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Biomaterials derived from agri-food waste to improve sustainability in crop production and groundwater bioremediation

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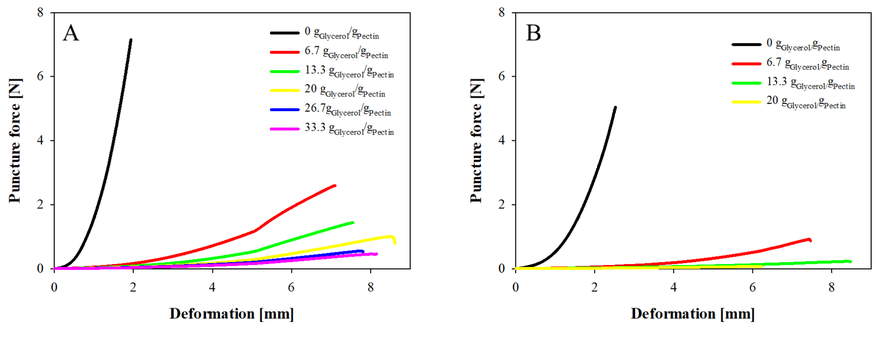
Water contamination, dependency on agrochemicals and the amount of waste within the agri-food sector pose major environmental, economic, and ethical issues. Aim of this work is the recovery of materials from agri-food waste, exploitable in improving crop production or the bioremediation of contaminated groundwaters, enhancing the sustainability of the agri-food production chain. Two applications are under development: i) the obtainment of food waste-derived biopolimers, functionalised with Plant Growth Promoting (PGP) bacteria, achieving biodegradable and biofertilizer sustainable alternatives to conventional plastic materials, ii) the application of food waste derivatives as biostimulants for chloroethenes bioremediation in groundwater.

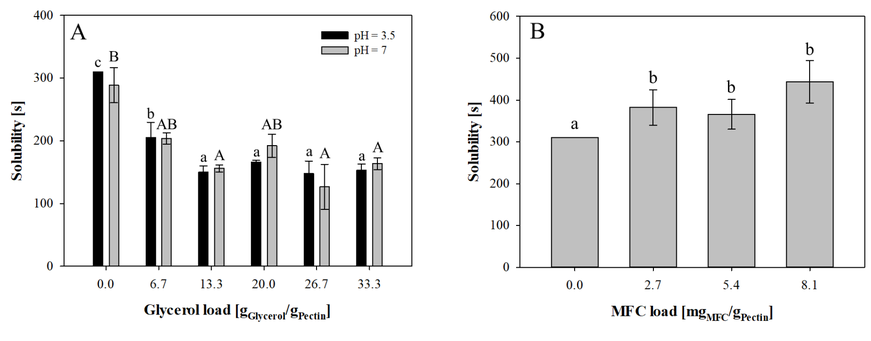
PECTIN-BASED FILMS FOR APPLICATIONS IN THE HORTICULTURAL SECTOR: A PRELIMINARY CHARACTERIZATION

An intriguing and emerging application is given by the fabrication of bio-based plant plugs for the horticultural sector to replace conventionally employed plastic-based configurations. The latter typically suffer from hampered recyclability owing to contamination by organic matter and chemicals after usage in plant nurseries [1, 3]. In this study, we aimed to produce and characterize pectin-based films as a function of their composition (e.g., concentration of glycerol as plasticizer, presence/absence of microfibrillated cellulose (MFC) as filler within film-forming solutions) in terms of mechanical (e.g., puncture resistance) and water solubility properties, so as to possibly move a step forward in generating biodegradable plugs.

"Puncture force vs deformation" curves for pectin films at pH = 3.5 (A) or 7 (B)



Water solubility of pectin films with increasing load of glycerol (A) or MFC (B)

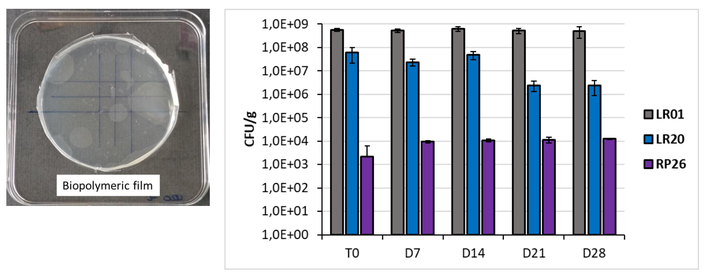


- Films from formulations at pH = 3.5 exhibited an overall better mechanical behavior over their counterpart at pH = 7 (1).
- The best puncture resistance and water solubility were displayed by films from the least glycerol-loaded formulations (1 – 2).
- The intrinsic inability of cellulose and its derived forms, such as MFC, to dissolve in water yielded a worsening effect toward water solubilization times (2).

