

BIOPROCESS FOR REDUCING RHIZOSPHERIC CADMIUM SOLUBILITY

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1 Isolation and cultivation

Surface disinfection of root fragments. Incubation in drops at 25°C until hyphae emerging were observed from the end.

Each fragment with an endophytic fungus was cultured in the appropriate medium.

2 Identification

Isolates were classified using colony characteristics and the morphology of the reproductive structures.

3 Germoplasm conservation

The obtained pure cultures are preserved in the Soil Microbiology Laboratory (IBBEA/UBA-CONICET) and multiplied for its application in the project.

Cacao endophytic fungi

Potential native resources for cadmium reduction in cacao



AIMS

Isolation, cultivation, propagation, and identification of endophytic fungi from cacao plant roots from Ecuador (Chone and Lodana).

Valuation and conservation of the Ecuador's native biological resources and biodiversity, that are part of the FONTAGRO project "Bioprocess for reducing rhizospheric cadmium solubility" in cacao.

Mycorrhiza-assisted phytoremediation of raw materials of interest

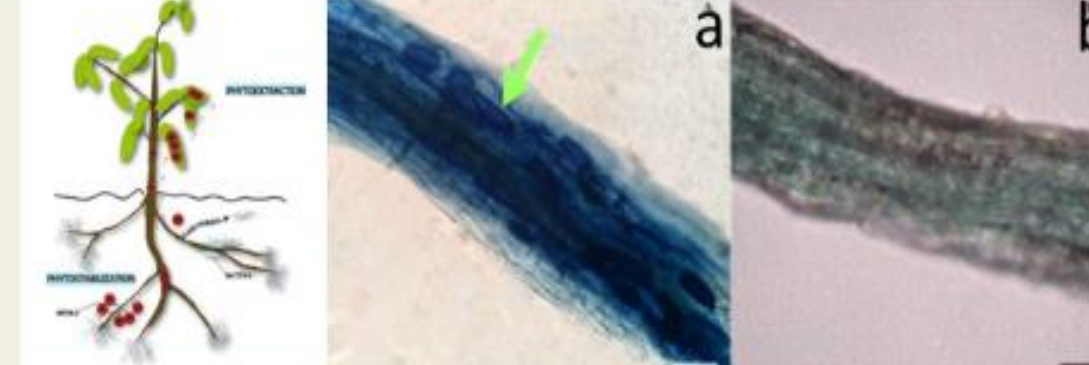


Selected mining waste are treated by FAM at TRL6 scale at MDV and the recovery of SRM (e.g., Zn, Cr, As, Ni, Cu, Ca, Al, K, S, Rb, Fe, Mn, Cd) and CRMs (such as Ga, Ti, P, Ba and Sr) is being investigated.

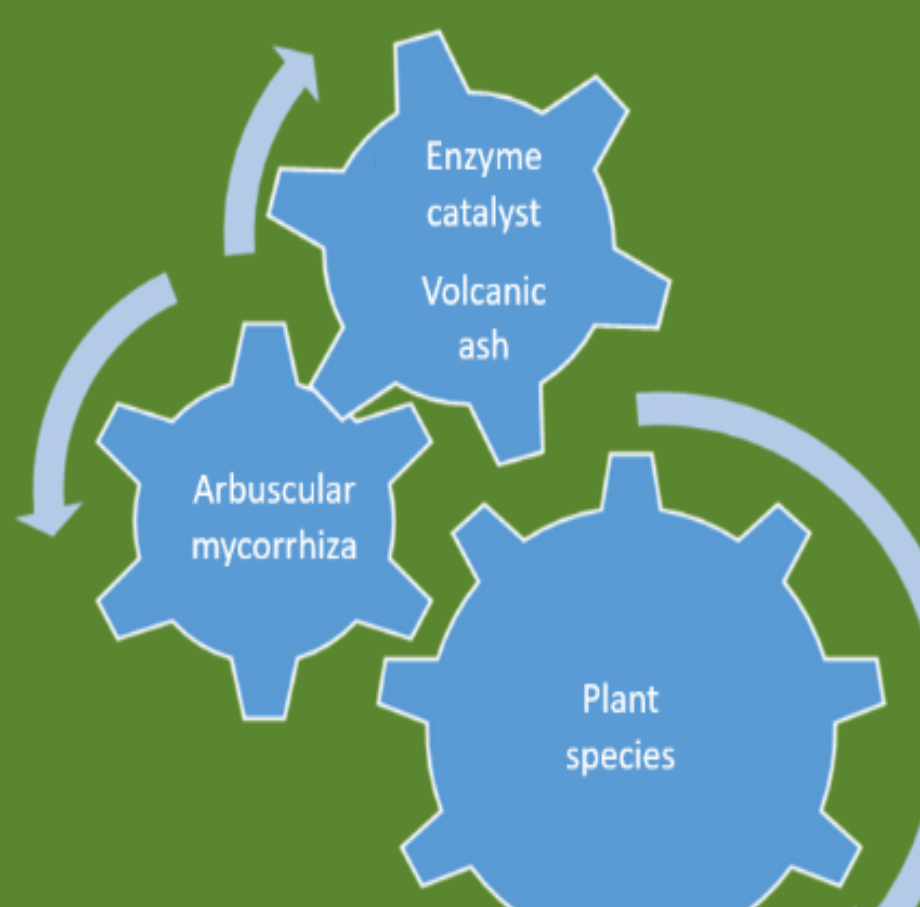
Phytoremediation system: *Helianthus annuus* colonized by arbuscular mycorrhiza.

