NATIONAL ENERGY TECHNOLOGY LABORATORY

University of Nevada, Reno

Sustainable and cost-effective phytoremediation technologies in the management of contaminated soils adjacent to a coal combustion product impoundment
FE0032195

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University of Nevada, Reno

2024 FECM/NETL Carbon Management Research Project Review Meeting
August 5 – 9, 2024

Project Overview

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Project Overview

Participants

Dr. Ehsan Vahidi (PI)
Mohsen Rabbani (PhD student)
Frida Muthoni (PhD student)
Trista McLaughlin (Undergrad student)
University of Nevada, Reno,

NV Energy (Industrial Partner)
Operator of North Valmy power plant, Humboldt County, Nevada

Duration

3 years

Fund

$396,835

Objectives

- Develop low-cost methods leading to keeping contaminants within CCPs (coal combustion ponds)
- advance environmentally friendly technologies remediating affected sites.

Technology Background

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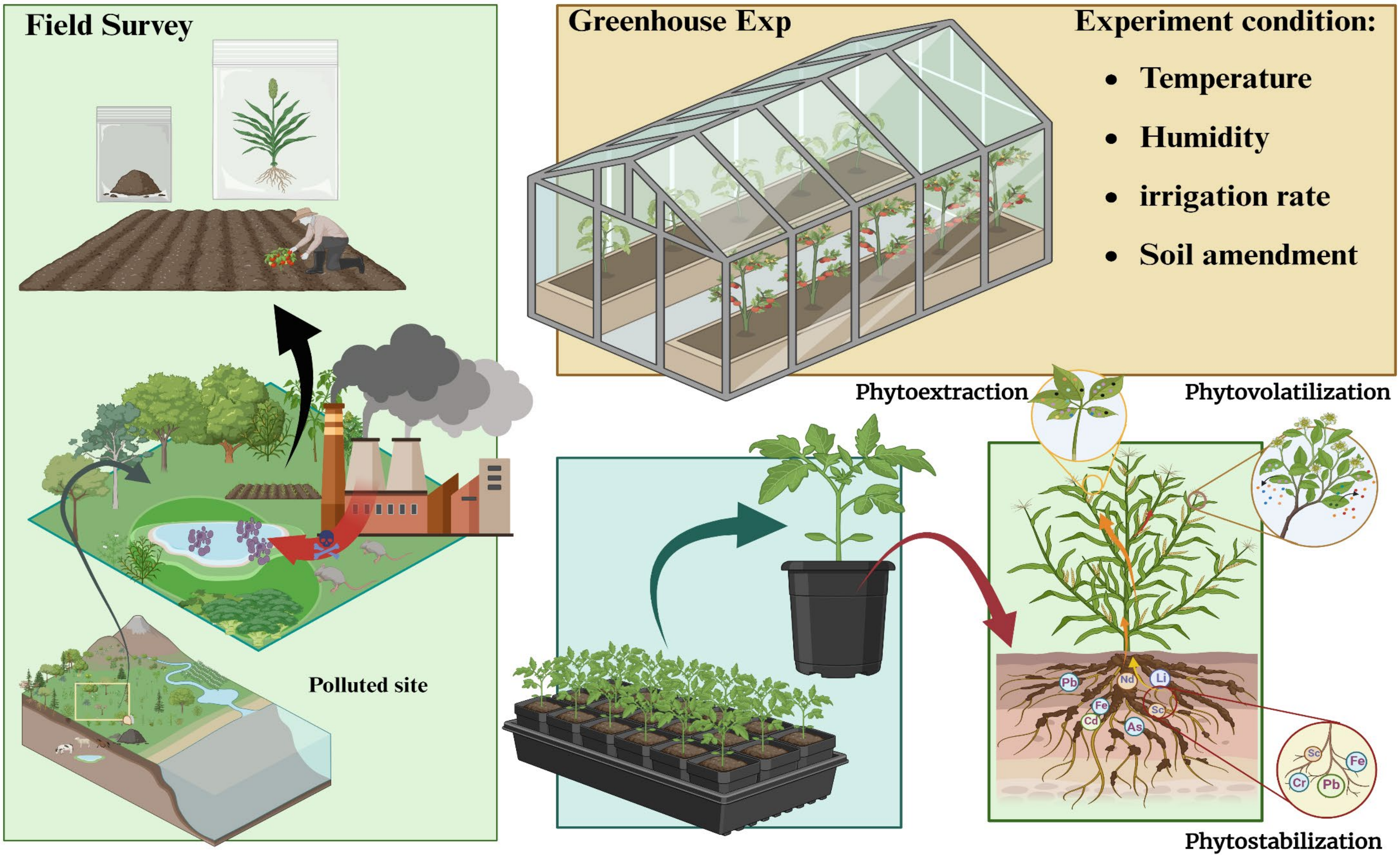

