Unveiling the Agronomic Potential of Extracellular Polymeric Substances Recovered from Aerobic Granular Sludge on Maize

Catarina Miranda[1], Sofia I.A. Pereira[1(*)], Ana S.S. Sousa[1], Philipp Wilfert[2,3], Mark van Loosdrecht[2], António Martins[4], Paula M.L. Castro [1], Catarina L. Amorim[1]

[(*)]sapereira@ucp.pt

[1]Universidade Católica Portuguesa, CBQF – Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Rua Diogo Botelho, 1327 4169-005 Porto, Portugal
[2]Department of Biotechnology, Faculty of Applied Sciences, Delft University of Technology, Van der Maasweg 9, Delft, 2629 HZ, The Netherlands
[3]University of Applied Sciences Lübeck, Urban Water Management, Mönkhofer Weg 239 in 23562 Lübeck, Germany
[4]Águas do Algarve S.A., 8000-302, Faro, Portugal

Topic: Environmental Microbiology & Biotechnology

ABSTRACT

Background: Extracellular polymeric substances (EPS) recovered from waste aerobic granular sludge (AGS) generated during wastewater treatment represent a promising route for resource recovery. As valuable biopolymers, EPS have garnered special attention across multiple sectors, particularly agriculture, although their benefits in this field remain understudied. This study assessed the agronomic potential of EPS recovered from three AGS sources, including two full-scale wastewater treatment plants in Utrecht (EPS_U) and Faro (EPS_F), and a laboratory-scale reactor (EPS_R), as soil amendments.

Methods: A greenhouse pot experiment was conducted to evaluate the effects of two EPS doses (0.5% and 1% w/w) on maize growth, nutrient uptake, and soil enzyme activities, compared with vermicompost at the same doses and a non-amended soil (control).

Results: Both the source and dose of EPS strongly influenced their performance, with EPS often outperforming vermicompost. Notably, application of 1% of EPS, regardless of the source, markedly enhanced maize chlorophyll content, with EPS_R at 1% increasing it by 62% compared to 1% vermicompost and by 105% compared to the control. Similarly, applying 1% of EPS_R significantly increased shoot fresh weight and stem thickness. Nutritionally, 1% of EPS_R and 1% of EPS_F enhanced magnesium and potassium contents in shoots by 46% and 34%, respectively. Regarding soil enzymatic, EPS_U_1% greatly stimulated urease activity and fluorescein diacetate hydrolysis, while EPS_R_1% maximized acid phosphatase activity, underscoring the role of EPS in fostering a healthy rhizosphere.

Conclusions: Using EPS as soil amendments offers a viable alternative to conventional fertilizers, while their recovery for agricultural use supports circular economy principles within the water sector.

Acknowledgments: This study was financed by the project ReCROP (PRIMA/0002/2020) under the framework of the Program for Research and Innovation solutions in the Mediterranean region (PRIMA). The authors thank the CBQF scientific collaboration under the FCT project UIDB/50016/2020. Catarina Miranda thanks the research grant from FCT (doi.org/10.54499/2020.06577.BD) and POCH, supported by the European Social Fund and MCTES national funds. Catarina Amorim and Sofia Pereira thank FCT for the Assistant Researcher

contract (2023.15056.TENURE.048 and 2023.15056.TENURE.047, respectively) through the FCT-TENURE Program funded by the Recovery and Resilience Plan (PRR).