Rhizophagus intraradices (strain GA5).

Fragments of colonized roots (a) with vesicles and (b) uncolonized roots.

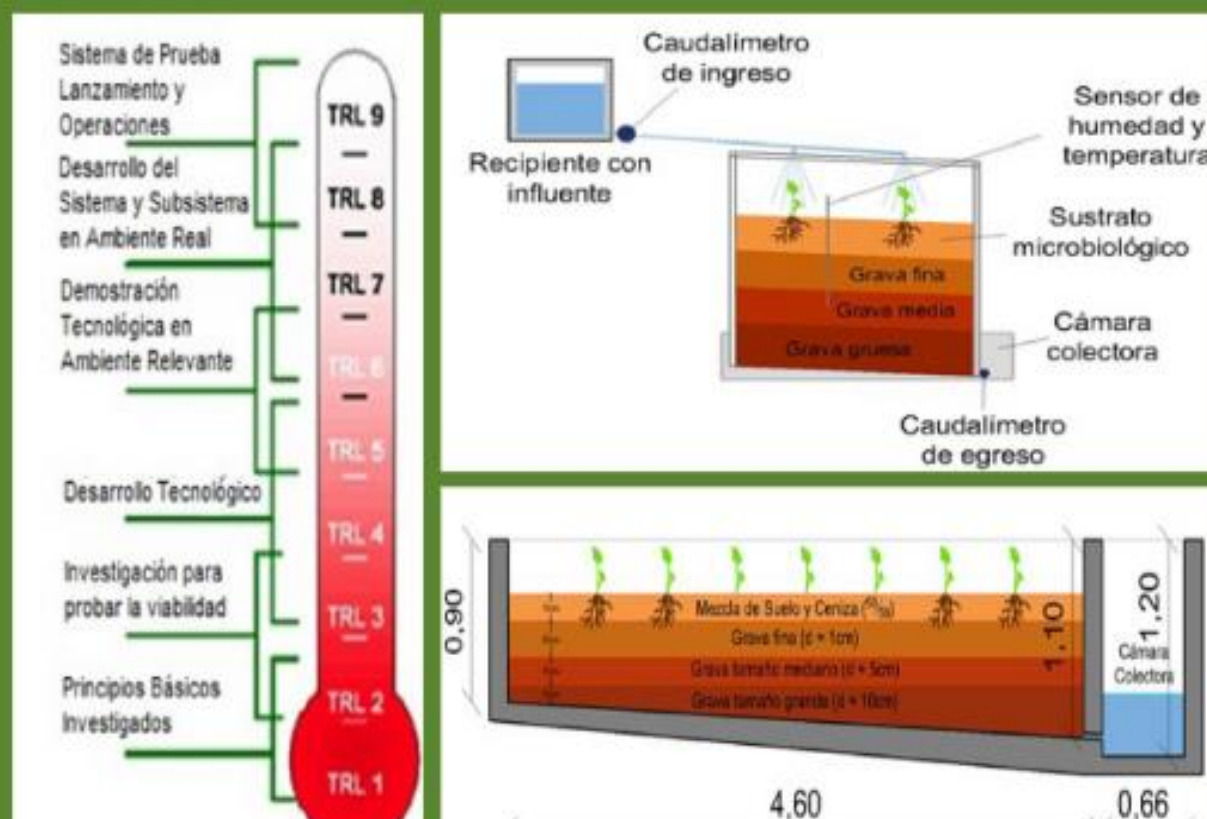


Scaling from TRL 1 to TRL 6



Scotti A, Godeas A, Silvani V. Inventors: Comisión Nacional de Energía Atómica, Universidad de Buenos Aires, asignada. 2022. Procedure to affect the bioremediation capacity of hyperaccumulating plants through arbuscular mycorrhizal fungi (AMF) for the treatment of contaminated soils and/or waters. Argentine Patent N°: AR090183B1.