Technology Background

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No	Coal source	HMs	Plant species	Amendment	Results
1	CFA	Mn, Cu, Zn, Fe and Cr	*Sida acuta Burm. f. and Cassia tora (L.) Roxb*	fly ash (50%)	High tolerance of selected plants
2	CFA	As, B, Cu, Mo and Se	*Dactylis glomerata*	On CFA pond	high adaptive potential to As stress a good As phytostabilizator
3	CFA/ CBA	As, B, Ba, Be, Co, Cd, Cr, Cu, Mo, Pb, Sr, Ti, Tl, and V	(barley (*Hordeum vulgare*), oats (*Avena sativa*), wheat (*Triticum aestivum*)	FA and/or FA + BA	Reducing germination rate
4	CCA	Cd, Pb, Zn and Cu p	*Populus tremula L, Betula pendula Roth, Solidago virgaurea L.*	In-situ sampling	High ability of these species for phytostabilisation

1. Panda, D., Mandal, L., & Barik, J. (2020). Phytoremediation potential of naturally growing weed plants grown on fly ash-amended soil for restoration of fly ash deposit. International journal of phytoremediation,
2. Gajić G, et al. Phytoremediation Potential, Photosynthetic and Antioxidant Response to Arsenic-Induced Stress of Dactylis glomerata L. Sown on Fly Ash Deposits. Plants.
3. Bilski, J., et al. (2012). Agro-toxicological aspects of coal fly ash (FA) phytoremediation by cereal crops: effects on plant germination, growth and trace elements accumulation. Advances in bioresearch, 3(4), 121–129.
4. Szwalec A, Mundała P, Kędzior R. Suitability of Selected Plant Species for Phytoremediation: A Case Study of a Coal Combustion Ash Landfill. Sustainability. 2022;

