The Role of Mycoremediation in Alaska

The applications, strengths and limitations of mushroom-based bioremediation in cool climates and high latitudes

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Fungi Alliance

Outline

1. Fungi Alliance Business
2. Principles of Mycoremediation
3. Potential of fungi in remediation
4. Mycoremediation development in Alaska
5. Discussion

A social enterprise is an organization that addresses a basic unmet need or solves a social or environmental problem through a market-driven approach.

Social Enterprise Alliance

The Fungi Alliance is a social enterprise for-profit collaboration providing services, consulting, and products using fungi for environmental soil remediation.

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Fungi Alliance
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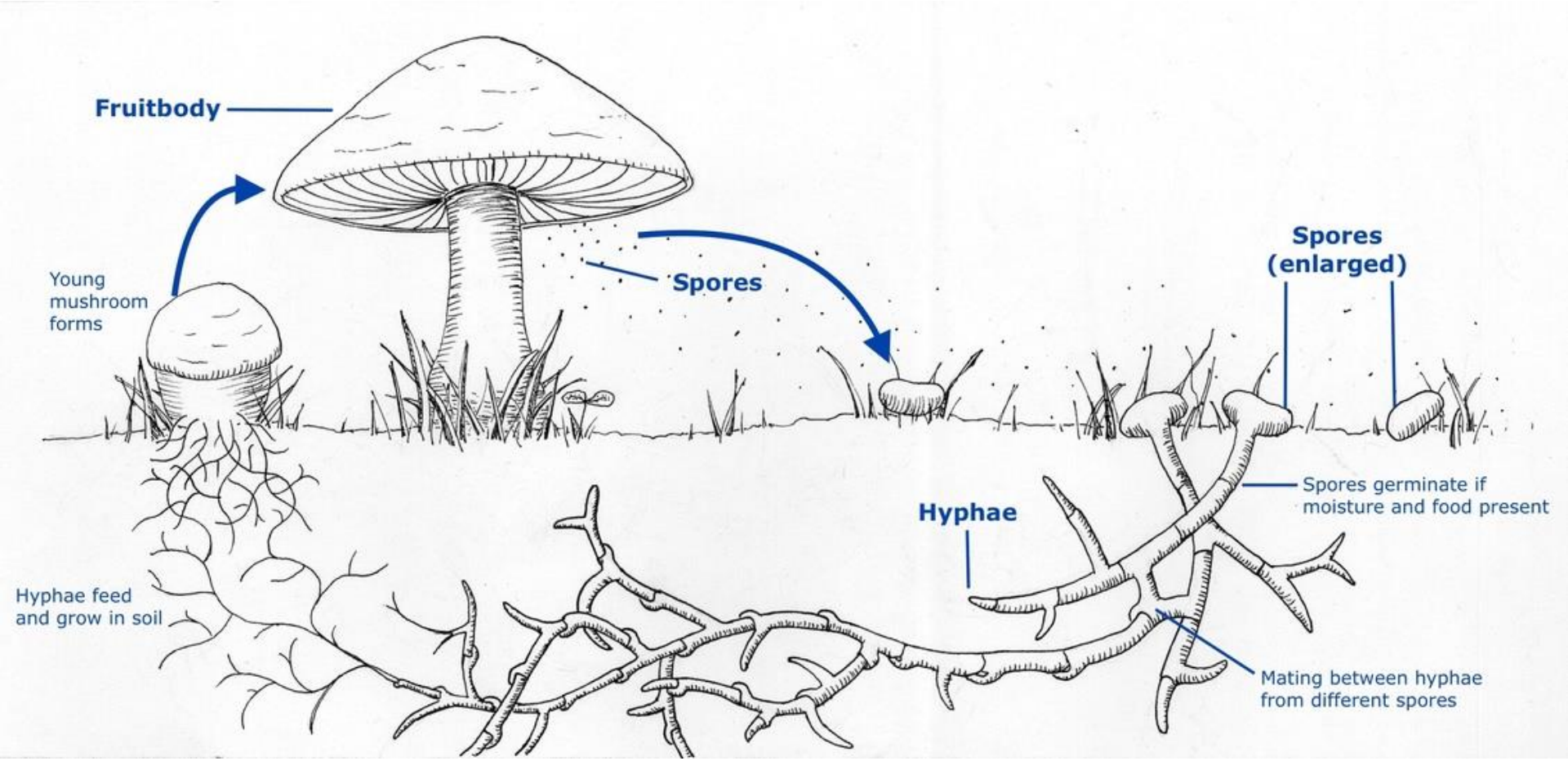
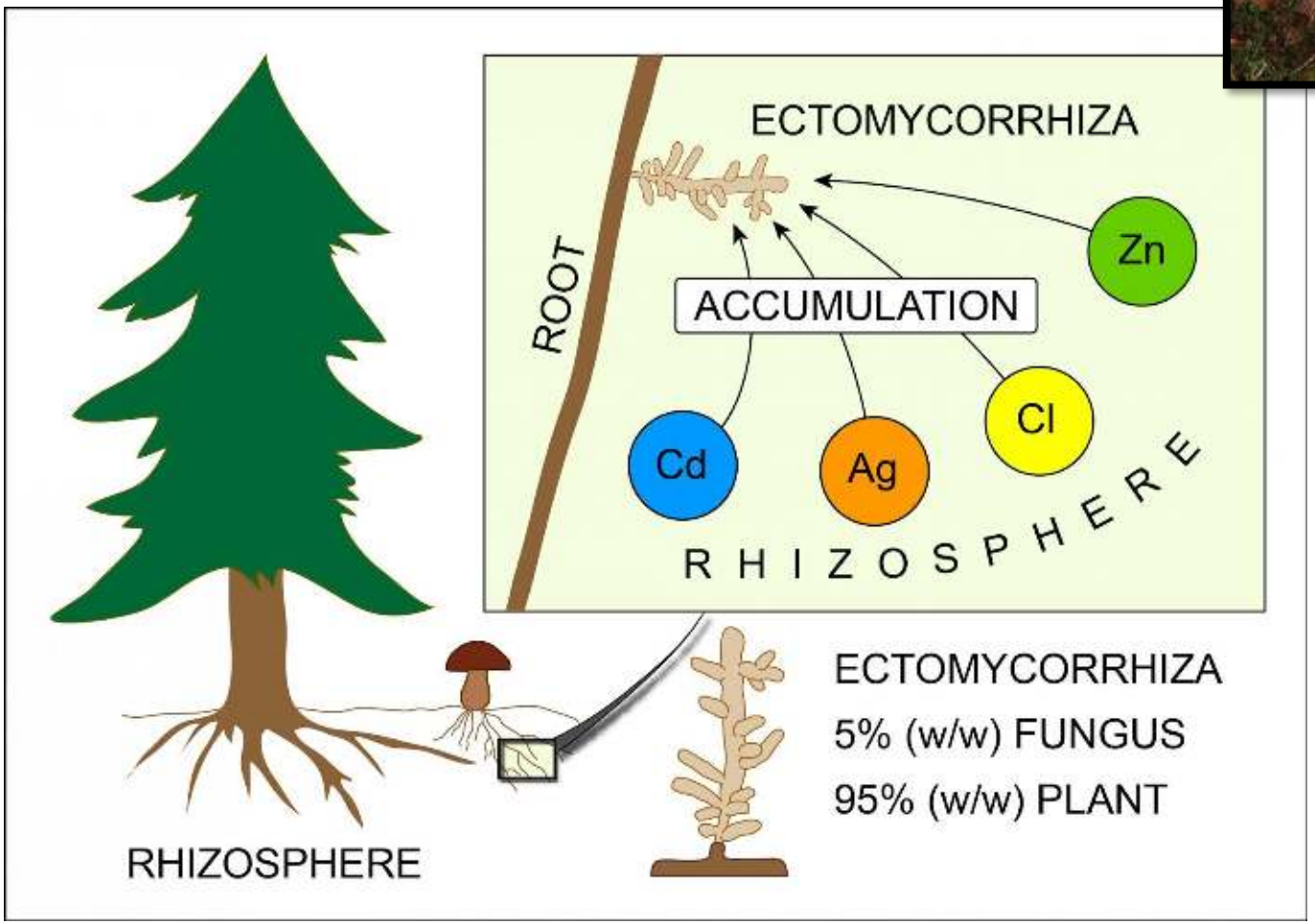
Principles of Mycoremediation



