



Phytoremediation of Soil Contaminants

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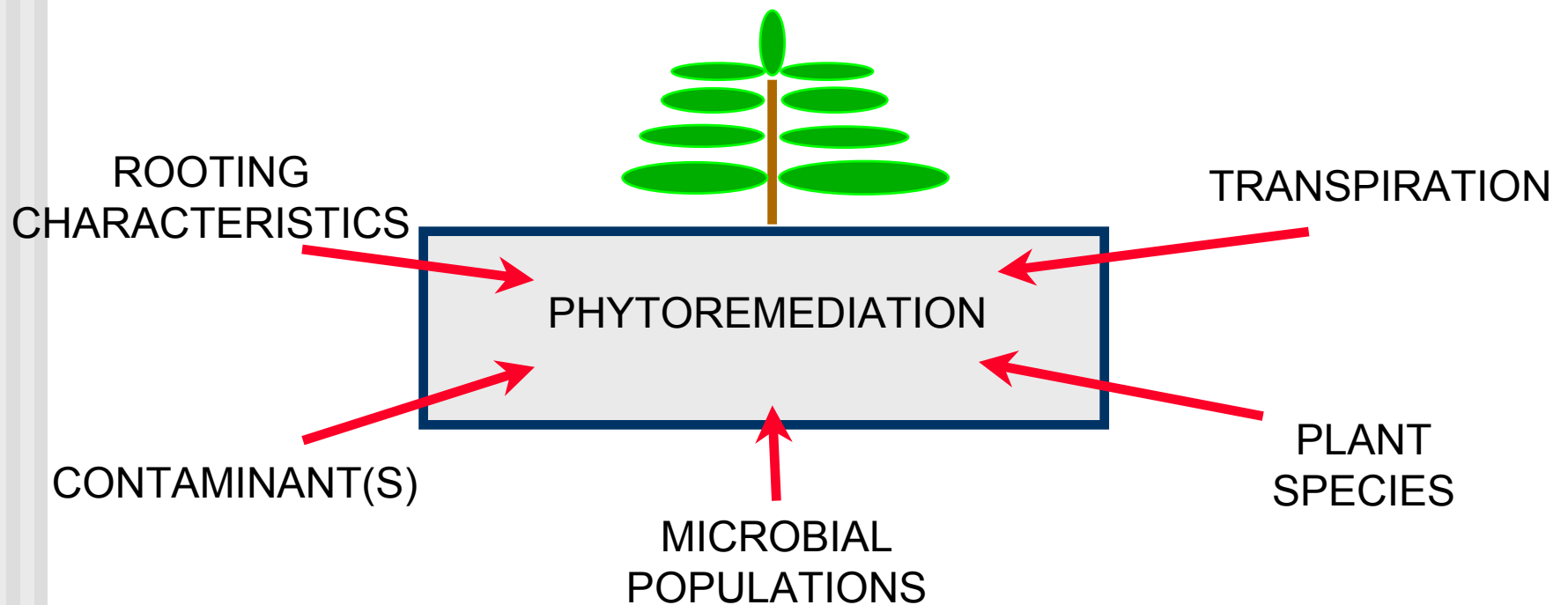
Phytoremediation Applications

- **Phytoextraction – removal of contaminants from soils.**
- **Phytodegradation – plant degradation of contaminants after uptake.**
- **Phytoaccumulation – contaminant accumulation in above ground biomass.**