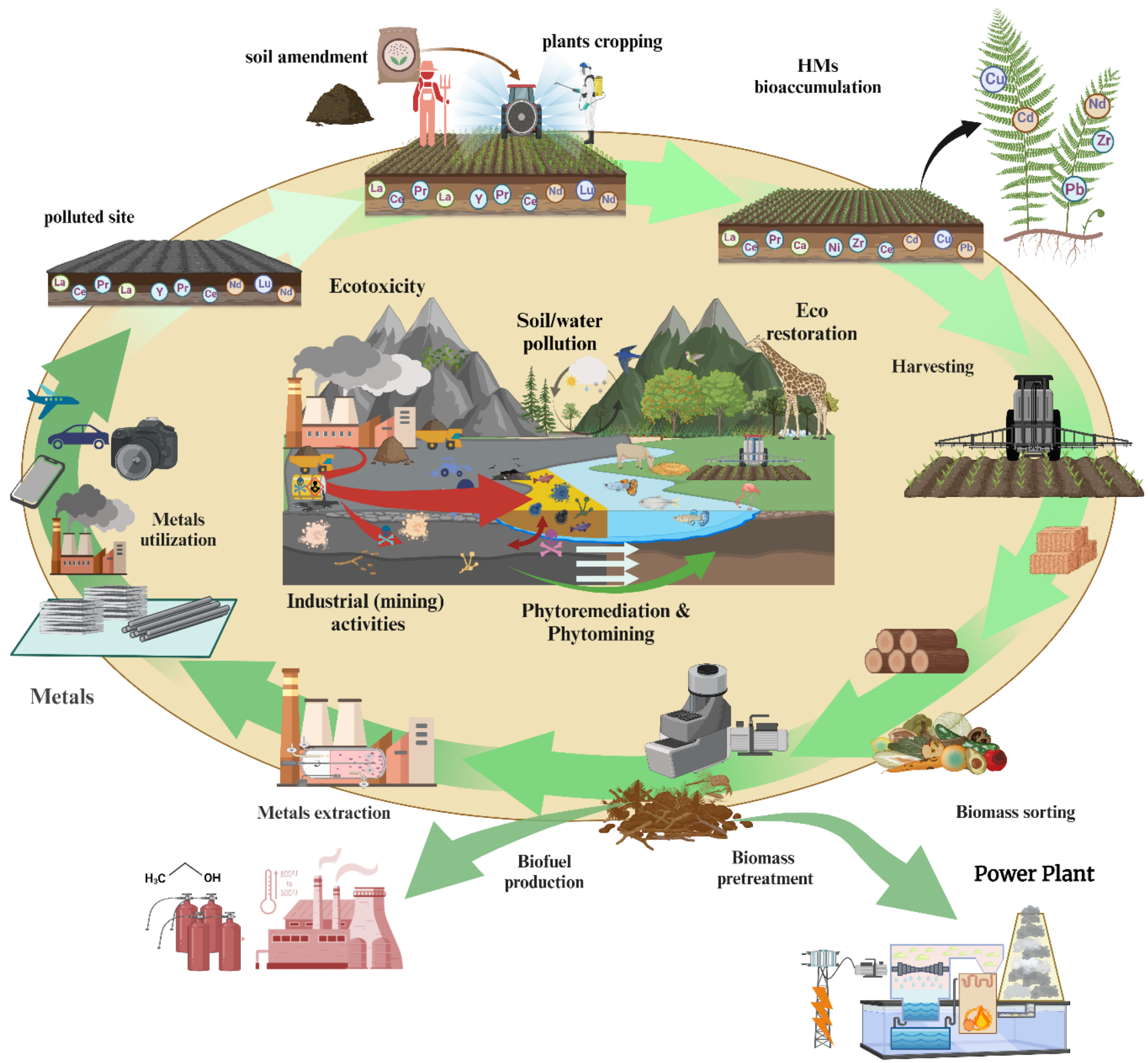
Technology Background

Advantageous:

- Permanent solution:
- Easy to use
- Low-cost approach
- Environmentally friendly
- mitigate CCPs ponds impacts
- establishing a vegetation cover
- (Phyto)extract heavy metals
- (Phyto)stabilization

Challenges

- limitations of vegetation growth
- Plant selection
- Cost of mobilization
- Operational costs



Technical Approach
Tasks and subtasks.

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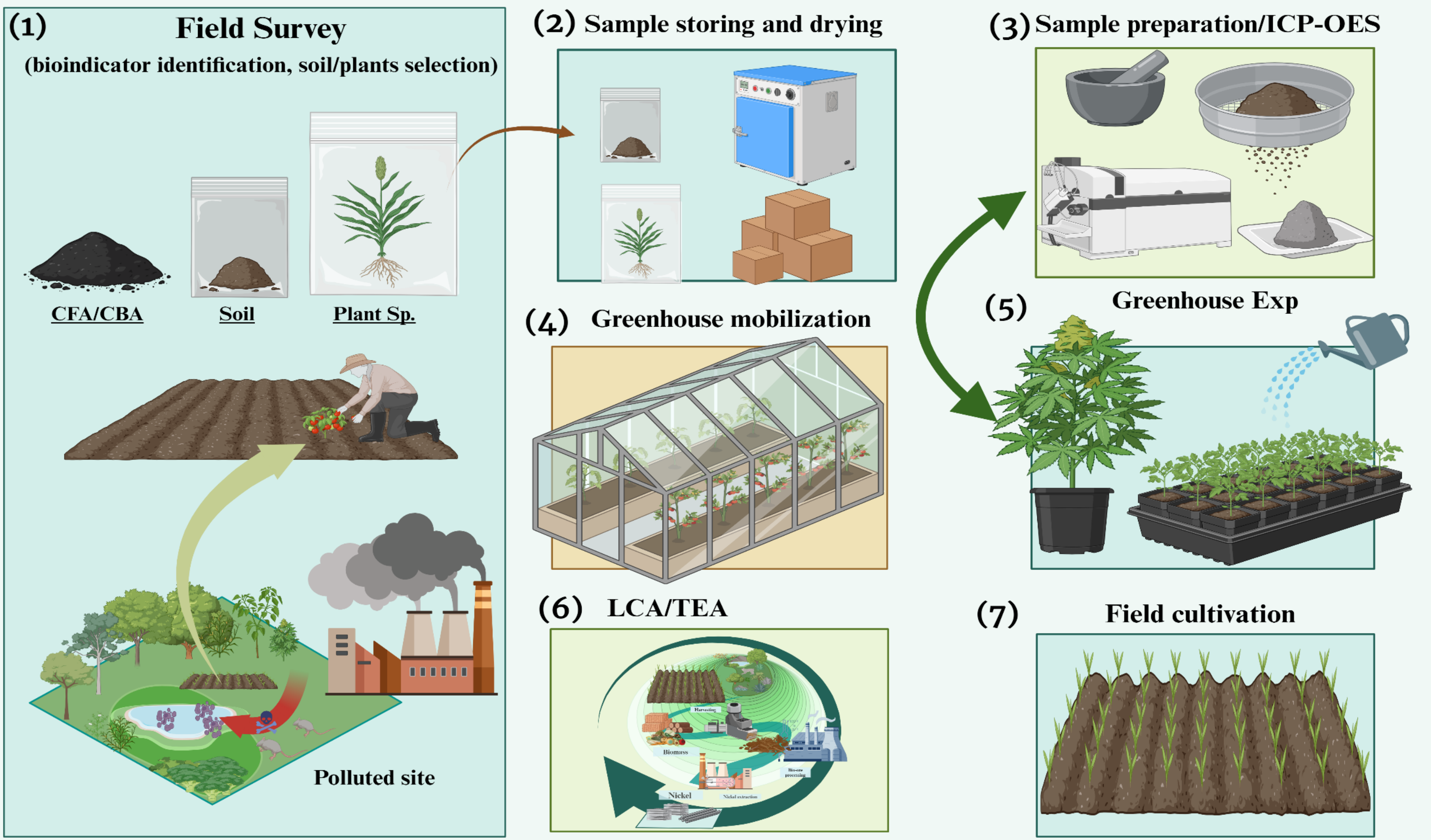