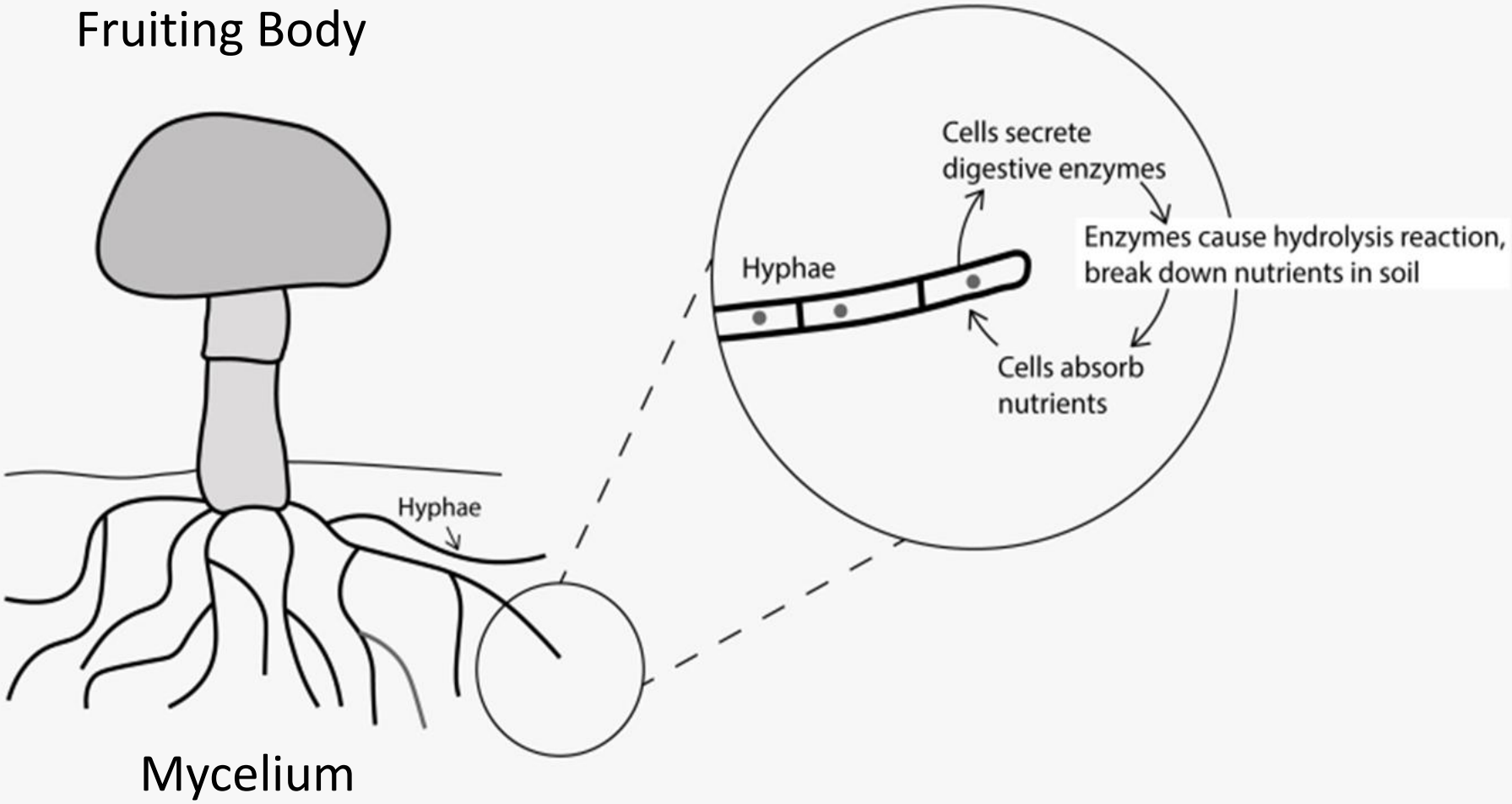
Principles of Mycoremediation Mycorrhizer



