A Rotational Phytoremediation and Mycoremediation Protocol

Using Willow, Hemp, and Fungal Mycelium to Rejuvenate Contaminated Agricultural Soil

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Abstract

This paper outlines a low-cost, low-technology rotational remediation protocol for restoring contaminated agricultural and industrial-adjacent soil using three biological agents in sequence: willow (Salix spp.), industrial hemp (Cannabis sativa), and saprotrophic fungal mycelium. Unlike single-species remediation studies, this protocol is designed as an ongoing land-management system: the same species used to remediate the soil are retained afterward as a secondary crop stream once contamination has cleared, rather than being abandoned once the soil is clean. This work is released freely for use, adaptation, and field testing by any research institution, extension program, or land manager, with the sole request that authorship be credited to Jason McCoy and the Pre-Failure Research Group (PFRG).

1. Background and Rationale

Phytoremediation (plant-based contaminant uptake) and mycoremediation (fungal-based contaminant breakdown) are each individually well established. Willow is widely used for heavy-metal uptake and as a riparian buffer due to its high water demand and root density. Hemp is fast-growing, deep-rooted, and known to accumulate heavy metals such as lead and cadmium within a single growing season. Fungal mycelium, particularly oyster mushroom (Pleurotus spp.) mycelium, is effective at breaking down petroleum hydrocarbons and certain pesticide residues, and can bind heavy metals within its tissue.

This protocol combines all three in a deliberate sequence rather than treating them as independent options, and treats the remediation period as the first phase of a longer-term land use plan rather than a one-time intervention.

2. Rotational Methodology

2.1 Willow — Continuous, Sited Around Water

Willow is planted around all ponds, streams, and source water on the site and maintained on an ongoing basis rather than rotated out. Its role is to buffer and protect water sources from contaminant migration throughout the entire remediation period and beyond.

2.2 Hemp — Years 1 through 2-3

Following initial site assessment, hemp is planted across the contaminated area for a period of two to three years. Hemp's rapid growth and deep taproot are used to draw down the bulk of heavy metal and organic contaminant load during this phase.

2.3 Mycelium — Years 3-4 through 5-6

After the hemp phase, the site transitions to fungal mycelium treatment for a further two to three years. This phase targets residual petroleum hydrocarbons and organic contaminants that plant uptake alone does not fully address, and continues heavy-metal binding within fungal tissue.

2.4 Retesting

At the conclusion of the mycelium phase, soil is retested for the contaminants originally identified on-site. Results determine whether the site is released for general use, requires an additional rotation cycle, or needs a targeted follow-up treatment for specific residual contaminants.

3. Biomass Handling During Remediation

During the active remediation phases, all harvested hemp and mycelium biomass is treated as contaminated material. None of it is sold, processed, or used in any product, food, or fiber stream. It is disposed of separately from any clean agricultural output, following applicable hazardous/contaminated waste handling requirements for the specific contaminants present on-site.

4. Post-Remediation Continuation Model

Once soil testing confirms the site is clean, the same site is well-suited to continue producing hemp and mycelium — now without the contamination handling constraint — alongside grain or other harvest crops already suited to the reclaimed land. This gives a project two practical, non-remediation outputs that continue after the cleanup phase is complete:

- Hemp for its established natural uses (fiber, hurd, oil, and other existing hemp product streams), which remain underutilized relative to hemp's availability.
- Mycelium grown for material applications such as bio-based adhesives and composite materials, including experimental use in components such as wind turbine parts.

These two continuation paths are related to, but distinct from, the remediation-phase crops: the remediation-phase biomass is disposed of as contaminated waste, while the post-remediation biomass is clean and can be used or sold without restriction.

5. Intended Use and Licensing

This protocol is released for open use by any college, university, extension program, nonprofit, or land manager who wishes to test, adapt, or build on it. There is no fee, license cost, or ownership claim attached to its use. The only request is that Jason McCoy and the Pre-Failure Research Group (PFRG) be credited as the originating source when this work is used, cited, published, or built upon.

6. Status and Invitation to Collaborate

This protocol is offered to any college, university, or research group interested in field-testing, refining, or partnering on this work. Inquiries, field data, and proposed refinements are welcome and can be directed to Pre-Failure Research Group LLC via pfrg.org.

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