Progress of Project

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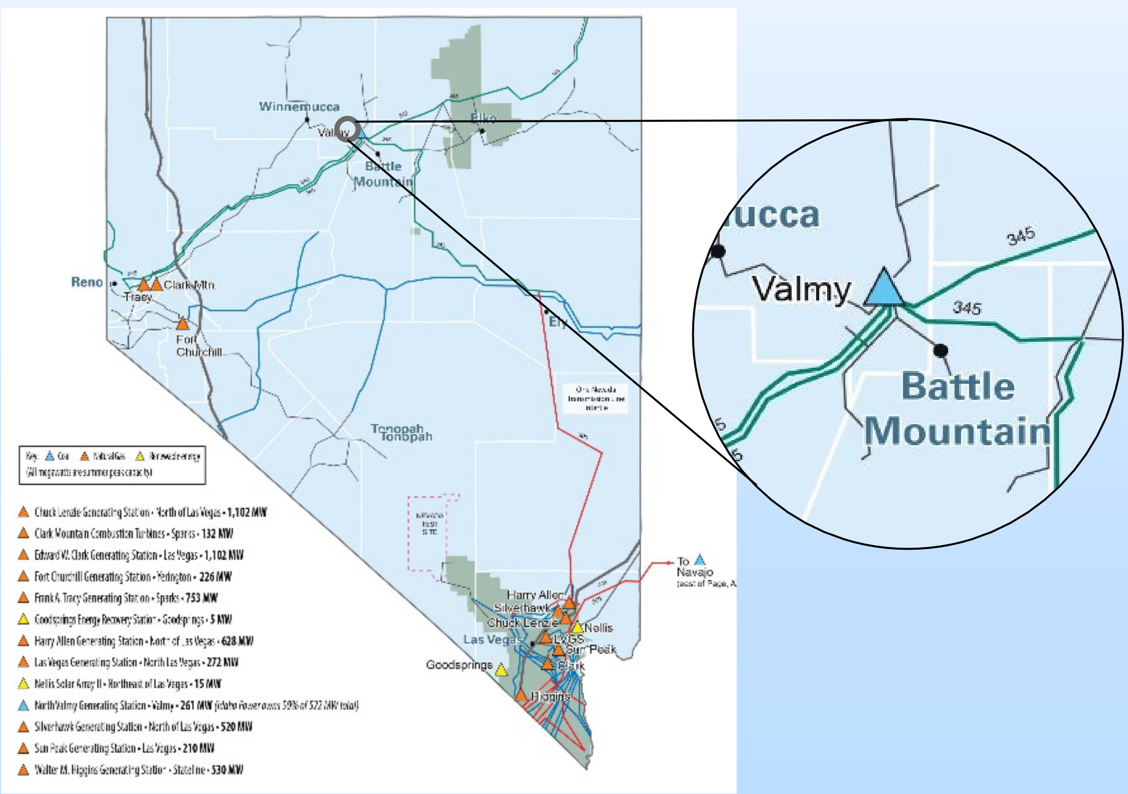
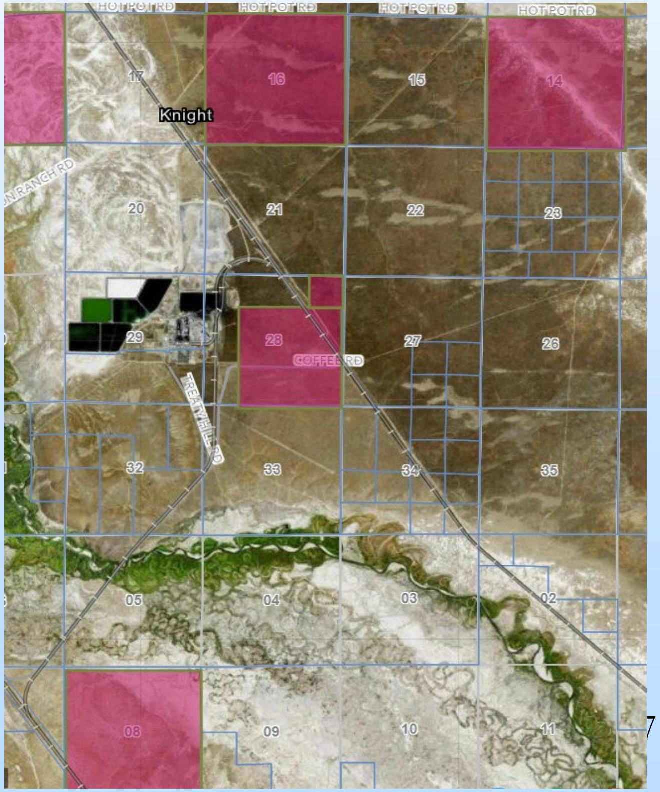
Site selection for field survey:

