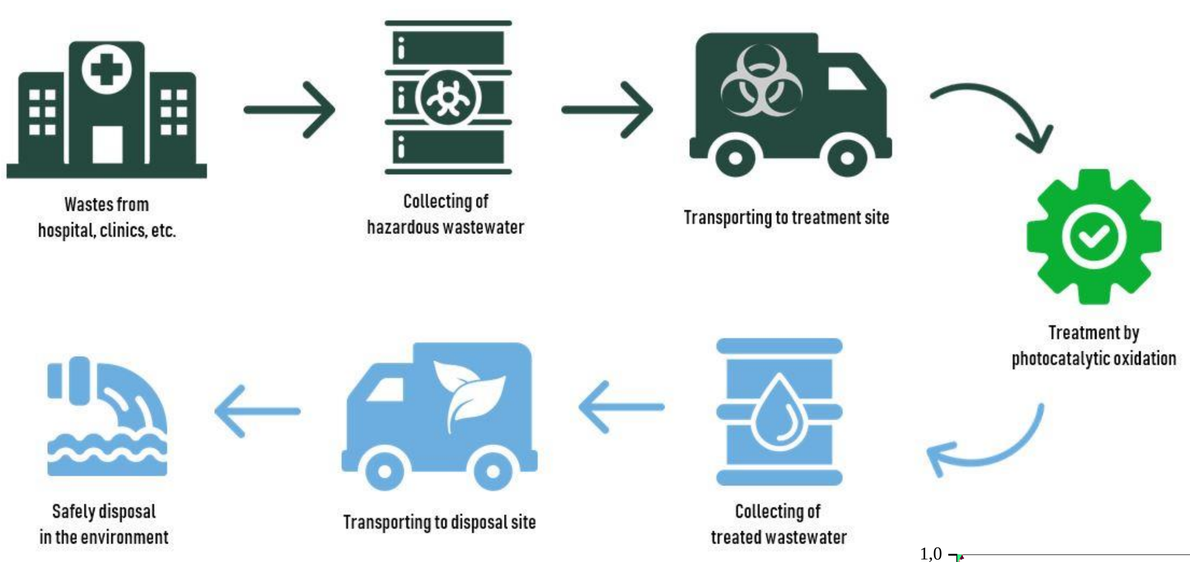


Problem, definition and objectives

Health units such as medical, biochemical and molecular laboratories produce liquid hazardous medical waste (LHMW). Depending on its composition, LHMW may be classified as toxic (LHMW-TC), infectious (LHMW-IN), or mixed (infectious and toxic, LHMW-MC). LHMW is heterogeneous regarding its constitution, a property that hampers the use of a universal processing method that would effectively deactivate any kind of pollutant and pathogen. Furthermore, application of currently available, traditional, liquid waste processing methods entails several intermediate processing steps that require expensive equipment, which results in high processing costs. Moreover, available methods are not fully effective at several cases, as they are unable to completely inactivate the abovementioned pollutants.

This study is part of a research project aiming to the development and application of a prototype for the photocatalytic inactivation of LHMW containing toxic pollutants and/or pathogens. The aim of this work was the implementation and optimization of heterogeneous and homogeneous photocatalytic oxidation that are able to completely inactivate both chemical organic pollutants and pathogens. More specific, in this work is presented the application of the preceding methods at the degradation of simulated medical wastewater, in order to provide a further insight to oxidation kinetics (i.e. determination of factors affecting oxidation rate) and estimate mineralization degree towards the corresponding oxidation process. Simulated medical wastewater was synthetically produced in the laboratory, taking into consideration the characteristics of real medical wastewater samples taken by local health units.



Strategy and methods

•*Photocatalytic experiments*

All photocatalytic experiments were conducted in a thermostated pyrex reaction cell of 0.5 L capacity (Figure 1), with an Osram Dulux® S blue UV-A lamp (9W/78, 350−400 nm) fitted centrally and a black cloth on it in order to avoid any interaction with ambient light (Figure 1). The radiation intensity was determined, using potassium ferrioxalate [$K_3Fe(C_2O_4)_3 \cdot 3H_2O$] actinometry, at $1.116 \cdot 10^{-4}$ Einstein min^{-1}.