Principles of Mycoremediation

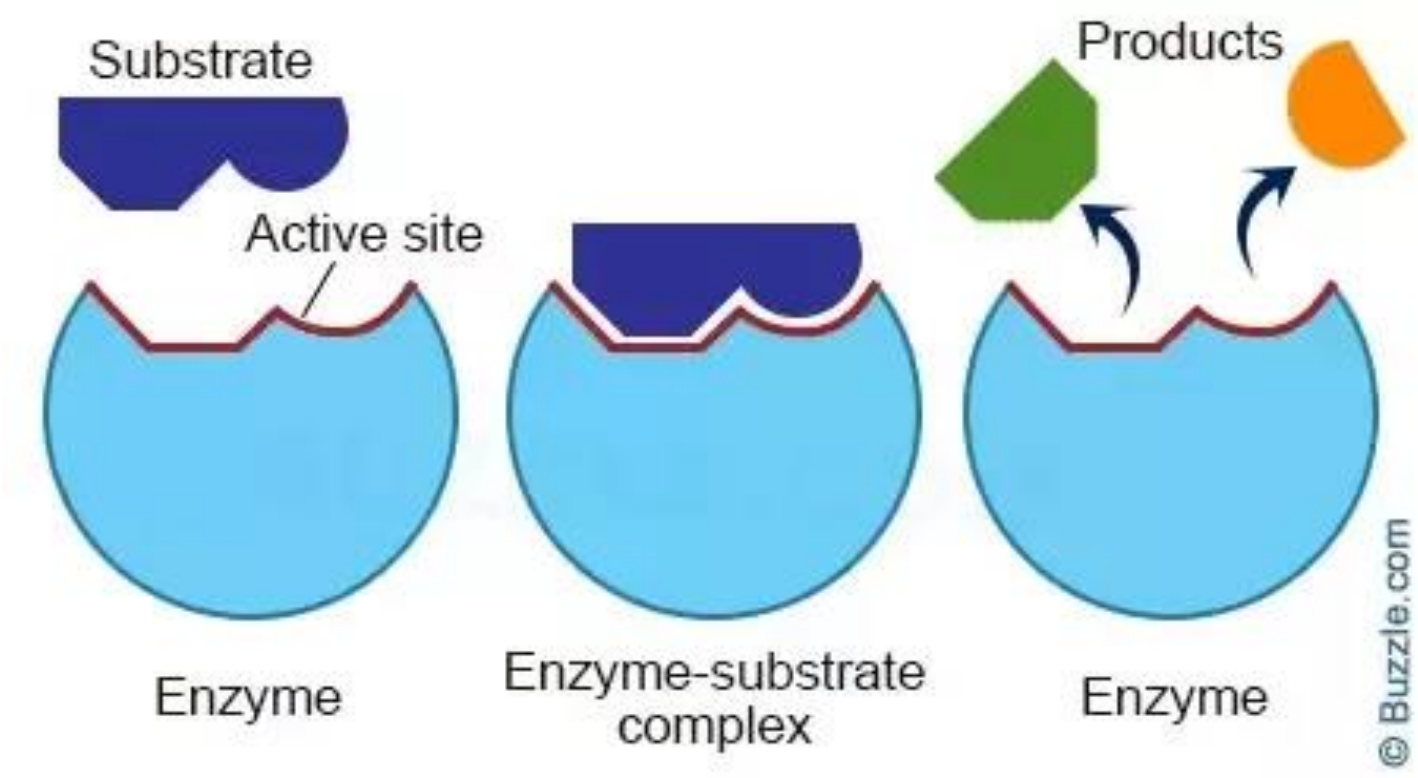
Largest Organism in the World at over 2000 acres

Principles of Mycoremediation

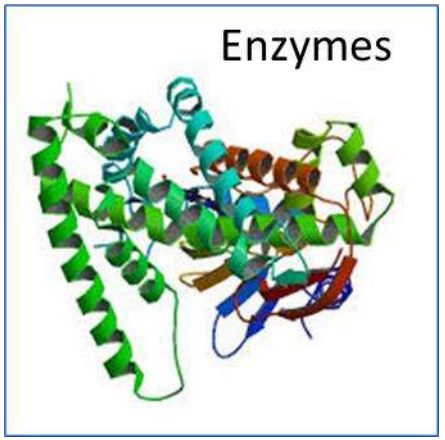


Principles of Mycoremediation

Enzymes



LIGNINOLYTIC ENZYMES

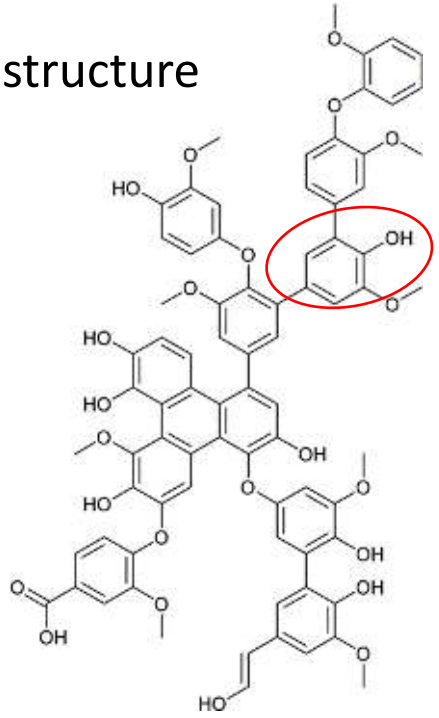


- Laccase,
- Manganese Peroxidase (MnP),
- Lignin Peroxidase (LiP)
- Versatile Peroxidase (VP)