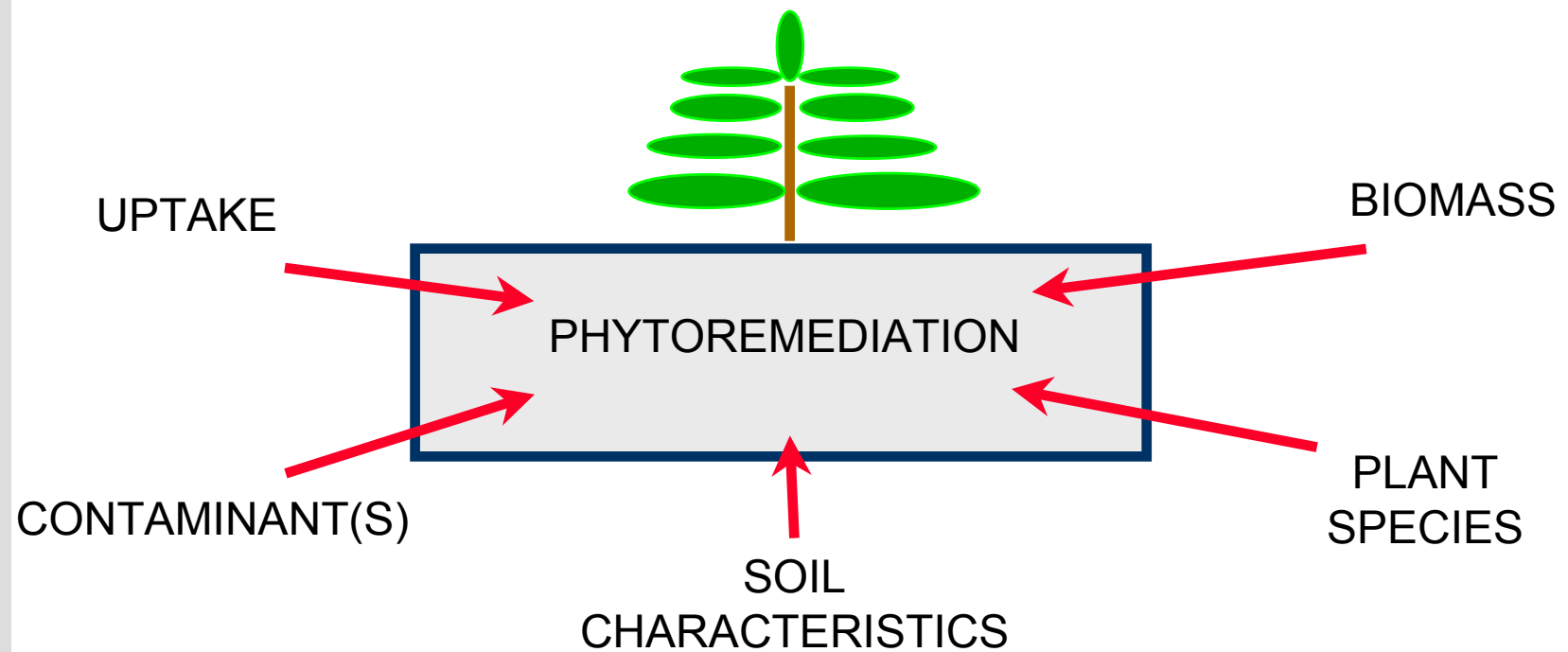
Phytoremediation Applications

- **Rhizosphere Degradation – enhancement of rhizosphere microbial bioremediation.**
- **Groundwater Interception – plants with large water requirements reduce contaminated groundwater movement.**
- **Living Caps – Reduction of leachate in landfills.**

Phytoremediation Processes Organic Contaminants



Phytoremediation Processes Heavy Metal Contaminants



Advantages

- **Low-cost approach.**
- **Aesthetically pleasing and appealing to the public.**
- **Site use and remediation can occur simultaneously.**

Disadvantages

- **Long time period required for remediation.**
- **Unknown impact on ecosystems and bioavailability.**
- **Scientific understanding of mechanisms is limited.**

Field Sites

- ***Port Hueneme Site*** - Fuel oil contaminated soil located in test cells at a DoD National Test Site.
- ***Bedford Site*** - Manufactured gas plant site with high PAH contamination at depths of 3 to 6 feet.

Port Hueneme Site (1997-2000)

- Site was located at the Port Hueneme DOD National Test Site.
- Study area consisted of 60' x 100' plots with three treatments and four replicates.
- Fertilizer and irrigation was used as needed.
- Soil samples were analyzed for petroleum contaminants, microbial characteristics, and toxicity for 30 months.

