World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:12, No:03, 2018

Degradation of Emerging Pharmaceuticals by Gamma Irradiation Process

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Abstract : Gamma irradiation applied in removing pharmaceutical contaminants from wastewater is an effective advanced oxidation process (AOP), considered as an alternative to conventional water treatment technologies. In this purpose, the degradation efficiency of several detected contaminants under gamma irradiation was evaluated. In fact, radiolysis of organic pollutants in aqueous solutions produces powerful reactive species, essentially hydroxyl radical (·OH), able to destroy recalcitrant pollutants in water. Pharmaceuticals considered in this study are aqueous solutions of paracetamol, ibuprofen, and diclofenac at different concentrations 0.1-1 mmol/L, which were treated with irradiation doses from 3 to 15 kGy. The catalytic oxidation of these compounds by gamma irradiation was investigated using hydrogen peroxide (H_2O_2) as a convenient oxidant. Optimization of the main parameters influencing irradiation process, namely irradiation doses, initial concentration and oxidant volume (H_2O_2) were investigated, in the aim to release high degradation efficiency of considered pharmaceuticals. Significant modifications attributed to these parameters appeared in the variation of degradation efficiency, chemical oxygen demand removal (COD) and concentration of radio-induced radicals, confirming them synergistic effect to attempt total mineralization. Pseudo-first-order reaction kinetics could be used to depict the degradation process of these compounds. A sophisticated analytical study was released to quantify the detected radio-induced radicals (electron paramagnetic resonance spectroscopy (EPR) and high performance liquid chromatography (HPLC)). All results showed that this process is effective for the degradation of many pharmaceutical products in aqueous solutions due to strong oxidative properties of generated radicals mainly hydroxyl radical. Furthermore, the addition of an optimal amount of H_2O_2 was efficient to improve the oxidative degradation and contribute to the high performance of this process at very low doses (0.5 and 1 kGy).

Keywords : AOP, COD, hydroxyl radical, EPR, gamma irradiation, HPLC, pharmaceuticals
Conference Title : ICWTT 2018 : International Conference on Wastewater Treatment and Technologies
Conference Location : Paris, France
Conference Dates : March 15-16, 2018