Harnessing the potential of extracellular polymeric substances (EPS) for use in agriculture

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The growing demand to enhance crop yields has intensified the use of synthetic fertilizers, whose indiscriminate and long-term application has been directly associated with adverse effects on the environment, soil health, and water quality. This scenario highlights the need to explore environmentally friendly alternatives that alleviate dependence on synthetic fertilizers while maintaining crop productivity and resilience. In this context, extracellular polymeric substances (EPS) recovered from waste aerobic granular sludge (AGS) have emerged as promising, bio-based plant growth enhancers. Their potential is linked to their richness in organic matter and nutrients, remarkable water-holding capacity, and protective effects against environmental stressors. This study aimed to elucidate the role of EPS recovered from AGS obtained from two full-scale Nereda® reactors operating in Utrecht (EPS_U) and Faro (EPS_F), as well as from one laboratory-scale reactor (EPS_R), when applied as soil amendments.

In a 7-week greenhouse pot experiment, maize (*Zea mays* L.) was cultivated in soils amended with EPS at two application rates (0.5% and 1%, w/w). EPS effects were compared against vermicompost and non-amended soil (control), assessing maize physiological and nutritional responses alongside changes in soil enzymatic responses. Applying higher EPS application rates, irrespective of their source, significantly increased maize chlorophyll content. Particularly, the incorporation of 1% of EPS_R increased chlorophyll contents by 105% and 62% comparative to the control and to 1% of vermicompost, respectively. Similarly, EPS amendments offered nutritional benefits, as evidenced by increased K and Mg accumulation in maize shoots following the application of 1% EPS_F and EPS_R, respectively. Either EPS or vermicompost amendments effectively limited the translocation of Na to maize shoots, although a stronger effect was noted with EPS. Concerning soils' enzymatic activity, applying 1% of EPS_U translated into positive effects on the urease (31%) and fluorescein diacetate hydrolysis (41%) activities, while acid phosphatase increased by 35% in soils amended with EPS_R_1%. The observed variability in enzymatic and nutritional responses likely reflects the compositional differences among EPS from different sources, demonstrating that both EPS source and application rate largely influenced their performance as soil amendments.

Overall, the use of EPS recovered from waste AGS offers advantages in maize physiological and nutritional traits as well as in soils' enzymatic attributes, representing a suitable alternative to conventional fertilizers. EPS recovery from waste AGS and their subsequent application as soil amendments represents a value-added pathway that supports resource recovery in the wastewater treatment sector and encourages the adoption of more sustainable agricultural practices.

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