- Soil sampling
- Native plants identification





Progress of Project

Equipment used/built in the project
Unmanned Aerial Vehicle (UAV): Field Survey, plant coverage
First field survey: May 2023




Progress of Project

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Detected plant species

Plant species	Scientific name	Plant species	Scientific name
Rubber rabbitbrush	*Ericameria nauseosa*	**Coastal sagebrush**	*Artemisia californica*
redstem filaree	*Erodium cicutarium*	**Quack grass**	*Elymus repens*
bristly fiddleneck	*Amsinckia tessellata*	**Goosegrass**	*Eleusine indica*
flixweed	*Descurainia sophia*	**lemongrass tea**	*Cymbopogon citratus*
reed grass	*Calamagrostis*	**tufted hair grass**	*Deschampsia cespitosa*
White Horehound	*Marrubium vulgare*	**western mug wort**	*Artemisia ludoviciana*
basin wild rye	*Leymus cinereus*	**vetiver**	*Chrysopogon zizanioides*
Wood Betony	*Stachys officinalis*	**Sorrel**	*Rumex acetosa*
Durango Beargrass Tree	*Nolina durangensis*	**Chee Grass**	*Stipa splendens*
Switchgrass	*Panicum virgatum*	**wheatgrass**	*Elymus trachycaulus*
squarrose knapweed	*Centaurea virgata*	**wild carrot**	*Daucus carota L*

