Enhancing photosynthetic efficiency and nutrient uptake in Maize (*Zea mays* L.) using extracellular polymeric substances recovered from waste sludge

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Extracellular polymeric substances (EPS) are biopolymers that can be recovered from waste aerobic granular sludge (AGS) generated in wastewater treatment plants (WWTPs). These biopolymers represent a valuable resource with attractive attributes, making them suitable for applications across different sectors. In agriculture, EPS has attracted growing interest, although their beneficial effects are still underexplored. In a 7-week greenhouse experiment, the effects of EPS recovered from waste AGS sourced from two WWTPs (Utrecht (EPS_U) and Faro (EPS_F)) and a lab-scale reactor (EPS_R) on maize growth, photosynthetic efficiency, and nutrient uptake and use efficiency were explored. EPS were incorporated into the soil at doses of 0.5% and 1% (w/w), and their effects were evaluated against equivalent doses of vermicompost and non-amended soil (control). EPS incorporation, especially with 1% EPS_R, enhanced stem thickness and shoot fresh weight, whereas lower doses of other EPS sources and vermicompost had only marginal effects. Additionally, EPS, regardless of their source, markedly enhanced the chlorophyll content compared to plants grown in non-amended soils, demonstrating their role in enhancing nutrient availability and maize photosynthetic efficiency. Moreover, the incorporation of EPS_R_1% and EPS_F_1% markedly increased the Mg and K uptake by 46% and 34%, respectively, compared to the control. Some EPS treatments were also able to increase the use efficiency of Ca, K, Na, and Zn, compared to plants in vermicompost-treated soils. As such, EPS can effectively enhance the availability, uptake, and use of nutrients in maize.

The study highlights the potential of waste-derived biopolymers to enhance maize nutritional traits and physiological responses while promoting sustainable agricultural practices and resource recovery strategies.

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