Scaling from TRL 3 to TRL 6







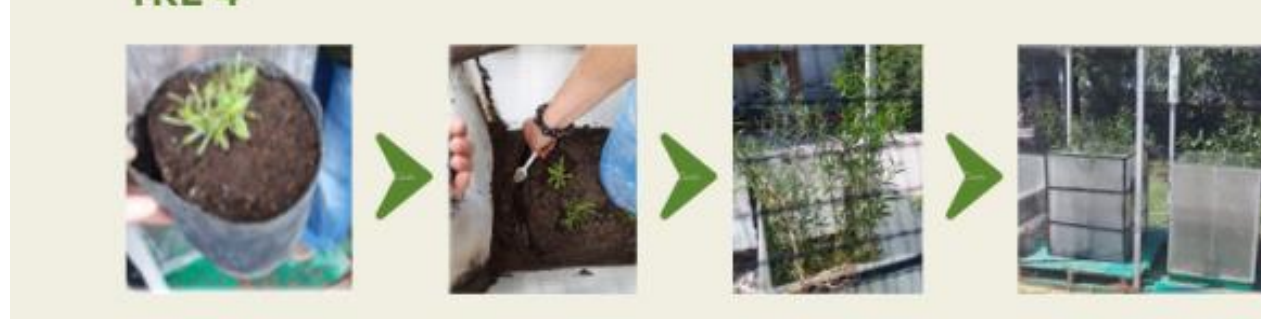
TRL 1-2: Verification of proof of concept and patent application..

TRL 3-4: Testing with all inputs and small-scale engineering, in bioreactors.

