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Treatment of water contaminated with diphenolic acid by gamma radiation in the presence of different compounds

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HIGHLIGHTS

- Gamma radiation was effective to remove diphenolic acid (DPA) from aqueous solution.
- The solution pH had a major influence on DPA degradation, which was highest at pH 7.
- DPA degradation was reduced in the presence of Br^-, Cl^-, CO_3^{2-}, NO_2^-, NO_3^-, and SO_4^{2-}.
- Lower degradation rate were obtained with wastewater than with ultrapure water.
- Both TOC and toxicity decreased during DPA degradation in all water types studied.

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ABSTRACT

The elimination of diphenolic acid (DPA) from contaminated water is an urgent challenge. The aim of this study was to investigate DPA degradation by gamma radiation, studying the influence of the dose rate, initial DPA concentration, solution pH, the presence of O_2, and the presence of different additives (e.g., Br^-, Cl^-, CO_3^{2-}, NO_2^-, NO_3^-, and SO_4^{2-}). A further objective was to study the effect of the water matrix (ultrapure water, surface water, and wastewater) and the variation in total organic carbon and toxicity as a function of absorbed dose. Results obtained showed that: gamma radiation was effective to remove DPA from aqueous solution; the dose constant was slightly dependent on the dose rate; and the solution pH had a major influence on DPA degradation, which was highest at pH 7. DPA degradation was reduced in the presence of Br^-, Cl^-, CO_3^{2-}, NO_2^-, NO_3^-, and SO_4^{2-} and was lower with higher concentrations of these species, largely due to their competition with DPA for the reactive radicals generated, especially $HO^{\cdot}$. Lower yield of DPA decomposition were obtained with wastewater and surface water than with ultrapure water due to the presence of organic matter and HCO_3^-, Cl^-, SO_4^{2-}, and NO_3^- ions, which react with the reactive radical species ($HO^{\cdot}$, $H^{\cdot}$ and e_{aq}^-). The TOC and toxicity of the medium decreased during DPA degradation in all water types studied.

1. Introduction

Endocrine-disrupting compounds (EDCs) are natural and synthetic chemicals that cause adverse effects in humans and animals by influencing the endocrine system. They are considered to be a significant cause of reproductive and sexual disorders in animals [1]. Various EDCs are released into the aquatic environment, mainly *via* the effluent of sewage treatment plants [2]. EDC concentrations detected in the aquatic environment range from ng/L to μg/L [3,4]. Even at low concentrations, EDCs can pose a serious threat to the endocrine system of humans and animals.

The widespread presence of EDCs in waters indicates that they are inadequately removed by conventional wastewater treatment processes and are eventually released into surface waters [2]. Advanced oxidation processes (AOPs) have been proposed as alternative methods for the treatment of EDCs [5–9]. They are based on the generation of species with high oxidizing power (e.g., $HO^{\cdot}$ radicals), which interact with the pollutant, degrading it into byproducts with lower molecular weight and even achieving its complete mineralization. However, the oxidative pathway is very slow for some pollutants, for which reductive radicals (e.g., electrons, e_{aq}^-, or hydrogen radicals, $H^{\cdot}$) are more effective [10].

Ionizing radiation is a promising water treatment option because it simultaneously generates oxidizing and reductive radical species ($HO^{\cdot}$, $H^{\cdot}$ and e_{aq}^-) from water radiolysis (Eq. (1)) [11], allowing the degradation of a wide variety of compounds. Guo et al. [12]

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