➢ Extracellular, low substrate specific, oxidize many recalcitrant xenobiotic organic compounds

WHITE-ROT FUNGI

Lignin structure

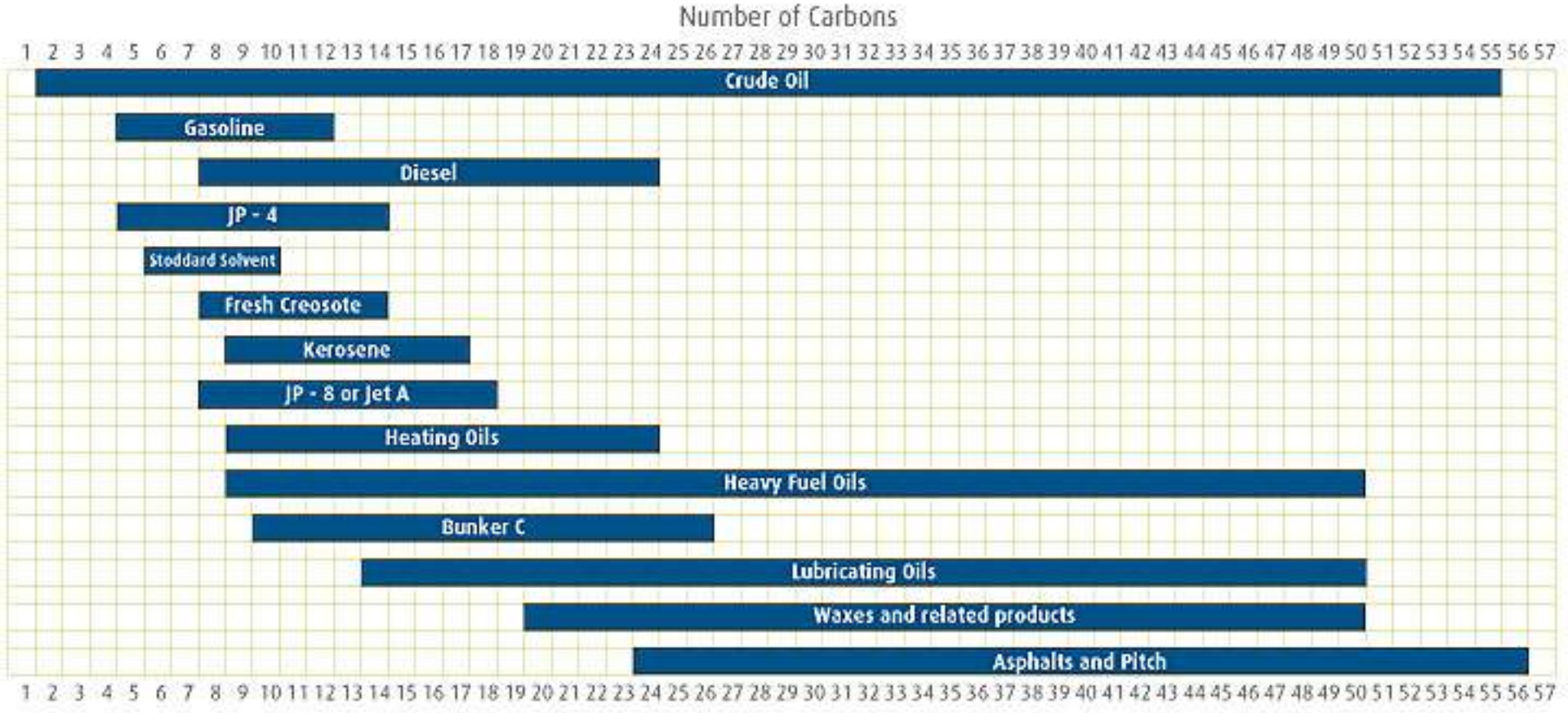


Persistent Organic Contaminants

Laboratory and benchtop studies

- Petroleum Hydrocarbons*
  - Gasoline, Diesel, Crude Oil, Polynuclear Hydrocarbons
- Chlorinated Compounds*
  - Polychlorinated Biphenyl's (PCBs), chlorinated solvents, Dioxane, chlorinated pesticides, insecticides.
- Pharmaceutical & Personal Care Products
  - Antibacterial, Antidepressants, Anticonvulsant, and more
- Bacterial contamination
  - E.coli and other pathogens

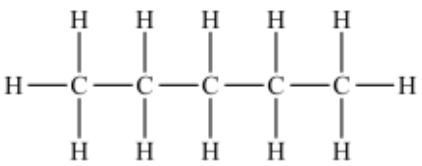
Petroeum Hydrocarbons



Petroleum Hydrocarbons

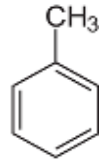
- Gasoline, Diesel

  Seidu et al 2015



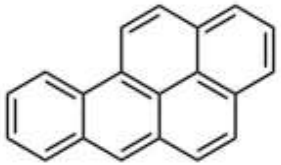
Pentane

Cyclohexane



Toluene

- Polycyclic Aromatic Hydrocarbons (PAHs) >100 different
  - Gramass et al. 2009
  - ➢ Compared 58 fungi for PAHs degradation, different fungi prefer different PAH compounds, 19-95% degradation.

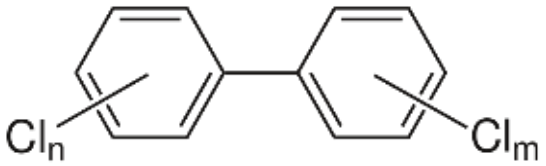


Benz[a]pyrene

- Crude Oil
  - Isikhumhen et al 2003, Ezekoye et al 2018,
  - ➢ Decline of contamination, making soil more fertile, increases growth of other vegetation.