TRL 5-6: Modular scale testing in a simulated environment

100BR:1MDV

TRL 4

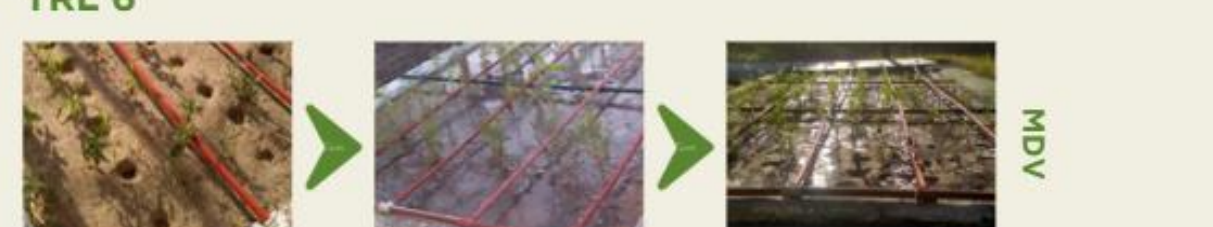


Variable values
Irrigation type
Mycorrhizal strain
 Φ Eh
exudates
Ks MO pH

Adjusted values
 V_{energy} QI Qs
Va Vol sustrate
WHC Tc Filter bed

Scaling protocol

TRL 6



Application in food safety

An example in Ecuador with cocoa

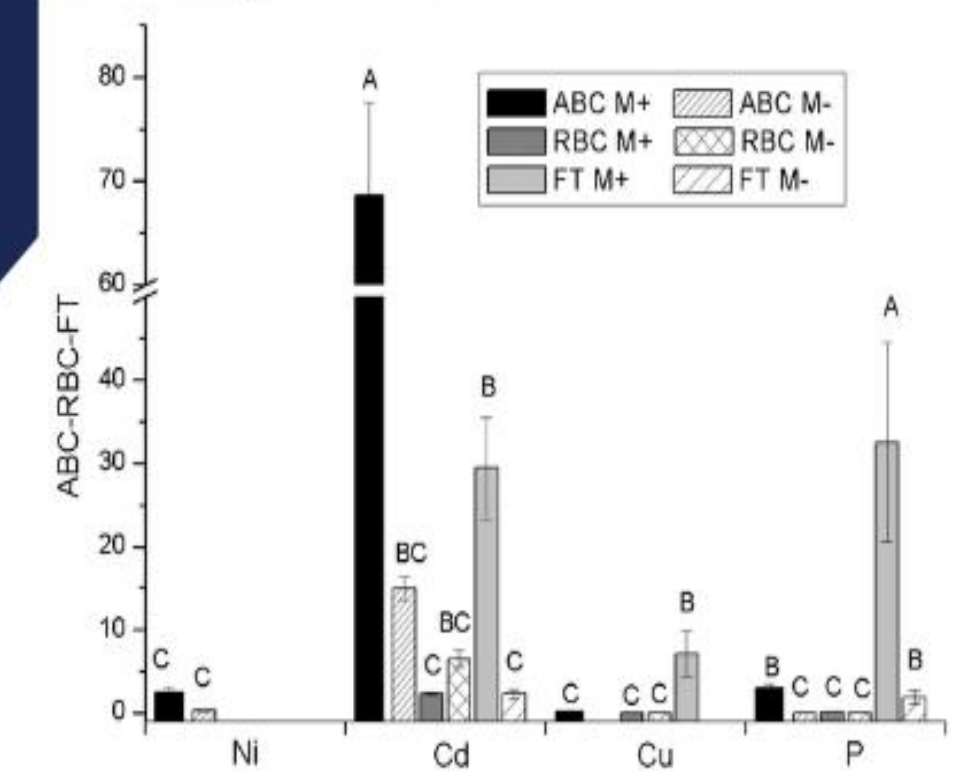


Product 6: Bioprocess for reducing rhizospheric cadmium solubility. Technical Note with the 10 tools and methodologies designed for TRL 6 engineering scaling in MDV.

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<http://vid-20231031-wa0088.mp4/>
<https://www.fontagro.org/new/proyectos/bioprocso-cd/es>





Bioaccumulation coefficients and translocation factor for the studied elements in inoculated and uninoculated *Baccharis salicifolia*

Conclusions I

Obtained saprobic and mycorrhizal fungi strains are capable of acting in the rhizosphere to capture cadmium in their structures, reducing translocation to the flower in model species such as sunflower, and increasing it in other test species such as *Baccharis salicifolia*, in which cadmium hyperaccumulates 70 times more than the cadmium present in the soil. They also solubilize phosphorus, creating a cadmium-binding biofertilizer. A paper has been published in a high-impact journal, and doctoral thesis are being developed based on these results.

The scaling up in MDV has been carried out, determining the variables that must be taken into account and the ranges of values to which they must be adjusted for a reproducible bioprocess. Technical notes have been written, and papers have been published in Q1 and Q2 journals that reflect these considerations. A thesis is being developed using these methodologies.

Conclusions II

In educational and scientific terms, undergraduate and graduate theses were defended, and research articles were published above the initial projected number, reaching more than 16 events, more than 10 articles published in high-impact journals, more than 10 full-length papers in proceedings and book chapters, more than 21 conference presentations, one completed doctoral thesis, three doctoral theses in progress, and four completed and ongoing undergraduate theses. Regarding beneficiaries, 931 family farmers have been trained, reaching 3,452 people, 1,646 of whom are women, and more than 177 students, thesis students, and entrepreneurs have been trained.

Conclusions III

Three technological solutions and innovations were found:

- Linked to Arbuscular Fungi (AF): mycorrhizal symbiosis with distinct behavior: flower exclusion, phytostabilizing, cadmium hyperaccumulator. Stored in a Seed Bank (Bioenvironmental Laboratory, ICES CNEA UTN), and in vitro Glomeromycota Bank (UBA FCEN-IBBEA).
- Linked to Saprobic Fungi (SF): cadmium bioindicators, tolerant, and hyperaccumulators. Stored at CSIC-EI Zeidín Experimental Station.
- Linked to scaling and conservation of conditions for reproducibility of results with increasing technological maturity levels (TRL).