Simulated medical wastewater aliquots were sampled at frequent time intervals and filtered through a 0.45 μm syringe filter in order to remove any catalyst or iron particle before any further analysis. Total volume of the withdrawn samples was not exceeded 2% of the initial suspension volume. The results shown in this paper is the mean values, since all photocatalytic runs were conducted in duplicate and, occasionally, in triplicate; standard deviation never exceeded 10%.

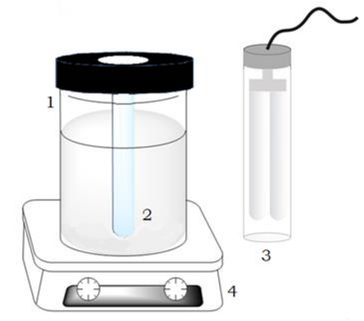


Figure 1. Schematic representation of UV-A-induced photocatalytic reactor1 thermostated pyrex cell of 500 mL capacity, 2 cylindrical sleeve where lamp (3) is inserted, 3 lamp, 4 magnetic stirrer

• *Analytical methods*

Sample absorbance was scanned in the 200-800 nm wavelength region on a Shimadzu UV-1700 spectrophotometer, while the changes were monitored to assess the extent of degradation that had occurred during photocatalytic treatment

A Shimadzu V_{CSH} Total Organic Carbon Analyzer was used to measure the dissolved organic carbon (DOC) as a monitoring indicator of mineralization, while pH was determined with a Mettler Toledo S20 SevenEasy pH meter. Colorimetric determination with MQuant™ Peroxide test strips and spectrophotometric detection (Shimadzu UV-1700, 410 nm, glass cuvettes, 1 cm path length) with titanium (IV) oxysulfate-sulfuric acid solution according to DIN 38409 H15 were used for residual H_2O_2 measurement.

Moreover, phytotoxicity tests were carried out employing the eukaryotic plant species Sorghum saccharatum and Lepidium sativum.

Results

• The effect of TiO_2 loading on the mineralization of simulated medical wastewater was studied under varying amounts of TiO_2 i.e. 0.5, 1, 1.5 and 2 g L^{-1}, in the presence of 3 g L^{-1} H_2O_2 (inserted in 5 equal doses). In the experimental runs where the TiO_2 loading was above 1 g L^{-1} almost 90% of the organic load was mineralized within 720 min of illumination (Figure 2).

• In the case of photo-Fenton process, the increment of ferric ions from 0.014 to 0.112 g L^{-1} led to a remarkable improvement, with more than 90% mineralization percentage to be achieved from 900 min to 480 min (Figure 3).

• From Figures 4 and 5 it can be deduced that the homogeneous photocatalytic oxidation of simulated medical wastewater resulted in limiting the phytotoxic properties of the raw effluent, in both tested plant species

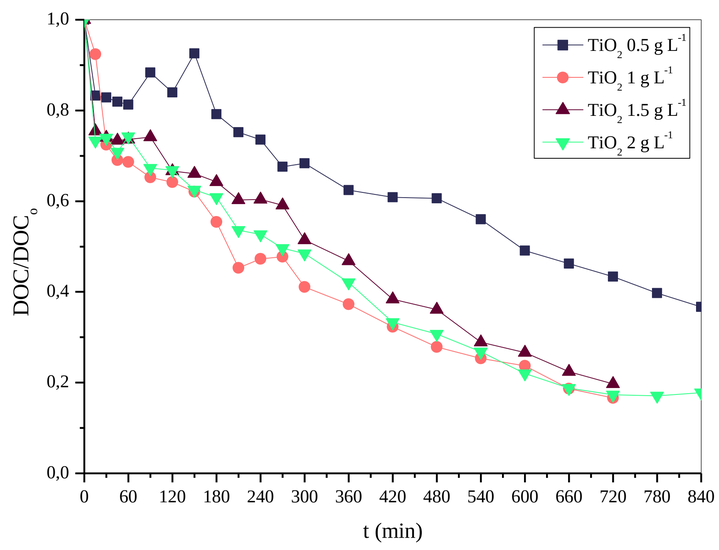


Figure 2. Effect of TiO_2 amount on smww heterogeneous photocatalytic mineralization (initial conditions: 0.3 g L^{-1} smww, 3 g L^{-1} H_2O_2, UV-A illumination).

