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How do the environmentally persistent free radicals impact chemical element behaviour in the soil–plant system?

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Environmentally persistent free radicals (EPFRs) are increasingly recognized as emerging contaminants due to their potential environmental and human health risks associated with oxidative stress. Characterised by prolonged stability, ranging from minutes to several months, EPFRs are particularly abundant in engineered transitional matrices such as biochar. Their persistence extends their influence beyond the primary matrix, affecting associated environmental compartments, including soil and plant systems, when biochar is applied as an amendment.

This study examined the role of EPFRs in modulating the uptake of chemical elements (CEs) by plants under field conditions. Over two years, biochar and fertilizers were incorporated into agricultural soil for winter triticale cultivation. A suite of analytical methods, including EPFRs quantification, bioaccumulation indices, biophilicity assessments, and dynamic factor analysis, was employed to elucidate the interactions between EPFRs, soil properties, and CE bioavailability.

Findings indicate that EPFRs significantly alter soil characteristics relevant to CE mobility and plant uptake. Changes in CE transport dynamics within the soil–plant continuum suggest that EPFRs influence the biogeochemical cycling of elements, thereby affecting plant nutrient acquisition and potential accumulation of hazardous elements. Notably, this study presents the first evidence of EPFR-induced modifications in CE bioavailability and bioaccumulation intensity, highlighting an increased uptake risk of certain toxic elements, such as chromium (Cr), by plants. These findings underscore the necessity for further research into the environmental implications of EPFRs in agroecosystems and their potential role in shaping element mobility within terrestrial environments.

Reference

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