Goldschmidt 2024 Abstract
https://doi.org/10.46427/gold2024.24032

In the search for efficient alternative phosphorus fertilizers: evaluation of potential synthetic and recycled phosphorus adsorbents through chemical behavior, soil microbiota responses and lettuce growth

IRIS ZOHAR[1], CLAUDE FORANO[2], HASAN E. GANEM[1], DAFNA DISEGNI[1] AND ADI JONAS[1]

[1]Tel-Hai Academic College
[2]Universit´e Clermont Auvergne
Presenting Author: zohariri@telhai.ac.il

Recycling of the essential macronutrient, phosphorus (P), is required to ensure global food security. Ideal adsorbents should exhibit both high P capacity and enhanced P phyto-availability within the soil-plant system. Our goal was to identify a chemical configuration of P adsorbent that enhances P solubilizing activity in both roots and microorganisms, thereby boosting plant growth. We investigated two types of adsorbents: synthetic layered double hydroxides (LDHs) and recycled water treatment residuals (Fe-WTR and Al-WTR). Dairy wastewater (WW) and inorganic P (Pi) solutions were used as P-sources (about 50 mg P L^{-1}).

Chemical behavior - LDHs fully removed P, while WTRs took out 50–80%. WW-Fe-WTR had higher phosphorus solubility in soil solution-like extract than WW-LDHs, with 14-180 times more total dissolved P (TDP). Chemical and structural alterations occurred when mixing adsorbents with WW. LDHs rapidly adsorbed orthophosphate onto their porous Mg- and Al-oxide surfaces, while WTRs contained diverse inorganic and organic P forms associated with heterogeneous entities (e.g., amorphous oxides, Calcite and Silicate surfaces and Ca-P minerals). *Soil microorganisms' responses* – Pi- and WW- LDH and Fe-WTR yielded the same sequence of responses in all incubated soils, including exudation of malic acid followed by elevation of phospho-di- and mono-esterase enzymatic activities and late nitrification. The WW-Fe-WTR had a significantly higher P solubility, likely contributing to enhanced microbial P and responses. Re-wetting likely governed the initial microbiota activities, producing labile P and C in microbial cells, for continuous growth. *Soil-plant system* - In a lettuce growth experiment, WW-Fe-WTR exhibited comparable performance to commercial fertilizer, whereas WW-LDH-lettuce showed poor growth. Metabolic analysis revealed reduced levels across all groups in WW-LDH lettuce, despite P concentrations being equal to or higher than other treatments. This suggests that soil P phyto-availability better predicts carbon assimilation and plant growth.

WW-Fe-WTR production costs were 160 times lower than those of WW-LDH, while recycling P from waste has direct savings of €935/ton. Dairy WW served as a P-rich source and its organic content enhanced P lability in the Fe-based adsorbent. We conclude that WW-Fe-WTR serves as an optimal P adsorbent, contributing to circular economy solutions and sustainable agriculture.