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Enhancing Heavy Metal Recovery from Contaminated Soil: The Synergy of Phytoextraction and Power Generation in a Plant Microbial Fuel Cell

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In an era where resource depletion is a growing concern, leveraging natural processes for the recovery of valuable materials from waste is becoming increasingly vital [1]. The recovery of resource using vascular plants (phytoextraction / phytomining) has been practiced in various media although extraction is limited by the bioavailability of the resource to roots [2]. Plant-microbial fuel cells (PMFCs) extract energy from the microbial degradation of root exudates or other organic molecules and have demonstrated metal removal from available phases such as wastewater [3]. We demonstrated the potential to enhance resource recovery from solid and recalcitrant wastes by promoting resource bioavailability via mobilising and transporting ionic species under the generated electric field, as well as trapping the metals through plant uptake in this work.

We used *Phragmites australis* (common reed) to explore the synergistic effects between the plant's phytoextraction capabilities and the microbial fuel cell's electrogenic activity, and the ability to boost overall resource recovery. Over a two-month period, we examined various configurations to assess the PMFC's efficacy in copper recovery in soils spiked with $Cu_2(OH)_2CO_3$, comparing PMFCs, plant only systems (no fuel cell), externally applied electric fields and no treatment controls.

During the second month, PMFCs in copper-spiked media exhibited a significant increase in power generation compared to those in unspiked soil and demonstrated an ability to enhance copper migration. This corresponded with the most copper uptake by *Phragmites australis*. Reflecting on the notion that electricity can bolster plant growth and enhance phytoextraction [4], our findings hint at a mutual reinforcement between power generation and phytoextraction. This synergistic relationship calls for further investigation into the underlying mechanisms, which are pivotal for optimizing PMFC technology and advancing it within the context of a circular economy.

[1] Kisser et al. (2020), Blue-Green Systems **2**, 138-172. [2] Dalvi et al. (2013), Annals of Plant Science **2**, 362-368. [3] Habibul et al. (2016), Environmental Science & Technology **50**, 3882-3889. [4] Cameselle et al. (2019), Chemosphere **229**, 481-488.