Groundwater pollution: an energy consumption challenge for electrochemical advanced oxidation processes

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Groundwater represents one of the primary freshwater sources, but its pollution is rapidly increasing, and the development of tailored processes is mandatory [1]. In this scenario, electrochemical advanced oxidation processes (EAOPs) represent a promising alternative to face this issue. Nevertheless, their application to groundwater is limited by low electrical conductivity, directly affecting cell voltage and energy consumption [2,3]. Three different approaches to overcome this constrain are compared using a BDD anode for the oxidation of Mecoprop herbicide. The first is the addition of a supporting electrolyte as sodium sulfate (Na2SO4); despite its efficacy to reduce energy consumptions, some new problems are introduced in water source management and treatment plant for the electrolyte removal. An alternative approach is the reduction of gap-electrode from 5 mm up to some microns, equivalent to the thickness of a plastic mesh, used to avoid electrodes short-circuit. The third innovative method proposed here is the substitution of insulated mesh with an ionic conductor layer, a solid polymer electrolyte (SPE), like Nafion®117 sandwiched between the electrodes. This modification allows increasing electrochemical performance such as herbicide and COD removal, preserving energy consumptions. Indeed, the new cell setup shows a lower cell voltage (-31%) with a beneficial impact on energy consumption. An improvement in COD degradation is reached (from 70% with Na_2SO_4 addition over 90% with SPE). Moreover, SPE does not show any performance deterioration in the first 30 hours of utilisation. The results suggest that the usage of SPE can be a promising approach for the treatment of groundwater.

In the second part of the talk, we will provide an energy consumption and removal efficiency analysis to compare the SPE-based system with the conventional groundwater treatment process. The aim is to highlight the strengths and weaknesses of the new proposed cell configuration and possible future groundwater treatments improvements.

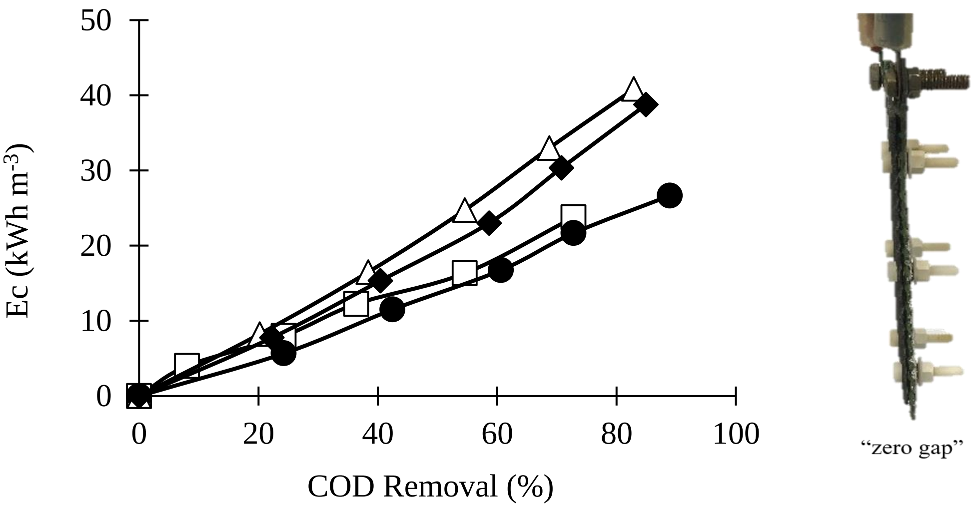

Figure 1 (LEFT) Energy consumptions as a function of COD removal during the degradation of MCPP with (□)50 mM Na_2SO_4 + 5 mm electrode gap, (△) 0 mM Na_2SO_4 + 3 mm electrode gap (◆) 0 mM Na_2SO_4 plastic mesh electrode separator(●) 0 mM Na_2SO_4 + SPE as electrode separator. Operating conditions [MCPP] = 100 mg L^{-1}; I = 0.5 A; stirring rate = 800 rpm. (RIGHT) Side view of SPE-based electrochemical cell

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[2] D. Clematis, M. Panizza, *Current Opinion in Electrochemistry 26 (2021) 100665*
[3] D.Clematis, G. Cerisola, M. Panizza, *Electrochemistry Communications 75 (2017) 21*