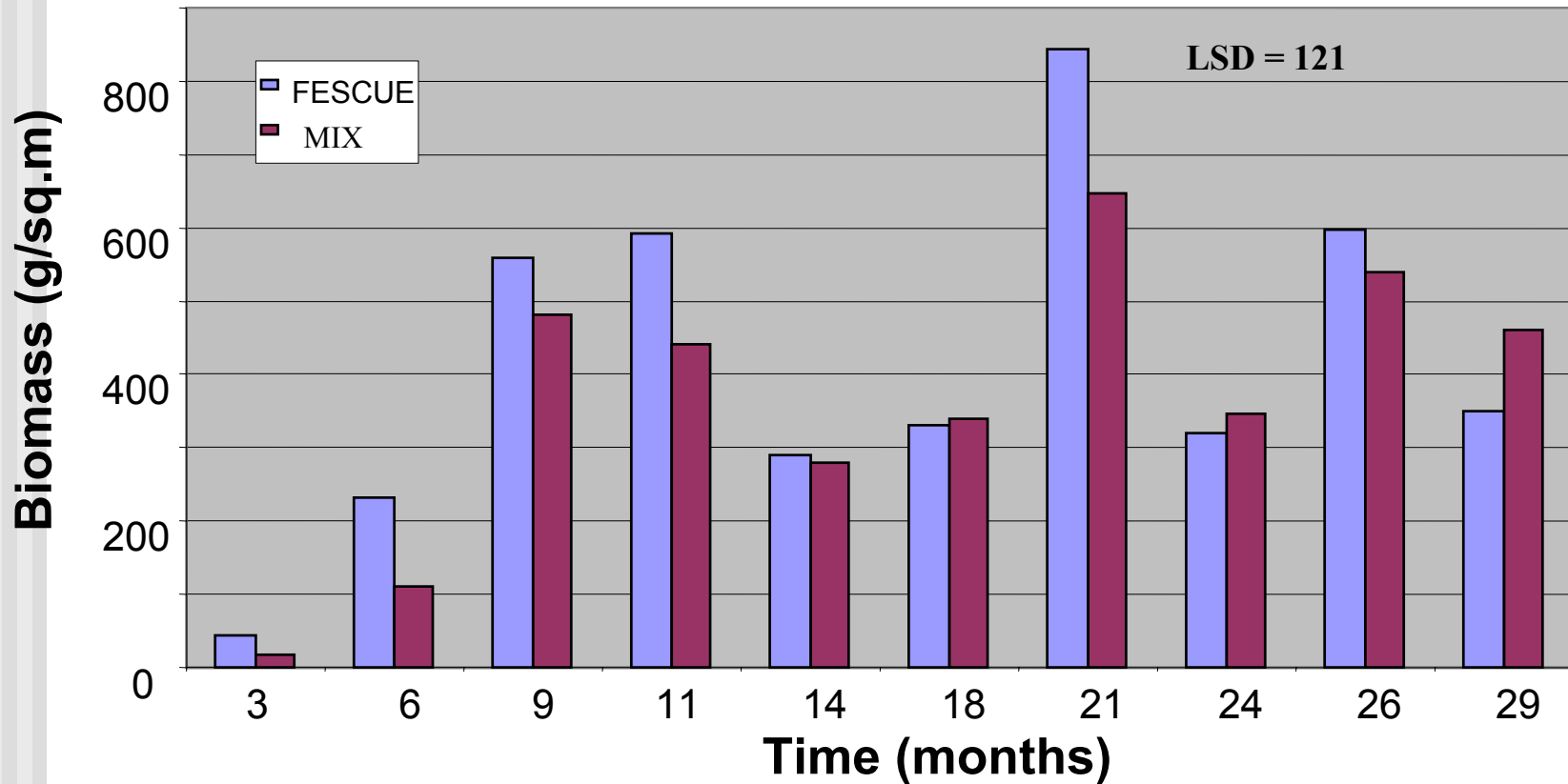


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