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Elimination of antibiotic resistance in treated urban wastewater by iron-based advanced oxidation processes

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ABSTRACT

Effluents from sewage treatment works are a major source of antibiotic resistance and thus create a serious risk to public health and in ecosystems. In this work, the application of alternative advanced treatment systems including iron-based heterogeneous and homogenous photochemical advanced oxidation processes (AOPs) were examined for the elimination of antibiotic resistant bacteria and their genetic materials in tertiary treated urban wastewater. Within the scope of this study, zero-valent iron (Fe^0) and goethite (α-FeOOH)-activated hydrogen peroxide (HP) oxidation as well as UV-A light-assisted photo-Fenton and photo-Fenton-like ($Fe^{2+/3+}$/HP/UV-A) treatment systems were applied to simulated tertiary urban wastewater bearing the conjugative, multi-antibiotic resistance plasmid RP4 carrier, multi-resistant *E. coli* J53 strain. Dissolved organic carbon (DOC) removals and in particular disinfection performance (removal of antibiotic resistance) were assigned as the target parameters and compared with those of conventional disinfection processes (chlorination, ozonation and UV-C radiation) by measuring inactivation of the selected multi-resistant bacteria and their genetic materials. Among the conventional disinfection methods, UV-C treatment at low doses was most effective in bacterial inactivation and reducing the gene copy numbers, followed by chlorination at high doses, whereas ozonation resulted in appreciable DOC reduction but was not very effective in reducing the gene copy numbers even at elevated doses. Fe^0, Fe^0/HP, and α-FeOOH, α-FeOOH/HP treatment systems were successful in removing DOC but exhibited very poor performance in the elimination of multi-resistant *E. coli* J53. Regarding the homogenous, photochemical iron-based AOPs, the photo-Fenton-like process was most efficient in DOC removal, whereas photo-Fenton treatment appeared to be superior in terms of bacterial inactivation. The genetic material of multi-resistant super bacteria was not efficiently removed by the application of selected homogenous photochemical, iron-based AOPs. Conclusively, although iron-based AOPs have a great potential in this application area, apparently inactivation of super bacteria and their genes by high-dose conventional disinfection remains the best option.

Keywords: Urban wastewater; Disinfection; Iron-based advanced oxidation processes; Multi-resistant *E. coli* J54 bacteria; Antibiotic resistant bacteria; Antibiotic resistance genes

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