Phytoremediation and Rhizodegradation Pilot Studies at a 73-Acre Former Wastewater Pond in Northern California

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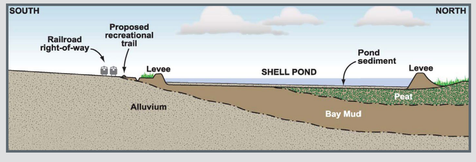
INTRODUCTION

A former 73-acre wastewater treatment pond is situated adjacent to a coastal estuary with surrounding wetlands. The site contains a surficial layer of historically discharged material composed of fine-grained material with total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), and metals as chemicals of concern (COCs). Due to the site setting and history, the surface material exhibits high salinity and sodicity.



A portion of the pond was isolated and dewatered. Pilot studies were performed to evaluate phytoremediation and rhizodegradation (via indigenous microbes) to achieve remedial goals.

The 1-acre research plot evaluated degradation processes/rates and plant uptake with different plant types (jaumea, saltgrass, alkali sacaton, fat hen, and meadow barley) and soil amendments, while the landfarming study looked at the effects of mechanical mixing of the soil.

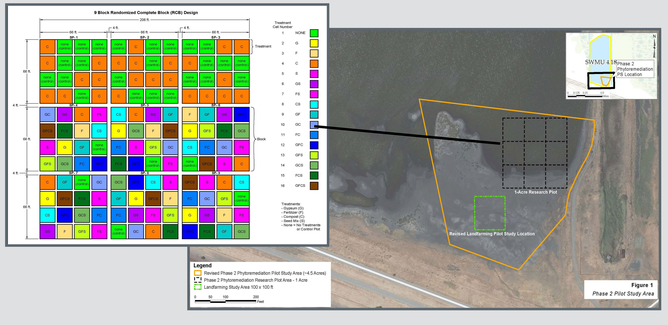


Figure 1
Phase 2 Pilot Study Area

APPROACH

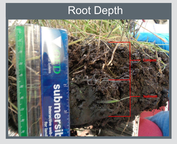
- Initial planting – fall 2016
- 2017 – winter storms flooded test area
- Replanting – May 2017
- Landfarming study – June 2017
- Sample analysis – December 2017
  - TPH, PAHs, metals, plant tissue
  - Molecular Biological Tool (MBT) Data
    - Next Gen Sequencing – DNA-based analysis of microbial community
    - Quantarray Petro – Microbial enzyme activity specific to TPH/PAH degradation
    - Stable Isotope Probing (SIP) – Measures degradation of stable isotope C^{13} (naphthalene)


Winter Flooding


Replanting


Landfarming Study


Plant Establishment



Root Depth

RESULTS

Plant Growth and COC Reduction

- Plant establishment in areas amended with compost and increase in plant growth promoting rhizobacteria Azospirillium
- Overall TPH/PAH reduction of 26%/16%
- Metals in pilot study plant tissue similar to levels in background plant tissue

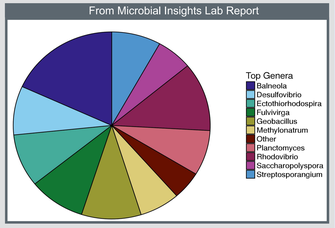
Ratios of Root to Shoot Concentrations

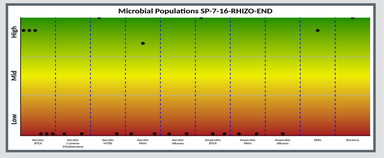
1st Parameter	2nd Parameter	Cadmium	Cobalt	Chromium	Copper	Nickel
Pond Root	Pond Shoot	2.5	8.4	2.5	5.6	3.6
Background Root	Background Shoot	1.5	8.2	5.0	2.5	5.6
Pond Root	Background Root	1.0	0.7	0.3	3.6	0.3
Pond Shoot	Background Shoot	0.6	0.6	0.6	1.6	0.5

RESULTS

MBT Analysis

- NGS data indicate transition in dominant microbes from typical coastal sediment microbes to hydrocarbon and PAH degraders such as the genera Balneola, Hydrocarboniphiga, and Methylophaga
- Quantarray Petro data indicate increase in aerobic and anaerobic hydrocarbon and TPH/PAH degrading enzymes, i.e., benzoyl-coenzyme A reductase (BCR) and benzylsuccinate synthase (BSS)
- SIP data showed that the C^{13} was taken up into microbial biomass and also observed in CO_2, indicating direct lines of evidence of microbial degradation of the COC. The C^{13} reduction was among the highest levels ever detected at Microbial Insights.





CONCLUSIONS

- Compost required for plant establishment
- Plant roots penetrated into waste sediment
- Positive changes in microbial community and enzymatic activity observed
- Reduction of TPH/PAH
- Phytoremediation with microbial/ rhizodegradation demonstrated to be a cost-effective and efficient remedy for full-scale implementation

Sustainable Remediation

Implementation of phytoremediation will minimize construction impacts during future work by eliminating the need for 350,000 tons of soil disposal, will improve community safety (minimizing the need for over 200,000 miles of trucking operations, air quality impacts, and vehicular risks), and will reduce approximately 800 tons of CO_2 emissions. This approach may be applied to other PG&E sites now that the proof of concept has been completed.

The business of sustainability