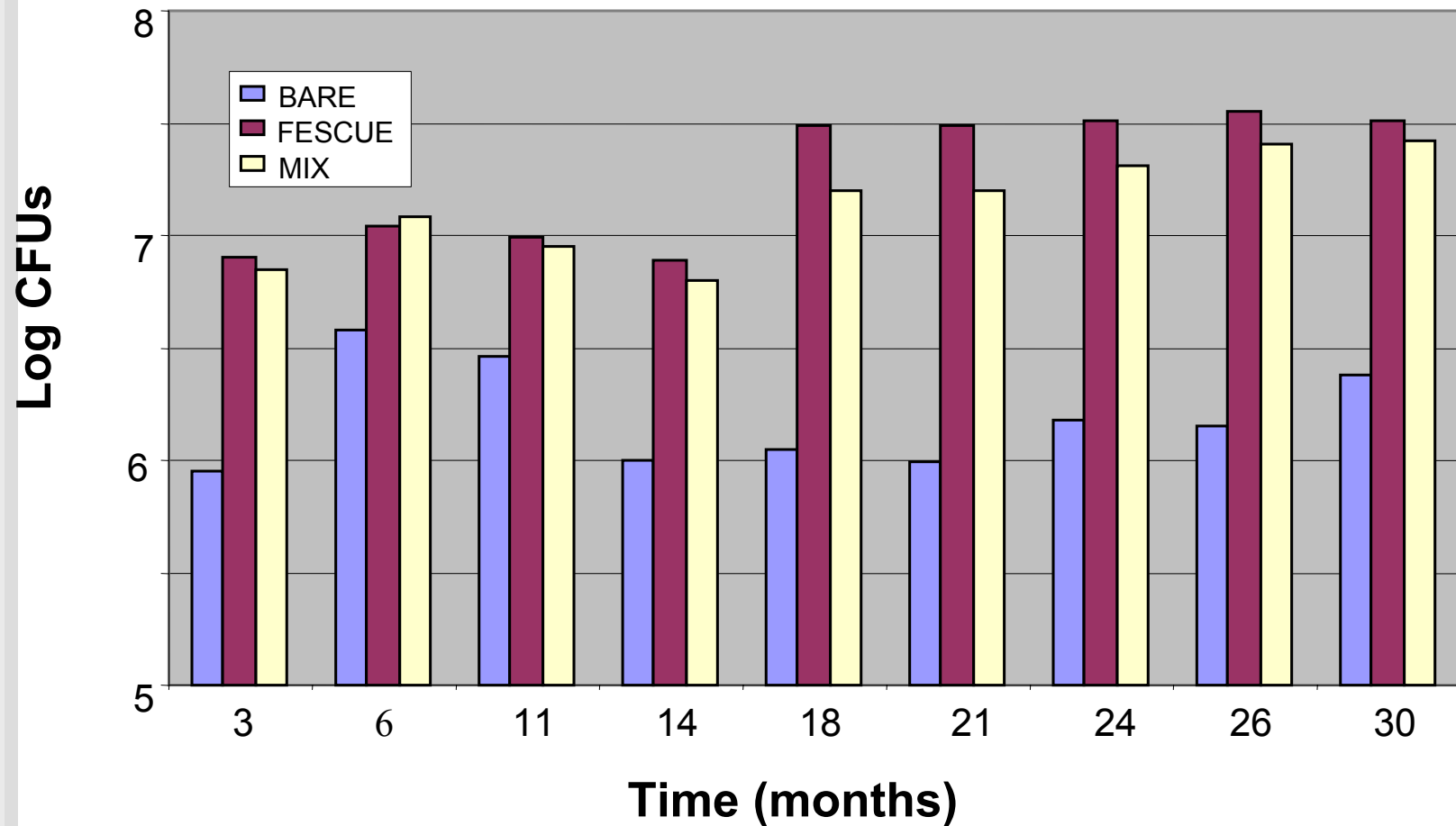


