Mycoremediation of Petroleum Hydrocarbons

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Objective

Observe the growth of Oyster Mushrooms in the presence of pollutants, such as petroleum hydrocarbons and analyze the differences in nutrients present in the substrate.

Background

- Remediation focuses on the removal of hazardous pollutants from the environment.
- Petroleum Hydrocarbons can be found in common fuels such as gasoline, engine oil and kerosene. They consist of large organic compounds that can be difficult to break down.
- Oyster Mushrooms can be helpful in remediating certain environments because they are saprophytic decomposers of substances such as lignin and cellulose (dead plant matter).
- Oyster Mushrooms can be important in remediating polluted environments due to their ability to degrade hydrocarbon bonds, which are present in both the pollutants and the substrates they typically grow in.
- Mycoremediation is possible because Oyster Mushrooms produce enzymes such as oxidase which break hydrocarbon bonds present in many pollutants.

Research

Materials Acquired:

- 6 bags of Blue Oyster inoculated substrate
- 6 bags of Golden Oyster inoculated substrate
- 6 bags of pure substrate with no mushrooms present
- 2 large jugs of spent engine oil
- 4 packs of Luster Leaf Rapid Soil Test Kits

Procedure:

- Allowed substrate blocks to become fully colonized before proceeding.
- Poured spent engine oil (pollutant) over top of half of the colonized blocks in 10% concentrations by weight.
- Oil Volume Calculation:
  Volume of Oil (ml)=(Weight of Substrate (kg)×1000×0.1)÷0.8220
- All blocks were placed in fume hoods to mitigate fumes created.
- Blocks were allowed to sit for about 5 days to absorb the pollutant.
- Bags were cut open to allow mushroom growth.
- Sprayed with water every few days to maintain moisture necessary for growth.
- Soil testing was performed.
- Results of soil tests were analyzed comparing experimental and control groups.

Results and Analysis

	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6
Weight (kg)	2.634	2.518	2.325	2.946	2.781	2.828
Oil Amount (ml)	320.4	306.3	282.8	0	0	0
pH	4.5 (very acid)	4.5 (very acid)	4.5 (very acid)	5.5 (acid)	5.5 (acid)	5.5 (acid)
N content	Depleted	Depleted	Depleted	Depleted	Depleted	Depleted
P content	Depleted	Depleted	Depleted	Deficient	Deficient	Deficient
K content	Surplus	Surplus	Sufficient	Deficient	Deficient	Deficient
	Blue Oyster 1	**Blue Oyster 2**	**Blue Oyster 3**	**Blue Oyster 4**	**Blue Oyster 5**	**Blue Oyster 6**
Weight (kg)	3.792	3.934	4.301	3.862	3.936	3.918
Oil Amount (ml)	458.5	478.6	523.2	0	0	0
pH	6.5 (slight acid)	6.0 (acid)	6.0 (acid)	5.5 (acid)	6.0 (acid)	5.5 (acid)
N content	Depleted	Deficient	Depleted	Depleted	Depleted	Depleted
P content	Depleted	Depleted	Depleted	Adequate	Adequate	Deficient
K content	Sufficient	Sufficient	Adequate	Sufficient	Sufficient	Deficient
	Golden Oyster 1	**Golden Oyster 2**	**Golden Oyster 3**	**Golden Oyster 4**	**Golden Oyster 5**	**Golden Oyster 6**
Weight (kg)	4.417	4.090	4.593	3.883	3.933	4.041
Oil Amount (ml)	537.3	497.6	552.2	0	0	0
pH	6.0 (acid)	6.0 (acid)	5.5 (acid)	6.0 (acid)	5.0 (very acid)	6.5 (slight acid)
N content	Depleted	Deficient	Depleted	Depleted	Depleted	Depleted
P content	Deficient	Adequate	Adequate	Deficient	Adequate	Deficient
K content	Depleted	Depleted	Deficient	Depleted	Deficient	Deficient

N content

Depleted

Depleted

Depleted

Depleted

Depleted

Depleted

P content

Depleted

Depleted

Depleted

Deficient

Deficient

Deficient

K content

The enhanced fungal growth in contaminated substrates indicate that Blue and Golden oyster mushrooms have the ability to metabolize petroleum hydrocarbons. The growth patterns and test results suggest that these fungi species could play a pivotal role in remediating polluted environments by balancing substrate pH and affecting the nutrients present in said substrate. By breaking down both the given substrate and pollutant present, the mushrooms created a growth environment that would be considered more suitable for other organisms such as plants or microbes.