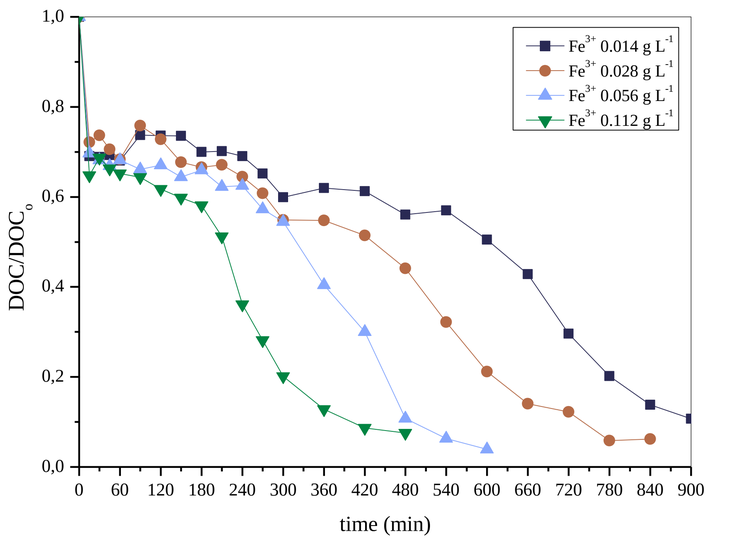


Figure 3. Effect of Fe^{3+} dosage on smww homogeneous photocatalytic mineralization (initial conditions: 0.3 g L^{-1} smww, 3 g L^{-1} H_2O_2, UV-A illumination).

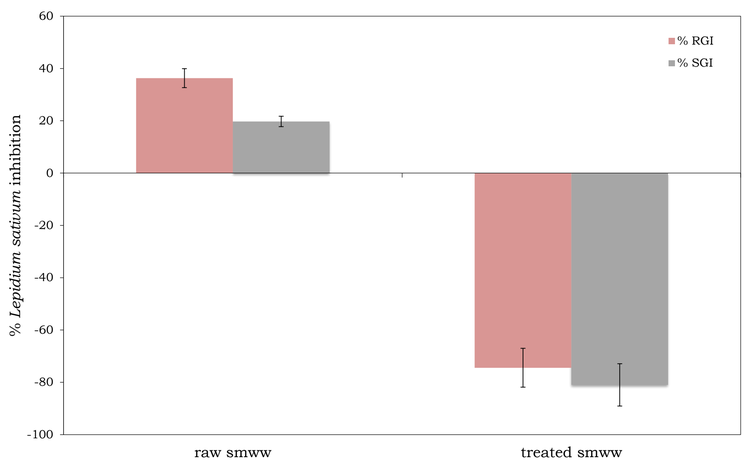


Figure 4. Inhibition effect (%) of smww before and after homogeneous photocatalytic oxidation on *Lepidium sativum.* GI-Germination Inhibition; RI-Root Growth Inhibition; SI-Shoot Growth Inhibition

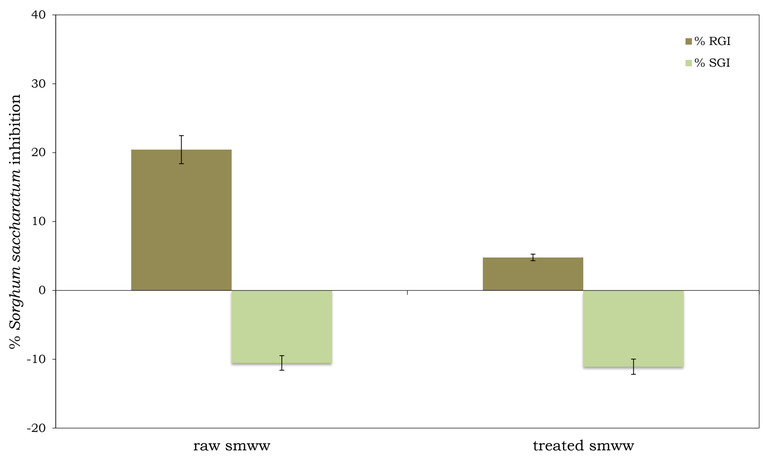


Figure 5. Inhibition effect (%) of smww before and after homogeneous photocatalytic oxidation on *Sorghum saccharatum.* GI-Germination Inhibition; RI-Root Growth Inhibition; SI-Shoot Growth Inhibition

Acknowledgments

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