ENHANCE BIOREMEDIATION AND PHYTOREMEDIATION BY LOCAL PLANT SPECIES AND FRUIT WASTE MICROCARRIERS

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CONTEXT

- Application of natural (Apple), synthetic (Urea, Alginate), and engineered (Micro-Apple) soil amendments aims to enhance plant growth and contaminant uptake
- Using two contrasting soils (clean OECD vs. contaminated soil) allows for comparison of plant performance and treatment impact under different contamination scenarios
- Alfalfa (*Medicago sativa*) and *Brassica oleracea* are selected for their agricultural relevance, fast growth, and local adaptability
- Combining bioremediation and phytoremediation offers a promising, sustainable approach to restoring polluted soils

OBJECTIVE

- Assess the impact of five different soil amendments on plant growth, biomass production, and the removal of arsenic (As) and lead (Pb) under controlled conditions
- Evaluate the combined effectiveness of phytoremediation and bioremediation using Alfalfa and *Brassica oleracea* in remediating contaminated soils

METHOD AND MATERIALS

Initial Soil Contamination Levels
• Arsenic (As): ~53 ppm
• Lead (Pb): 2150 ppm

STRATEGY

Contaminated Site

↓

Serious Risk to Ecosystems and Human

↓

Solution: Combined Bioremediation + Phytoremediation

↓

Study Aim: This strategy using Local Plants + Natural Amendments

Plants
Alfalfa (*Medicago sativa*)
Brassica oleracea

Amendments
Apple, Urea, Micro-Apple, Water, Alginate

Reason for Selection
Rapid growth
High biomass
Adaptability to local conditions

Purpose of Amendments
Enhance bioremediation by influencing nutrient availability, microbial activity, or contaminants mobility

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Experimental Conditions
Duration: 3 months
Controlled environment (greenhouse)

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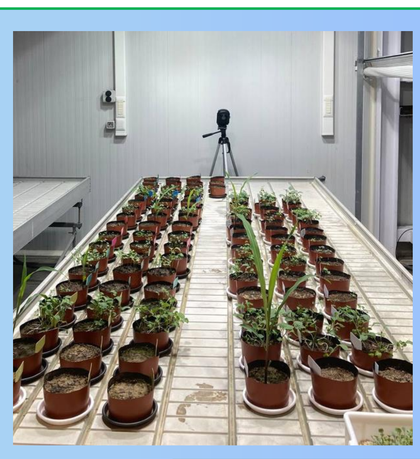
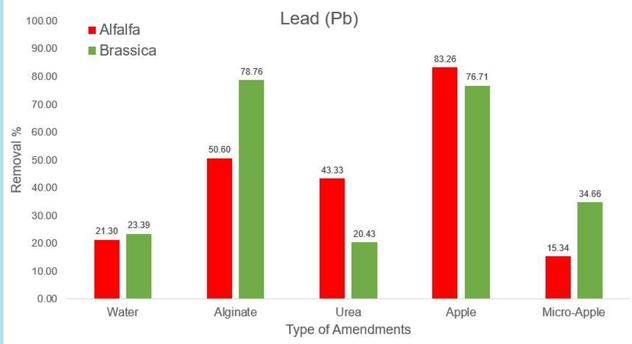
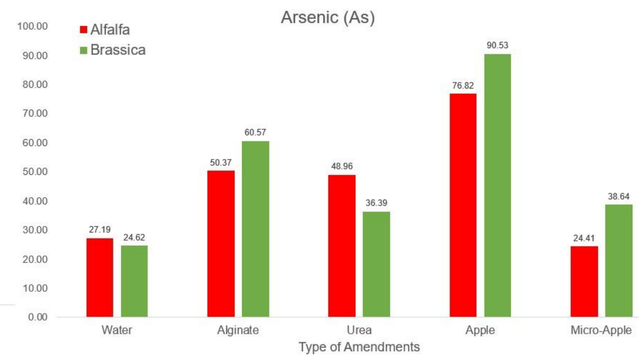
Evaluation Metrics
Stem & Root Length
Biomass Production
Contaminants Uptake (As, Pb)