Above-Ground Biomass

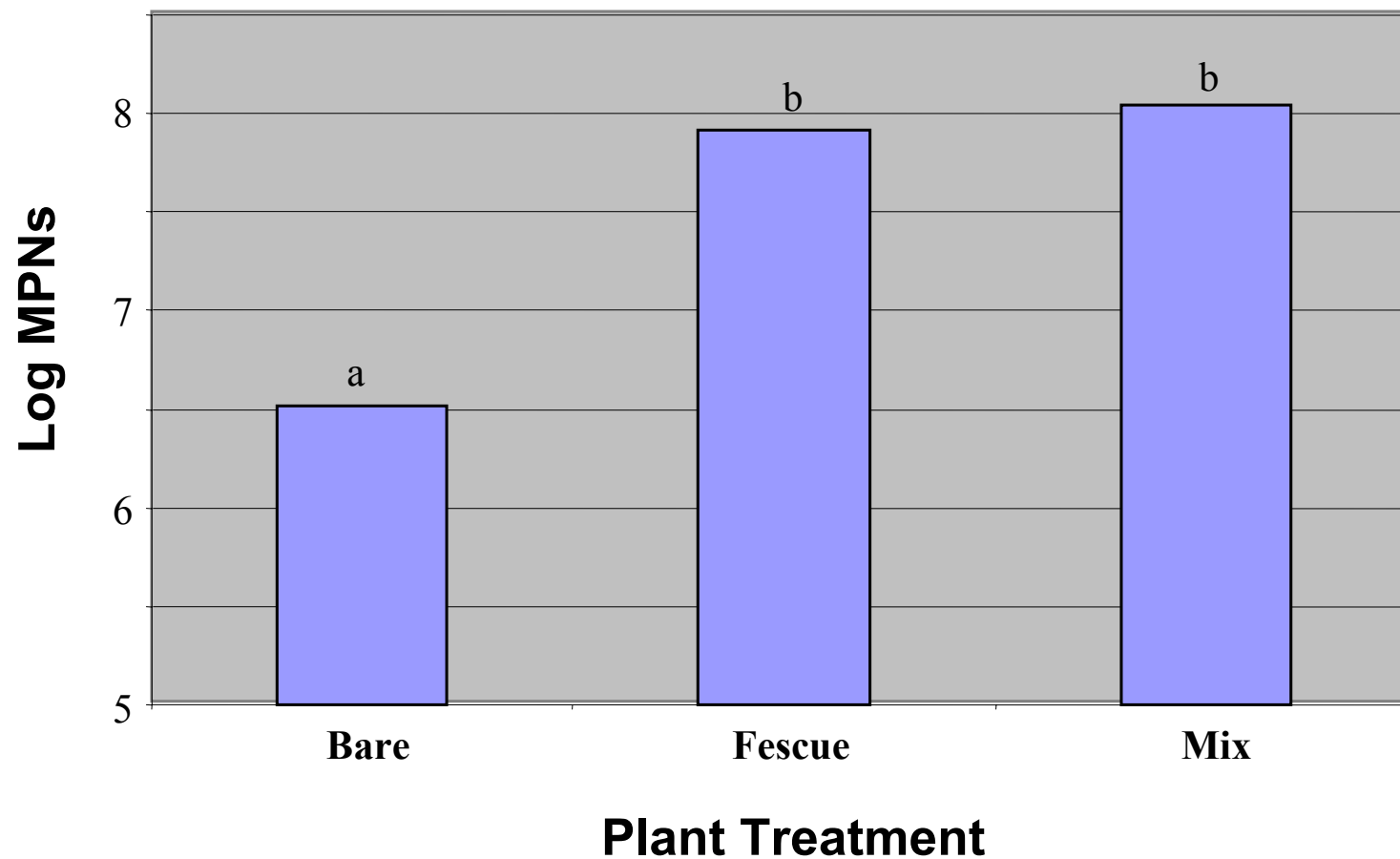
Port Hueneme Site