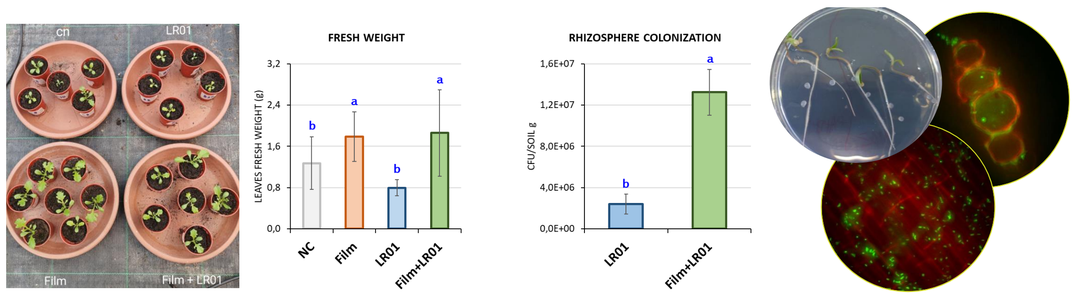
BIOMATERIALS FOR THE DELIVERY OF MICROBIAL BIOFERTILIZERS IN AGRICULTURE

Plant-growth promoting (PGP) bacteria represent a valid complement to reduce the use of chemical fertilizers and pesticides, acting as plant biostimulants [1]. Nonetheless, their successful delivery to crops still represents a challenge, depending on the microbe survival in the soil environment and the ability to associate with the plant [3]. Aim of this study is to explore bio-based materials derived from food wastes for the delivery of PGP bacteria, to improve their establishment and at the same time to increase sustainability in a circular economy perspective. Selected bacterial strains were embedded in a pectin-based or alginate material to assess their long-term viability and the capacity to establish in the soil and interact with crop plants.

Viability of PGP bacterial strains embedded in a biopolymeric film



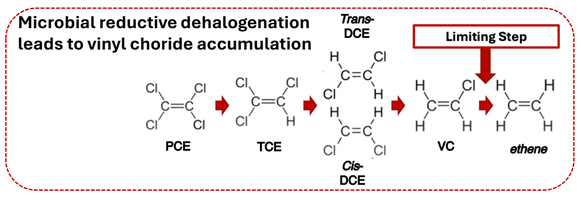
Colonization and PGP activity on lettuce and tomato plants by bacteria embedded in pectin film and alginate beads



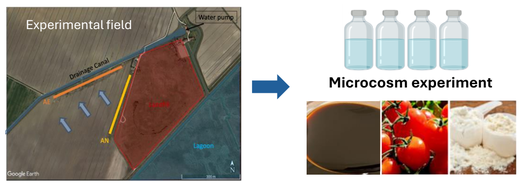
- Viable cells were re-isolated from 1 cm² of the biopolymeric film up to one month storage.
- Pectin film incubated in soil promoted plant's fresh weight.
- Strain LR01 embedded in pectin film increased survival and colonization of rhizosphere soil.
- Strain GR12 embedded in alginate beads colonises tomato roots

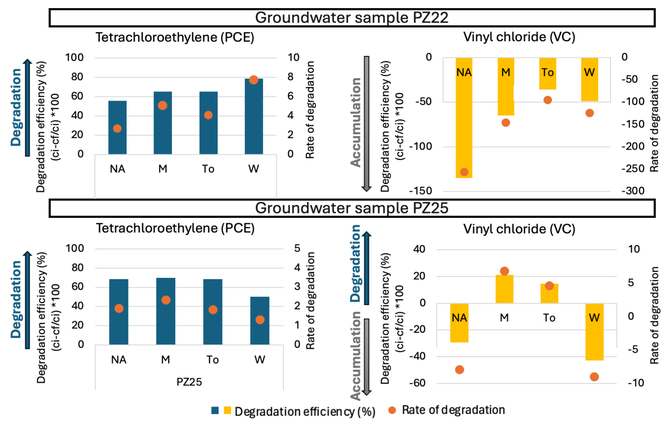
CHLOROETHENE REDUCTION IN GROUNDWATER: BOOSTING NATURAL CLEANUP WITH FOOD WASTES

Chloroethenes, including tetrachloroethene (PCE), trichloroethene (TCE), dichloroethene (DCE), and vinyl chloride (VC), are significant groundwater contaminants due to their extensive use as industrial solvents [4]. Anaerobic and reductive environments promote their biological dechlorination through the organohalide respiration (OHR) pathway mediated by organohalide-respiring bacteria (OHRB) [5].
This study evaluated the potential of molasses from sugar beet processing (M), tomato extract from lycopene biorefinery (To), and whey (W) to stimulate OHRB activity in contaminated groundwaters.

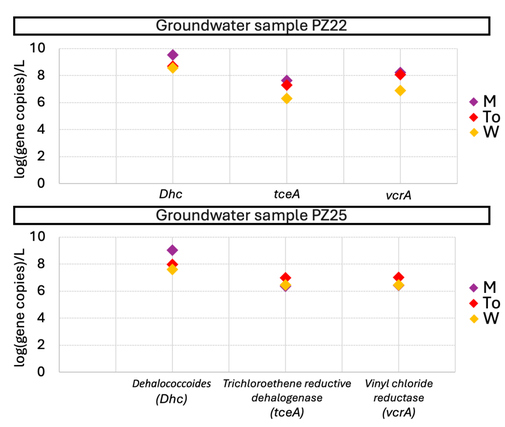


Microcosm-scale experiments with contaminated groundwaters





The addition of waste substrates promoted the degradation of vinyl chloride at different extents according to substrate nature



Molasses and tomato extract were more effective than whey in stimulating *Dehalococcoides* population growth and reductive dehalogenase genes *tceA* and *vcrA*.

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