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NanoMembraneWater: development of innovative hybrid processes for contaminated water treatment using nanoporous membranes

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ABSTRACT

This study aims at the development of a hybrid process for the efficient treatment of water and potentially of wastewater, by the combination of ozonation and membrane filtration and the investigation of the complete ozone utilization by the employment of a novel ceramic membrane reactor concept. The advantages of the process are mainly referred to the achievement of a homogeneous (down to microscale) transfer and distribution of ozone ("bubbles aeration") within the main body of bulk water stream, which results in very efficient oxidation. Ceramic membranes were prepared initially, in order to investigate the single filtration of groundwater; tubular shaped nonsymmetric ceramic membranes were developed and their efficiency was examined for the removal of As-loaded water. Microporous γ-Al_2O_3–17Fe (molar ratio Al and Fe: 1:1) membrane was found to adsorb the pollutant As (V) ions up to 95%. The combined process of ozonation and membrane filtration was examined in a bench scale unit, where ozone was added through a ceramic diffuser at low flow rates, under continuous and intermittent modes. Simulated ground and surface water containing 25 mg L^{-1} of kaolin and humic acid was fed to the reactor; it was found that the intermittent mode of ozone addition was beneficial over the continuous mode of operation, resulting in lower trans-membrane pressure values. However, the hybrid process of ozonation-membrane filtration resulted in a lower quality effluent with a higher Total Organic Carbon content, possibly due to the effect of ozone on organic substances: ozone resulted to the dissociation of large molecular weight compounds and the formation of smaller molecules that could easily pass through the membranes in the effluent. In addition, a new hybrid ozone-filtration unit has been constructed. In this unit, the water to be treated flows through the inner side of a tubular membrane while gaseous ozone stream flows along the outer. An appropriate pressure drop gradient causes ozone to flow towards the inner water stream through the nanopores of the ceramic membrane, causing oxidation (and decomposition) of

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the organic substances or complexes, which are present in the water stream. The retentate stream of the first step represents the influent to the second step where the removal of ions is achieved by ceramic membranes (ultrafiltration).

Keywords: Ceramic membranes; Ozonation; Water treatment; Hybrid process