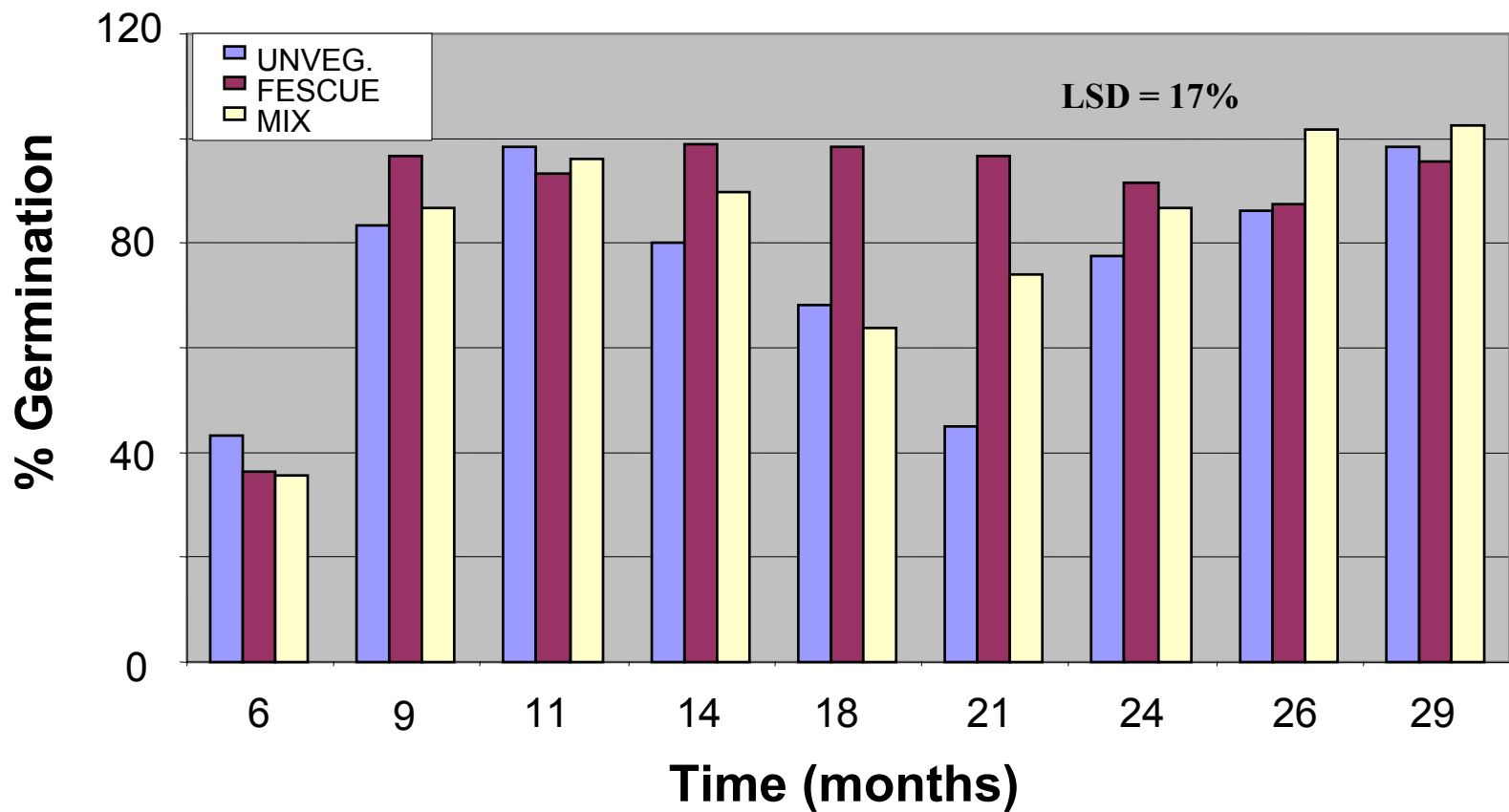
Microbial Analysis (Total Plate Counts) Port Hueneme Site