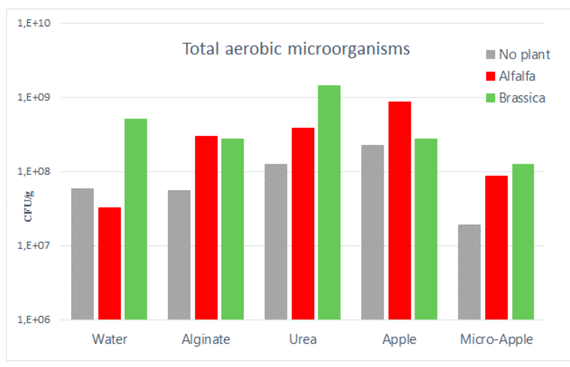
RESULT

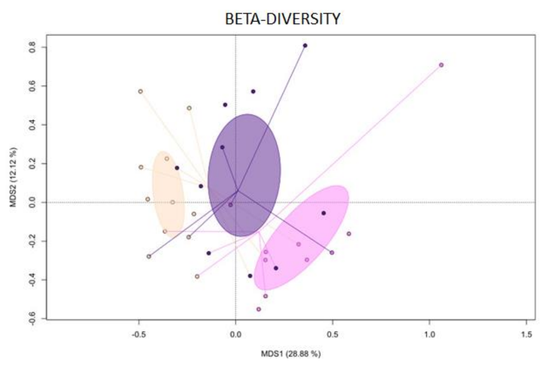
- Both Alfalfa and Brassica demonstrated good tolerance to contaminated soil conditions but Brassica showed better growth and removal contaminants compared to alfalfa under polluted conditions.





- Total aerobic microorganisms in the rhizosphere generally increased compared to control soil, without plants.
- Beta diversity showed a significant difference in genus distribution.





CONCLUSION

- The study supports the effectiveness of using locally adapted plants for both phytoremediation and bioremediation and they can offer a sustainable and efficient approach to reducing soil pollution.
- The application of soil amendments and microbial inoculants enhanced plant growth and contaminant breakdown.
- The integration of bioremediation techniques improved overall remediation efficiency.
- These approaches contribute positively to environmental restoration in contaminated areas.

ACKNOLEGMENTS

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9th EUROPEAN BIOREMEDIATION CONFERENCE

Fruit waste-based microcarriers for enhance bioremediation of organic pollutants: evaluation in real polluted soil.