Progress of Project

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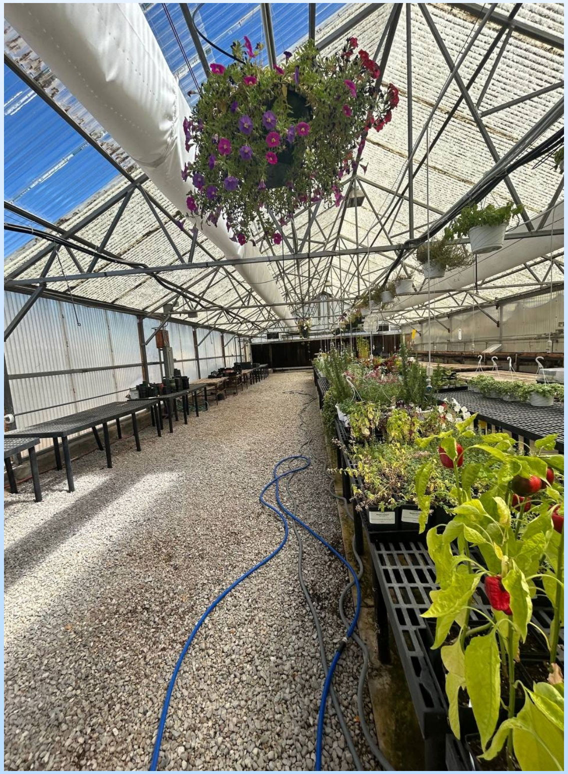
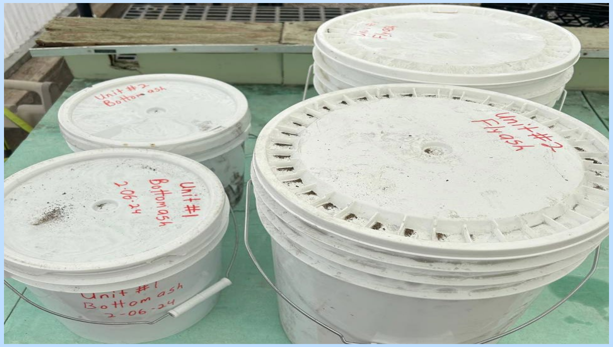
Equipment used/built in the project

Greenhouse selection: mobilization of the greenhouse for experiments





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Equipment used/built in the project

unmanned aerial vehicle (UAV): Field Survey, plant coverage

Second field survey:

- November 2023
- 300 pictures from each site

Area 8

Area 28

Area 16

Progress of Project

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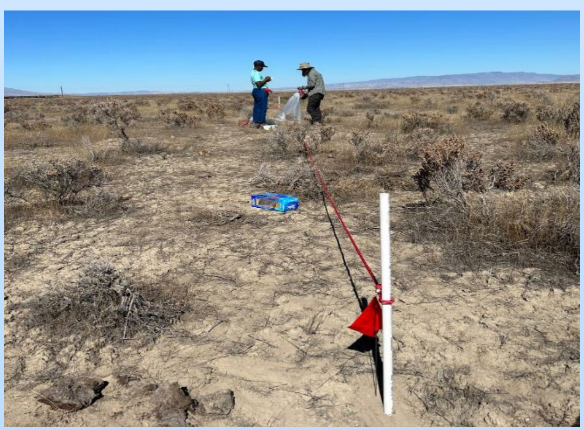
Field survey: Plant/soil sampling



Progress of Project

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Sample preparation/ ICP-OES

- Incineration of plant samples
- Digestion of soil

Progress of Project

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Greenhouse Mobilization

Irrigation system

Lessons Learned

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- An interdisciplinary study of mining, environment, and agriculture
- Drone-based plant identification and monitoring
- Provide a comprehensive database for hyperaccumulators
- use the highly sensitive spectrometric technique (ICP-OES)
- Published a review paper

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Bioresource Technology

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Review

Check for updates

Advancing phytomining: Harnessing plant potential for sustainable rare earth element extraction

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[c] *The Plant Molecular and Cellular Biology Laboratory, The Salk Institute for Biological Studies, La Jolla, CA 92037, USA*

Plans for the future

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In this project

- The selected hyperaccumulators will be cultivated in the Area of Interest
- Investigation/development of an integrated process to produce metals

After this project

- Development of the process.
- Optimization of factors affecting the process.

Scale-up potential

- This process can be scaled up as a phytomining process to produce metals from hyperaccumulators

Summary

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a. Learning opportunities from this project

1. Drone-Based Plant Identification and Monitoring
2. ICP-OES Analysis for Heavy Metals and Rare Earth Elements
3. Soil and Plant Sample Processing Techniques
4. Field Surveys and Ecological Assessments
5. Greenhouse Experimentation

b. Next steps:

1. Finding hyperaccumulators with high accumulation and suitable for metals
2. LCA/TEA on the entire process

c. The project is advancing towards developing efficient, low-cost phytoremediation methods for CCPs, with significant progress in research, field surveys, and training, laying a strong foundation for future environmental restoration efforts.