Microbial Analysis (Petroleum Degraders) Port Hueneme Site

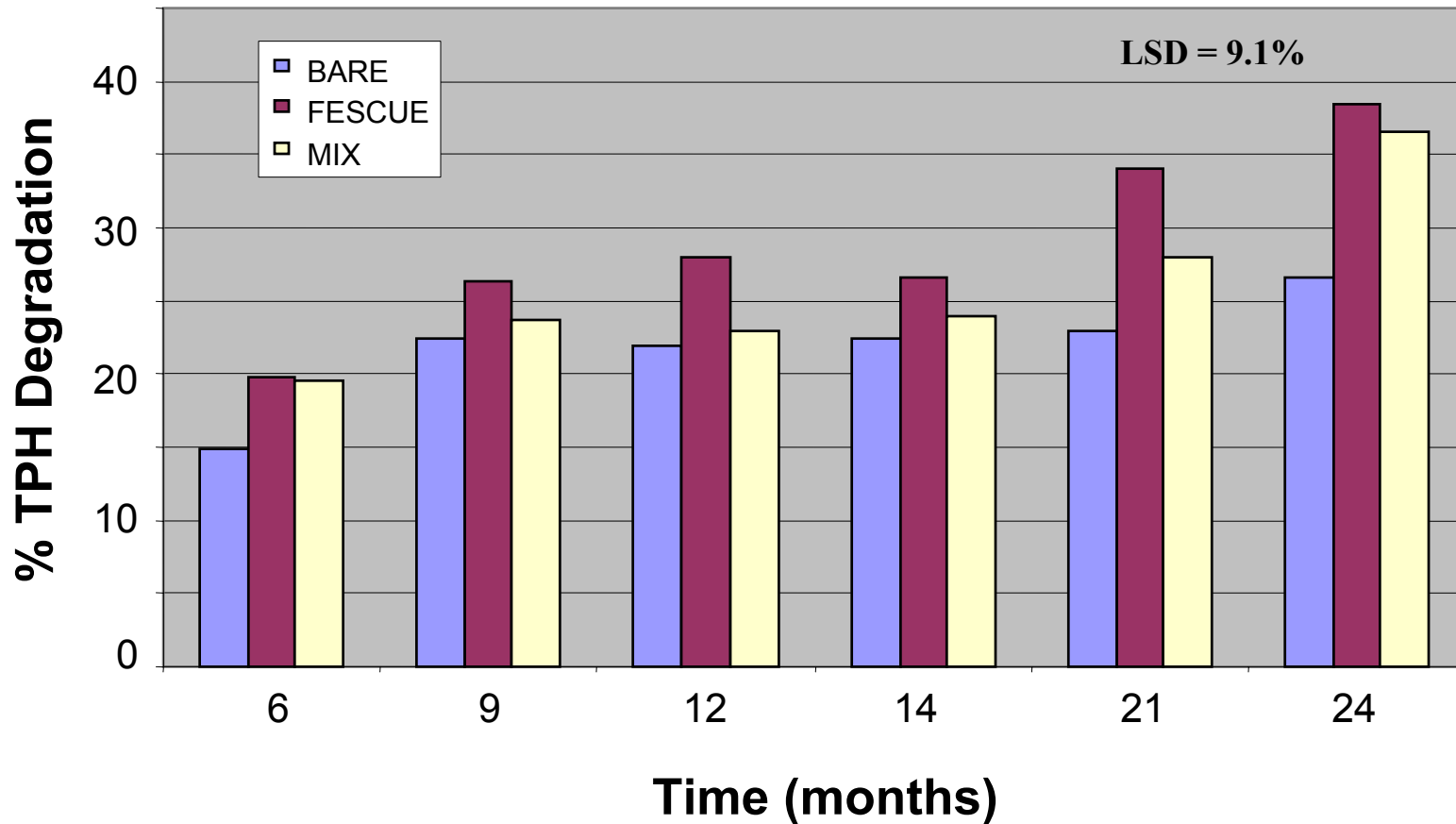


Toxicity Analysis (Germination) Port Hueneme Site