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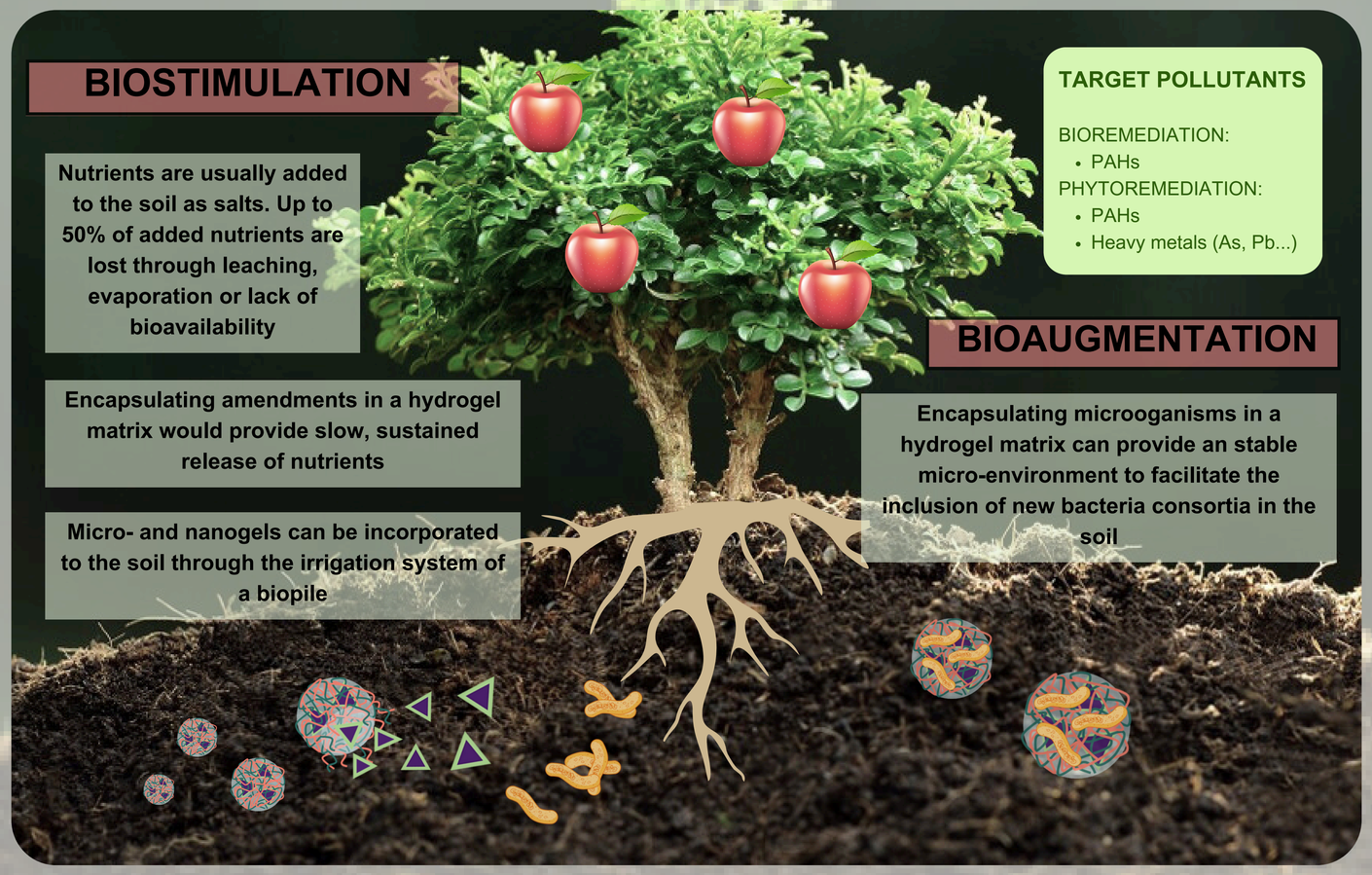
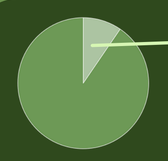


SYMBIOREM is a **EU-funded project** for the development of nature-based solutions for **soil and water remediation.** The objectives include reducing **mixed contamination, eutrophication,** and the **presence of microplastics.**

These technologies are being tested in five archetypes of **contaminated soil** from 9 locations in **Europe** and **USA.**



9.5% of fruit produced worldwide is discarded as waste

Fruit peels contain polyphenols (antioxidant), vitamins and sugars; so they are a good biobased alternative to synthetic fertilizers

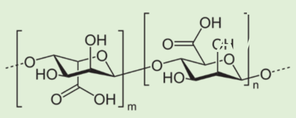
In this work we aim to encapsulate apple residues in biopolymeric microgels for sustained nutrient delivery. We also propose a technique for microorganism encapsulation for biorremediation application.

Bio-based MATERIALS

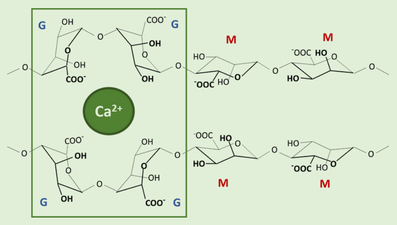
Alginate

Microgels are stable polymeric **3D networks** with **high water-holding capacity** that can be used for **immobilization and transport** of nutrients and microorganisms

Alginate is a **biopolymer** extracted from **brown algae**. It can easly **form gels** in the presence of **Ca^{2+}** ions