<15%
Sulfur
Nitrogen
Oxygen
Metal

Chlorinated Compounds



Polychlorinated Biphenyls (PCBs)

209 congeners

<u>With Ligninolytic Enzymes</u>

(Sredlova et al 2020, Cvancarove et al 2012)

- Basidiomycetes e.g. *fresh and spent Pleurotus ostreatus (oyster mushroom) in water and soil*

➢ Splitting of aromatic rings & De-chlorination

<u>Without Ligninolytic Enzymes</u>

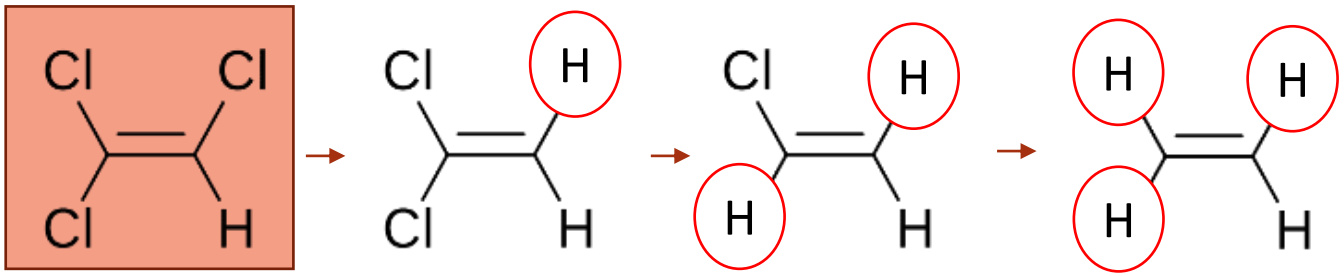
(Tigini et al 2009, Sredlova et al 2020, Marco-Urea et al. 2015 and more)

- Ascomycota (sac) fungi *Penicillium (chrysogenum, digitatum) Scedosporium apiospermum, Fusarium solani*

➢ De-chlorination

Chlorinated compounds

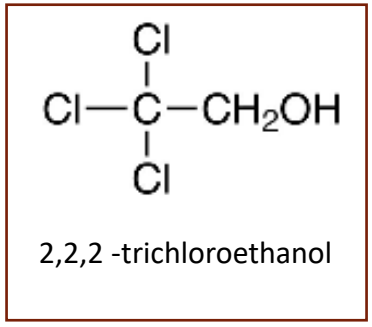
Trichloroethylene → *Vinyl Chloride* → Ethylene



Trichloroethylene (TCE) highly toxic compound derived from industrial cleaner (dry cleaner, auto shops) very soluble and found as groundwater contaminant

White Rot Fungi *Trametes versicolor* produced CO_2 and 2,2,2 Trichloroethanol

Successful remediation combining *Poplar sp.* and TCE degrading endophyte. (Doty et al 2017)



2,2,2 -trichloroethanol

https://oehha.ca.gov/chemicals/trichloroethylene

Metals

Cadmium, Copper, Chromium, Lead, Mercury, Nickel, Tin, Zinc

Biosorption and Sequestration :

- Modified mushroom material (mycelium and fruiting body): Dried mycelia, live mycelia, spent mushroom substrate, biomass immobilized on calcium alginate.
- Mushrooms take up and accumulate metal concentrations above permissible concentrations.

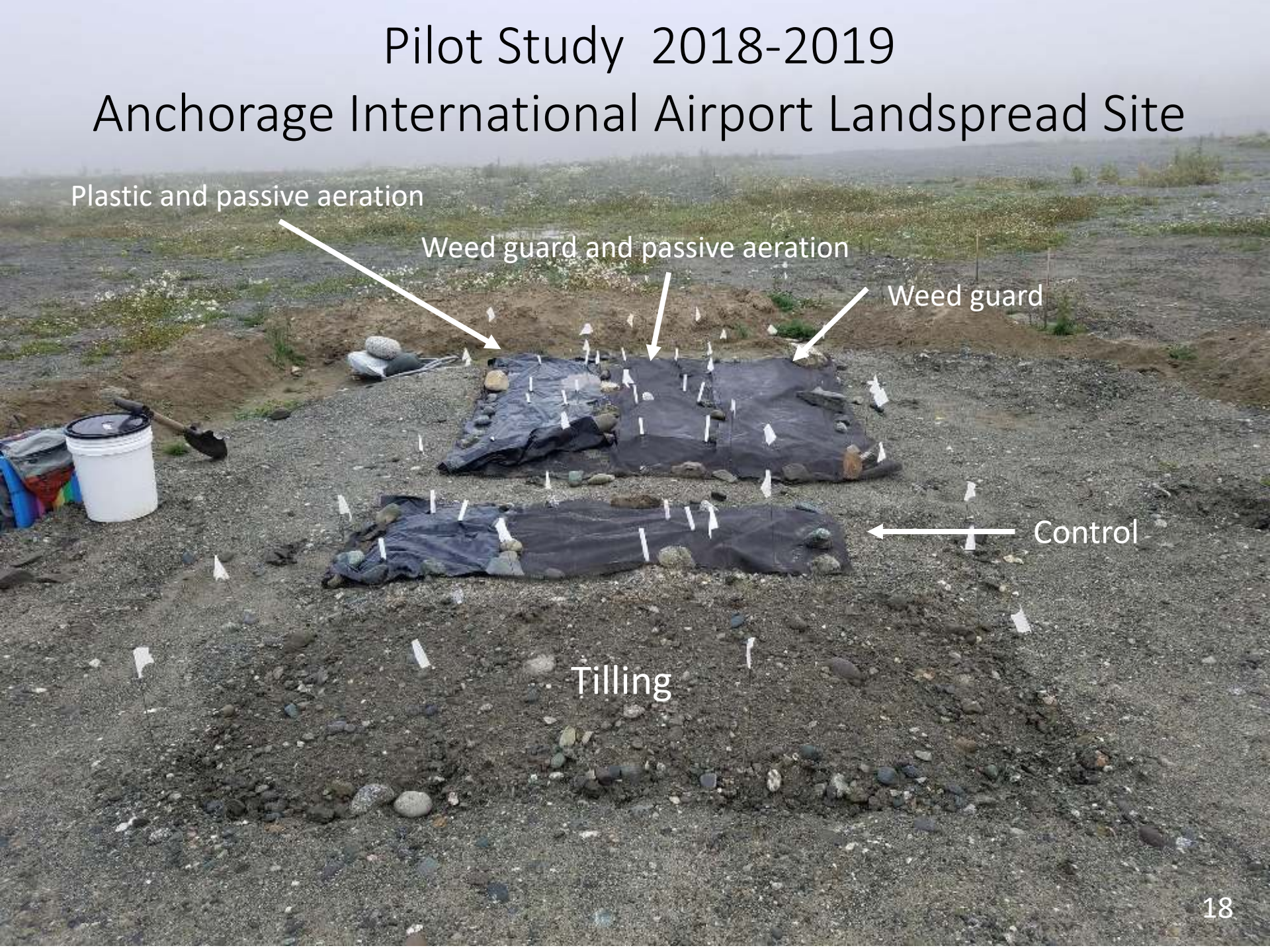
➢ Process: Ion-exchange and chemisorption

