Abstract of Ph.D. thesis titled

**Application of nanoparticles contaminated water on Spinacia oleracea: Effect on ZnO fate, plant growth and biochemical parameters and ZnO- root exudate interactions**

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Nanoparticles are emerging contaminants which are now increasingly being detected in environmental media, whose reuse for the purpose of irrigating crops poses two main questions: (a) what happens to the nanoparticles in the rhizosphere before their uptake by the plants, and (b) once the plant uptakes them, how does it affect the different parts of the plant, i.e. shoot and root. To answer these questions, the objectives of this work were designed. Spinach plants were weekly irrigated with synthetic groundwater dosed with ZnO nanoparticles at concentrations of 0.1 and 10 mg/L and harvested at 30, 45, and 60 days after sowing. The roots of the plants decreased the rate of the total organic carbon exudation as the age of the plants increased. The amino acid exudation rate by the roots of the youngest spinach plants was affected. 10 pm ZnO NPs irrigated plants showed the highest root exudation rates in terms of TOC (17.35 ± 4.23 mg TOC/ g root biomass/ day), carbohydrates (19.76 ± 1.36 mg dextrose/g root biomass/ day) and amino acids (14.44 ± 3.79 mg leucine/ g root biomass/day). Although the shoot length, biomass, and chlorophyll content remained unaffected, the biochemical parameters H2O2, MDA, and flavonoids were significantly enhanced. The nutritional quality (Zn, Ca, Mg, Fe) was also found to be affected due to NP exposure. Iron content in spinach shoots was found to be enhanced for young plants by at least 43.47%, while it was reduced in the long term for old spinach plants by at least 9.64%. The allocation of zinc to the upper ground portion of the plants reduced as the as the plants aged. The transformation of the nanoparticles in the rhizosphere of a soil-plant system was also studied. Their aggregation was affected by the interaction of the TOC of root exudates, concentration and type of nanoparticles. CuO NPs settled more than ZnO NPs and high SRE TOC promoted higher dissolution as 12.70% Cu and up to 63.36% Zn of initial metal content remained in solution as ions after 7 days. High TOC levels of root exudates promoted higher dissolution, while modifying the surface of nanoparticles. The presence of EPS did not bring significant changes in either the median hydrodynamic diameter or metal content when compared with non-EPS matrices. Both surface (XPS) and bulk (FTIR, CHN, TOC) methods revealed that the coating of organic molecules changed the surface of the nanoparticles. This study expands the scientific community's knowledge and understanding of the fate and effects of nanoparticles in soil-plant systems.