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Chemical and microbiological investigation on radiolytic degradation of antibiotic Amoxicillin in water

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The occurrence of antibiotics in wastewater effluents and their release into natural waters have significantly contributed to the development of antimicrobial resistance, posing an ultimate threat to human health. Resolving the issue becomes further challenging by the poor removal efficiencies in conventional wastewater treatment techniques. Advanced oxidation processes like gamma irradiation, have gained attention as better alternatives. In the present study, gamma radiation induced degradation of antibiotic Amoxicillin in aqueous medium was studied with the objective of examining the effectiveness of the gamma irradiation treatment. Aqueous solutions with variable initial concentrations of Amoxicillin trihydrate were irradiated at ^{60}Co gamma irradiation facility for varying radiation doses between 0.5 and 7 kGy. The irradiated solutions were directly analyzed using UV-visible spectrophotometry and High-Performance Liquid Chromatography (HPLC), while Fourier-Transform Infrared (FT-IR) spectroscopic and Proton Nuclear Magnetic Resonance (NMR) spectroscopic analysis were performed after freeze-drying. Antimicrobial activity was determined by the Agar well diffusion method against bacteria species *Staphylococcus aureus.* The aforementioned chemical and microbiological analysis were performed compared to the unirradiated solution (control) and the HPLC analysis results were utilized for the construction of the degradation curves. In comparison with the control, the disappearance of characteristic peaks of Amoxicillin including UV absorption at 228 nm, IR peaks at 1770 cm^{-1} and 1313 cm^{-1} and signature NMR peaks of the β-lactam ring, was observed in irradiated solutions. In HPLC analysis, the peak area of retention time corresponding to Amoxicillin was reduced by irradiation, while a number of new peaks emerged. Shifting of UV-Visible baseline to higher values, emergence of a new UV absorption band at 350 nm and gradual decrease of bacterial growth inhibition area with the increasing radiation dose were among the other observations of the study. Based on the chemical and microbiological experimental results, it was concluded that the effective destruction of the β-lactam chemical structure of Amoxicillin in an aqueous medium was feasible using gamma irradiation, leading to the elimination of its bioactivity.

Keywords: Amoxicillin, Gamma radiation, Degradation, Water radiolysis