➢ *Adsorption due to functional groups, and ionizable groups (carboxyl, amino groups) pH dependent, pH 5-6 favorable for most metals*

➢ Heavy metals are mostly enriched in fruiting body or stipe

➢ Metal concentrations may reduce growth of mycelia can stimulate or reduce enzyme production

Pilot Study 2018-2019
Anchorage International Airport Landspread Site



47 DAYS

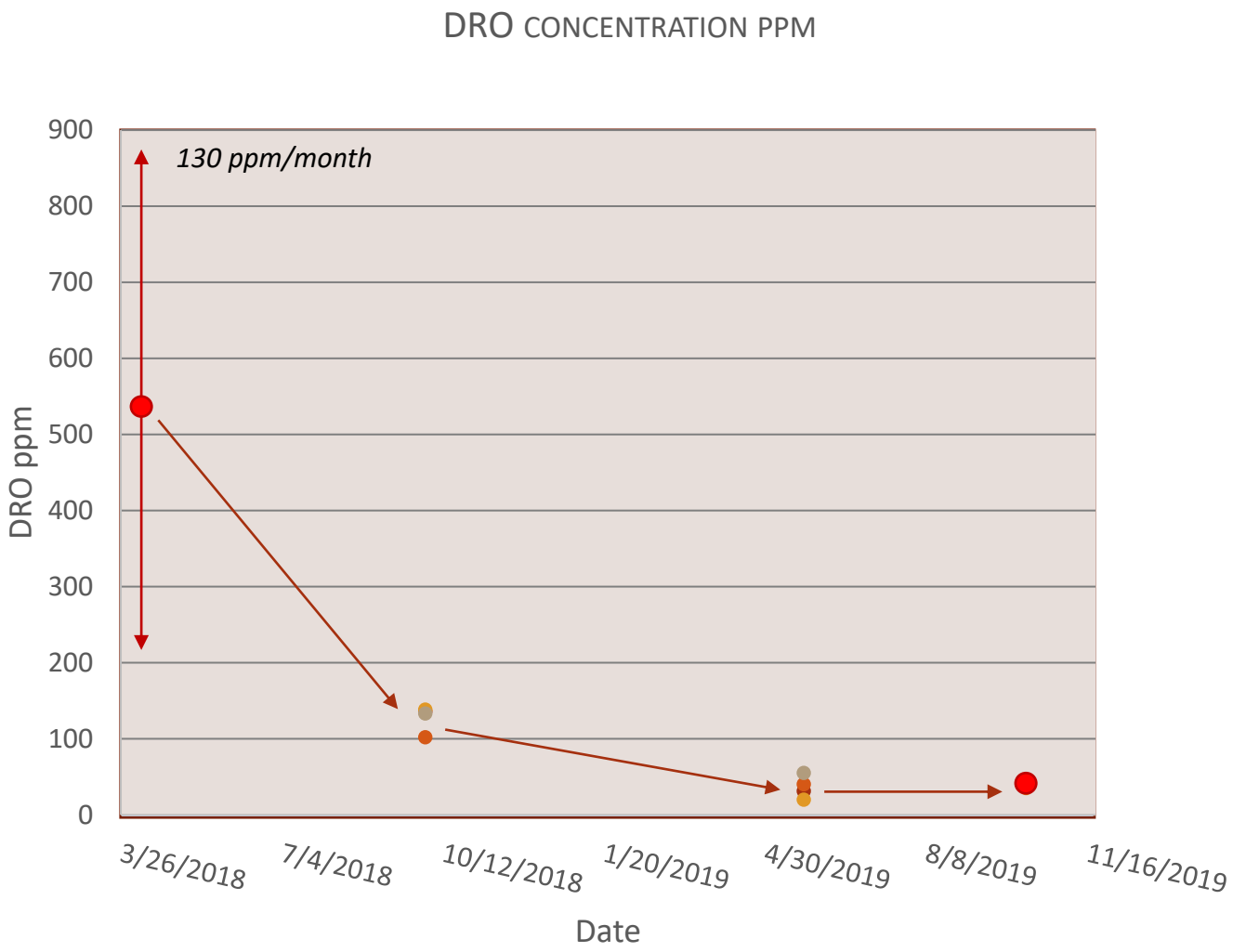
SITE VISIT IN AUGUST 8TH , 2018

100 DAYS

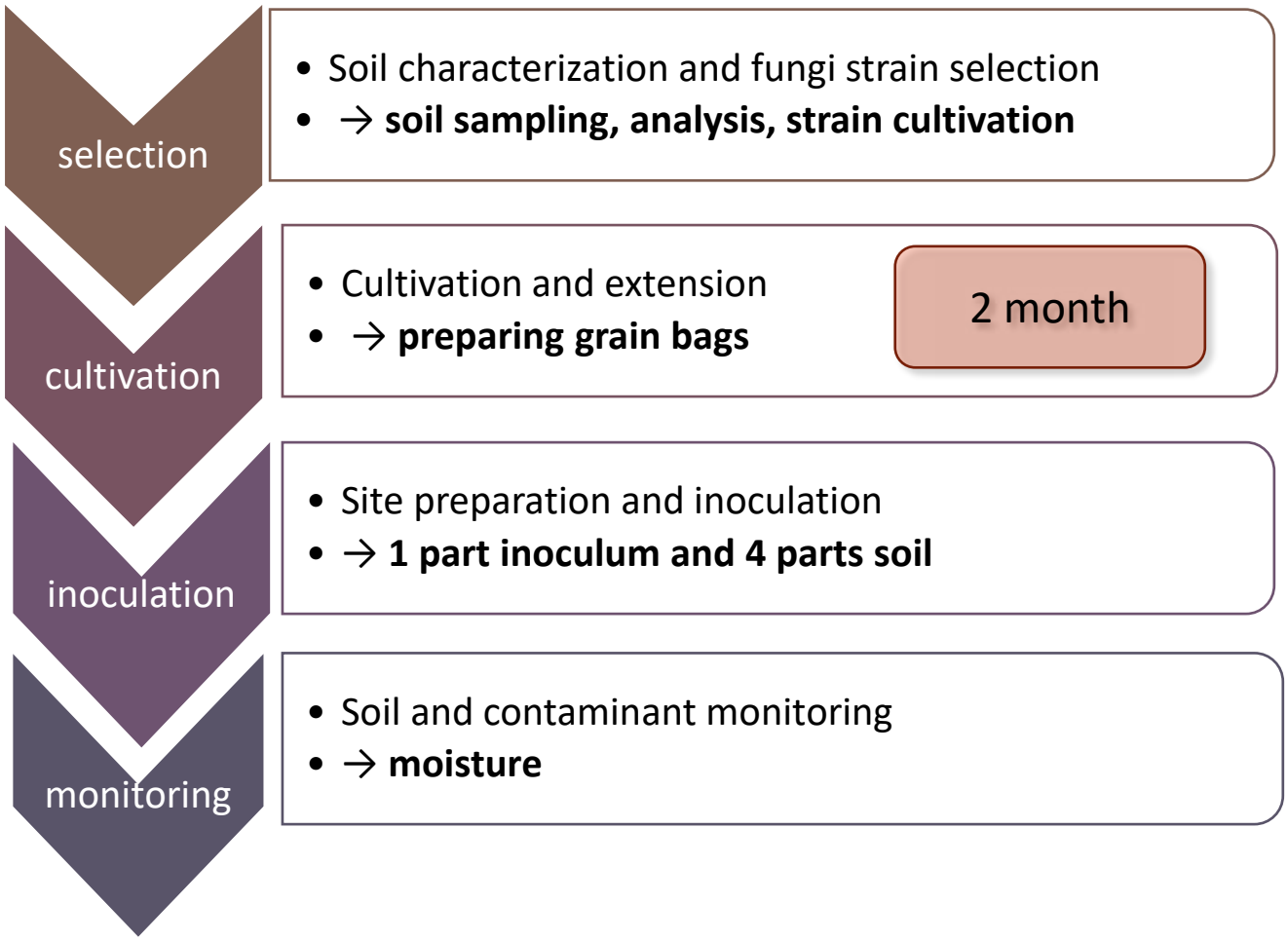