Substrate without mushroom presence:

- Contaminated (1-3)
  - Reduced airflow.
  - Extreme acidity (pH of 4.5 or lower).
  - Nutrient depletion (N, P) but surplus of Potash compounds.
- Non-contaminated (4-6)
  - Acidic substrate (pH 5.5).
  - Nutrient deficiencies (P,K), Depletion of Nitrogen.

Blue Oyster inoculated substrate:

- Contaminated (1-3)
  - Mushrooms thrived despite contamination, grew quickly.
  - Nitrogen and Phosphorus depletion, sufficient Potash.
  - Balanced pH (6.0-6.5).
- Non-contaminated (4-6)
  - Slower growth than contaminated counterparts.
  - More nutrient presence than contaminated counterparts, but more acidic pH (5.5-6.0).

Golden Oyster inoculated substrate:

- Contaminated (1-3)
  - Slightly acidic substrate (pH of 5.5-6.0).
  - Adequate amount of Phosphorus but deficiencies in other nutrients (N,K).
  - Faster and larger growth than non-contaminated counterparts.
- Non-Contaminated (4-6)
  - Slightly acidic substrate (pH of 5.0-6.5).
  - Nutrient deficiencies for all tested nutrients (N, P, K).
  - Slower growth than contaminated counterparts.

Observation and Analysis

Pictured on the left are mushrooms grown in non-contaminated substrate, on the right is their contaminated counterparts all in their third week of growth. As you can see, both Blue (top) and Golden (bottom) grew faster and larger in the presence of the pollutant.

Limitations and Future Work

This study faced many limitations including lack of lab and equipment access, time and budget constraints, as well as environmental conditions which all influenced both testing and results. Future research would include using more advanced technologies, a larger team, and possibly using pre-polluted soils. These changes to the research could foster simultaneous testing of all substrates and nutrients present, and expanding the types and concentrations of pollutants used. These changes could lead to a better understanding of Fungi, it's adaptable nature and its role in remediation.

Conclusions

While contamination was expected to hinder growth, the mushrooms grown in contaminated substrate grew faster and larger than their non-contaminated counterparts. This project showcases fungi's potential to degrade pollutants and remediate substrates, making more suitable living conditions for various other organisms. The findings emphasize that the adaptable nature of fungi makes them a great choice for remediating polluted environments.

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References

Engelbrecht, C. (n.d.). Helpful Fungus Among us. Iowa State University Extension and Outreach. https://www.extension.iastate.edu/news/2006/jan/071801.htm

Hawaii Department of Health. (n.d.). https://health.hawaii.gov/about/files/2021/12/21.12.16_What-Are-Petroleum-Hydrocarbons.pdf

Kulshreshtha, S., Mathur, N. & Bhatnagar, P. Mushroom as a product and their role in mycoremediation.AMB Expr 4, 29 (2014). https://doi.org/10.1186/s13568-014-0029-8

Method 4030: Soil Screening for Petroleum Hydrocarbons. (1996, December). Retrieved September 8, 2024, from https://www.epa.gov/sites/default/files/2015-12/documents/4030.pdf

Oil eating mushrooms bring contaminated soil back to life. (n.d.). Retrieved September 8, 2024, from https://resoilfoundation.org/en/innovation-technology/fungi-contaminated-soil/

Supporting Recovery Efforts After Oil Spills. (n.d.). https://appliedsciences.nasa.gov/what-we-do/disasters/oil-spills