Furthermore, the described OVIs in the logical framework matrix were fully achieved:

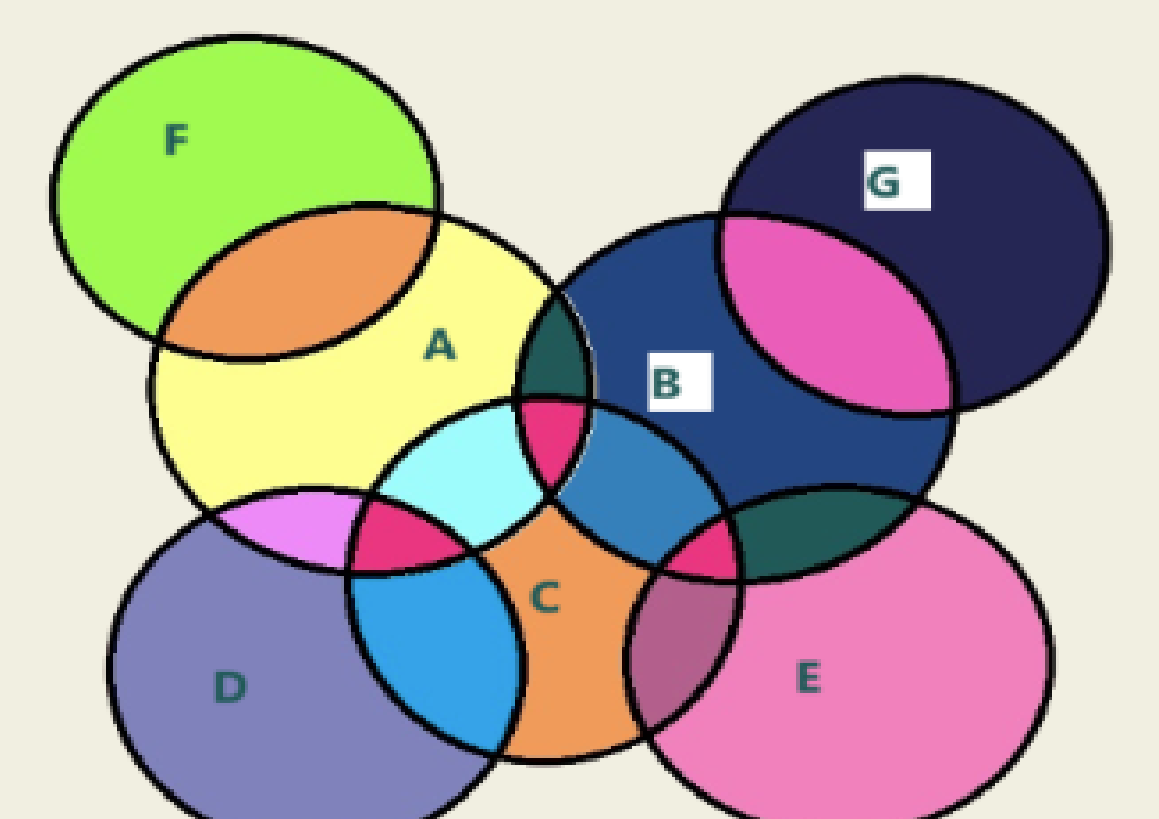
*Database of trained individuals, *Record of class materials, *Bioreactors operating with selected soils, isolated strains, and seedlings with CBra values < 1, *MDV operating at TRL 6 scale, *Knowledge management and dissemination documents.

The means of verification are the delivered products.

Impact

- The project has a high impact on the environment, organizational-institutional and communication and transfer
- The project has had a low economic impact to date.
- The project has generated structural changes to date (Chow F test) in the scientific environmental criterion
- The project is easily scalable and the biotechnological implementation is low cost.
- Strategies were generated for sustainability upon completion of the CT

Interactions and sustainability strategies



A- Initial and additional active project participant NETWORKS

B- ECUADORIAN NETWORK OF COCOA TECHNICIANS AND PRODUCERS

C- ECUADORIAN PUBLIC-PRIVATE ACADEMIC-GOVERNMENTAL NETWORK

D- ECUADORIAN NETWORK OF COCOA PRODUCERS, COLLECTORS, AND AGRICULTURALISTS

E- NETWORK OF COCOA GROWERS' ORGANIZATIONS. WOMEN'S NON-GOVERNMENTAL ORGANIZATIONS

F- INTERNATIONAL Public Research Entities

G- INTERNATIONAL EUROPEAN GOVERNMENTAL, ECUADORIAN, AND ITALIAN EMBASSIES

CURRENT COOPERATION AGREEMENTS BETWEEN THE TECHNICAL UNIVERSITY OF MANABÍ AND THE PUBLIC AND PRIVATE INSTITUTIONS PARTICIPATING IN THE EXECUTION OF THE FONTAGRO PROJECT

This project received the 2025 Excellence Award from Fontagro