SITE VISIT OCTOBER 1ST 2018

Sampling October 10th 2018

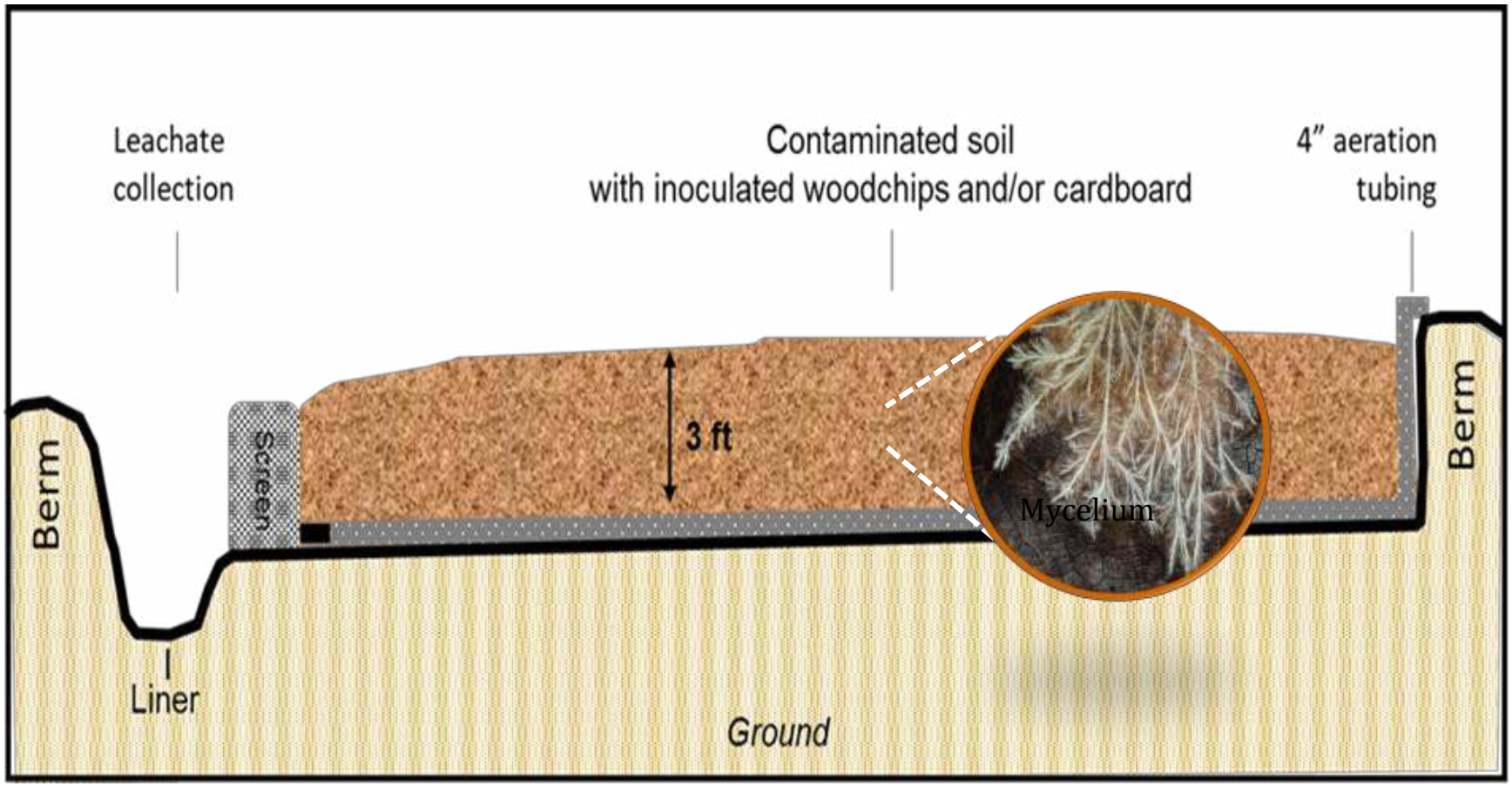
DEGRADATION PATTERN



RESULTS: THE PROCESS

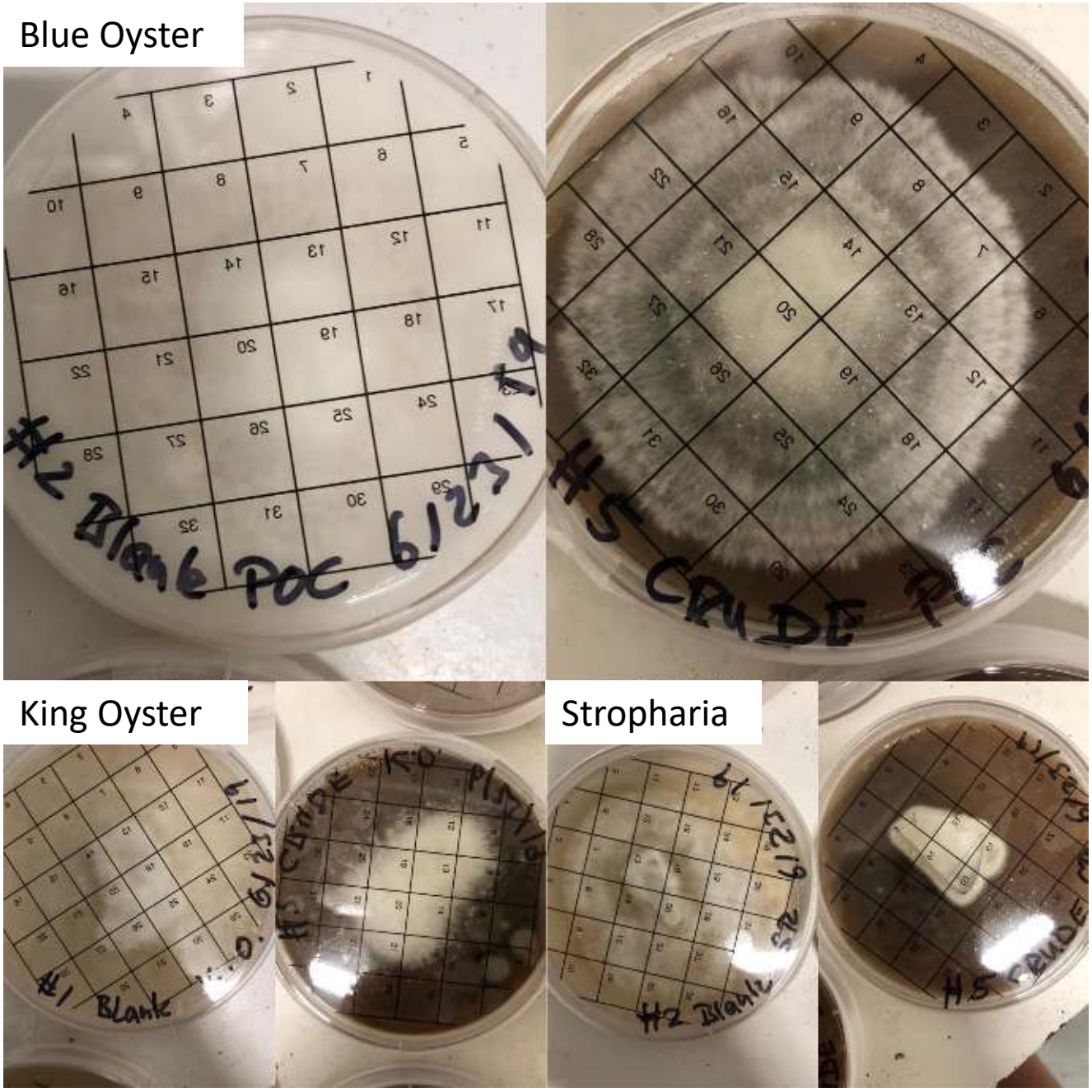


RESULTS: FUNGI-BIOPILE



Complies with ADEC requirements for Biopiles/bioremediation,
18 AAC 75.370/ 18 AAC 75.360.11(E)

Crude Oil Experiment



Agar-Agar with
1000 ppm Crude Oil

SUSTAINABILITY

- Waste materials
- Invasive species
- Faster (2 weeks)
- Minimal maintenance
- Retaining the soil on site

What Nexts ?

- There are many many positive studies
- Nobody developing/applying this in Alaska
- Establishing a business that brings Mycoremediation to Alaska
- Fulfilling agency regulations
- Real Applications – Pilot Study

Questions?


Phanerochaete
chrysosporium


Trametes trogii


Lentinus tigrinus


Penicillium


Pleurotus ostreatus


Aspergillus
awamori


Trametes
Versicolor


Fly Agaric

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