- ✓ **Abundant and renewable feedstock**
- ✓ **Tuneable funtional groups**
- ✓ **Non-toxic and biodegradable**
- ✓ **Highly biocompatible**
- ✓ **Gel forming ability under mild conditions**



Ionic cross-linking allows for a **"green synthesis"** in aqueous medium and mild conditions (avoiding the use of potentially contaminating organic solvents); so it is the preferable option for **ecological applications.**

Apple residues

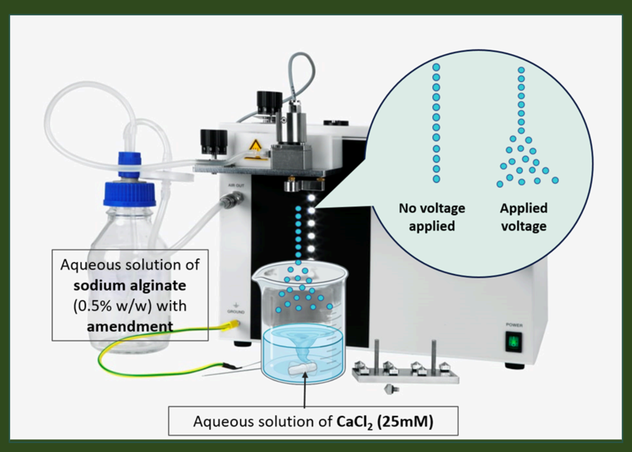
Apple-waste amendment preparation

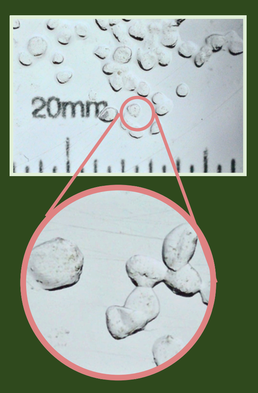
Collecting skin and core → Drying at 60ºC → Grinding → Sieving at 125 µm

Microgel FABRICATION

DROPLET-SPRAY ENCAPSULATION

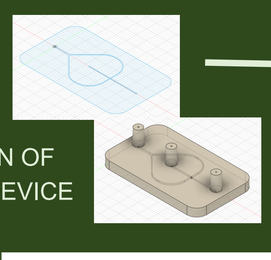
APPLIED FREQUENCY AND VOLTAGE FOR DROPLET GENERATION



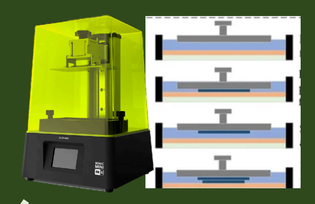


- The obtained microgels are < 1 mm in diameter, but with notable variation in size and shape
- Fast production of microgels, but the system is not easily portable
- Suitable for apple-residue encapsulation

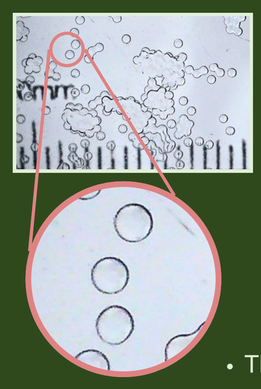
MICROFLUIDICS

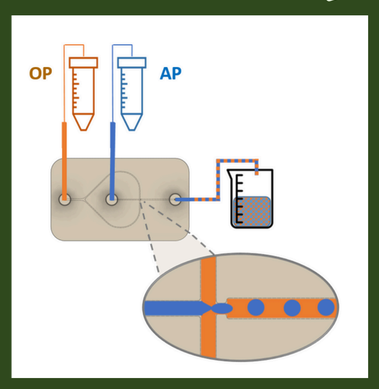


DIGITAL DESIGN OF MICROFLUIDIC DEVICE



LCD 3D PRINTING OF THE PIECE





DROPLET GENERATION:

- OP: Sunflower oil + HAc + Surfactant
- AP: Sodium alginate + CaEDTA

- The obtained microgels are < 400 µm in diameter, with small size variation and completely spherical
- Mild conditions facillitate the survival of microorganisms
- The system is portable, but the microgel production is slow

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