

Abstract

The indirect reuse of water requires the careful control of the quality of the treated wastewater. More than 95% of the wastewater is undergone incomplete treatment prior to the discharge into surface water or reuse. New approaches are needed to mitigate the risks associated with non-biodegradable recalcitrant pollutants (pesticides, pharmaceuticals, personal-care products, perfluoroalkyl-substances / PFAS), and pathogens remaining in the effluents of the wastewater treatment plants, and produce potable water. In this manner, recycled water in accordance with European Union directives will be produced for multiple uses. The main contaminants remaining in the effluents of Sewage Treatment Plants (STP) are emerging pollutants, associated with long-term health effects, and pathogens that may cause diseases in short-term. Microfiltration, ultrafiltration, and reverse osmosis are commonly used for the direct reuse of potable water. However, the process efficiency decreases due to the fouling of membranes and the need for frequent module replacement. On the other hand, advanced oxidation process (AOPs) such as UV-treatment, photocatalysis, ozonation, electro-oxidation, photo-Fenton, or their combination (hybrid AOPs) are capable to dissociate recalcitrant pollutants and pathogens. However, in most cases, the complete mineralization of organic molecules is not attained very fast and a time-consuming and very expensive treatment of the water stream is required. On the other hand, during a fast AOP-treatment, the decomposition of pollutants leads to the generation of intermediate products which might be equally if not more toxic than the parent molecules. The removal of such compounds by other methods, such as the adsorption could accelerate the reduction of the factors controlling the water quality (e.g. COD, BOD, TOC, NO₃⁻, PO₄³⁻).

In the context of OXADIPR project, a technology is proposed for improving the quality of water outflowing from STP units to make it suitable for indirect potable reuse. A synthetic contaminated water (SCW) containing recalcitrant contaminants representative of those encountered in typical effluents of STPs will be prepared. Three standalone and/or hybrid AOPs (e.g. photocatalysis, electrochemical oxidation, ozonation) will be selected and tested in batch/semi-batch experiments to quantify the degree of contaminant degradation and intermediates generated due to partial oxidation. One or two types of agricultural wastes will be selected to fabricate low-cost bio-sorbents (biochar/activated carbon), and tested as materials for the non-selective sorption of non-degraded species and intermediate byproducts. A method will be selected for the cost-effective and sustainable adsorbent regeneration. Based on the kinetic data of AOPs and sorption from lab-scale studies, alternative configurations coupling AOPs with adsorbents into an integrated continuous flow process will be suggested. Specific computational fluid dynamics (CFD) numerical models of the coupled processes will be developed. Setting the water treatment capacity to a fixed value (~10L/min), the alternative configurations of AOPs and adsorbents will be tested with the aid of CFD models, and the most efficient integrated process will be chosen to design, and manufacture a continuous flow pilot unit. The performance of pilot unit will be tested with real effluents of STP for water purification at levels satisfying the standards for indirect potable reuse. The results of pilot tests will be used for a life cycle analysis to assess the environmental impacts, and for calibrating the numerical model, which will further be used to design a large industrial unit. Simulations in the large-scale facility will be utilized for cost benefit analysis and benchmarking. Project results will be disseminated to academic society, stakeholders and public with scientific publications, conference presentations, workshops, website, leaflets, press releases, and social media.



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