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Ecotoxicological Impact of Microplastics-driven stress on Agroecosystems: A study on Soil health and *Spinacia oleracea*

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Microplastics (MPs) are pervasive emerging contaminants increasingly detected in terrestrial ecosystems, particularly agricultural soils. In India, MPs enter agroecosystems through irrigation pipes, mulch sheets, compost and insecticides. While the occurrence of MPs has been widely reported, less attention has been given to the functional impacts of abundant polymer types on agroecosystems (Soil-plant systems). This study focuses on the impact of four most abundant MP polymers, named as polyethylene terephthalate (PET), polyvinyl chloride (PVC), polypropylene (PP), and polystyrene (PS) on soil and plant physicochemical characteristics. The MP powder was used at various concentrations, 0.02%, 0.1% and 0.2%, (w/w) MP/soil. *Spinacia oleracea* (Spinach) was used as a model plant in this study. To assess soil health pH, electrical conductivity (EC), available NPK, organic matter, organic carbon, water holding capacity, micro-macro nutrient analysis, and microbial activity using fluorescein diacetate (FDA) hydrolysis were performed. Moreover, plant growth responses were assessed through growth parameters (fresh and dry weight, root and shoot length), heavy metal accumulation, and photosynthetic parameters (chlorophyll a & b, and carotenoid). The findings highlight that all the MPs used in the study impede plant growth, each with concentration-dependent responses. At 0.1% & 0.2% concentration, changes in soil pH and EC were significant as compared to 0.02%, indicating alteration in ionic balance. Also, a change in water retention behaviour may suggest MPs possible impact on the interaction between roots and soil. Reduced FDA activity implies that there is stress on the microbial community. The concentration of total chlorophyll varies from 1.55 to 12.06 mg/L, whereas the concentration of carotenoid ranged from 0.05 to 0.42 mg/g, indicating plant stress. The accumulation of heavy metals also showed that MPs could facilitate the transport of co-contaminants. Among all the tested MPs, PVC causes more stress on plant growth by inducing root and shoot length, leaf area, plant biomass, chlorophyll and carotenoid content. These results emphasise the potential risks involved with MPs in agroecosystems. These understandings are essential for evaluating the impact analysis on agroecosystems and developing novel remediation strategies.