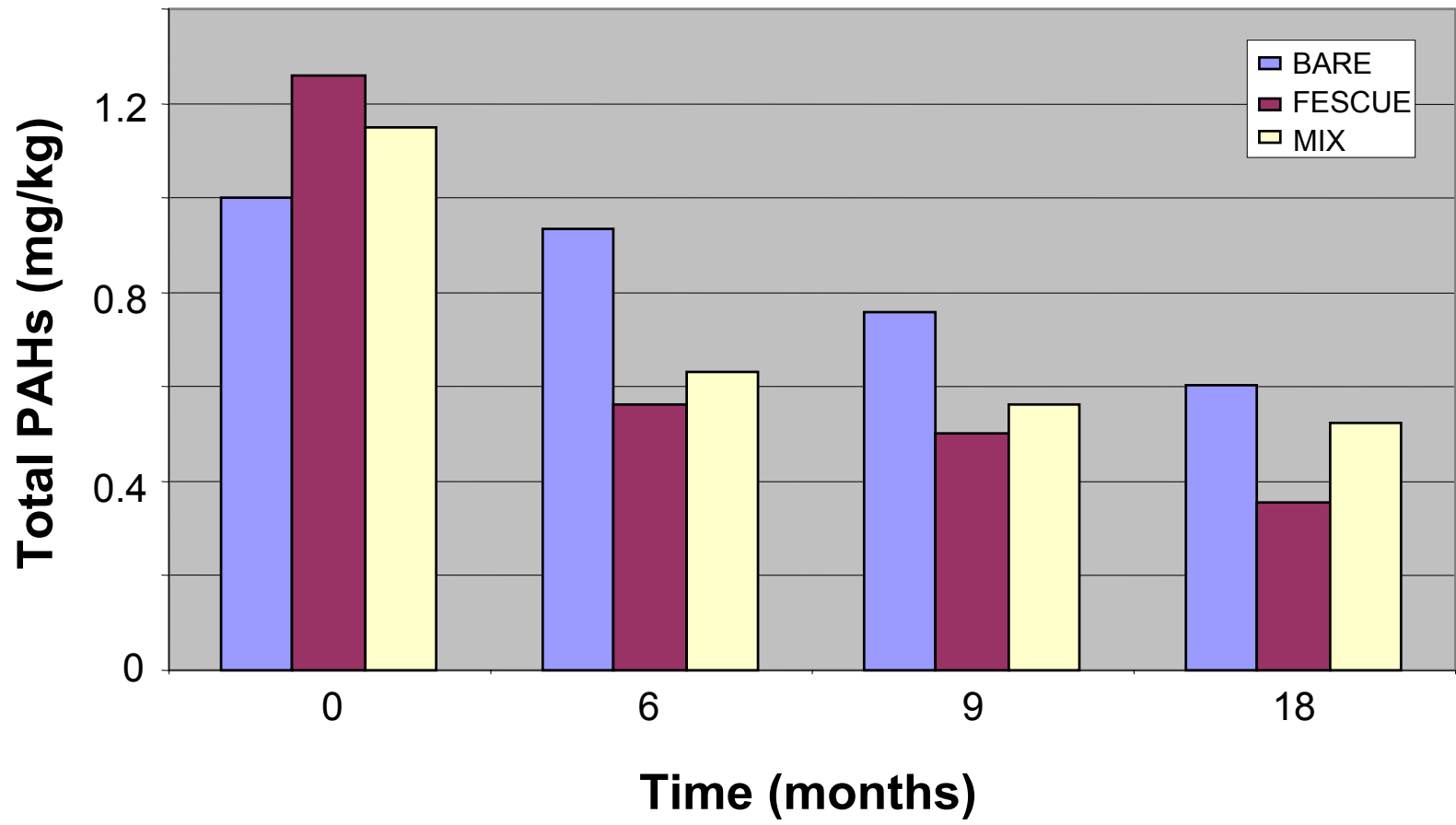


TPH Degradation (%)

Port Hueneme Site



Contaminant Analysis (PAHs) Port Hueneme Site



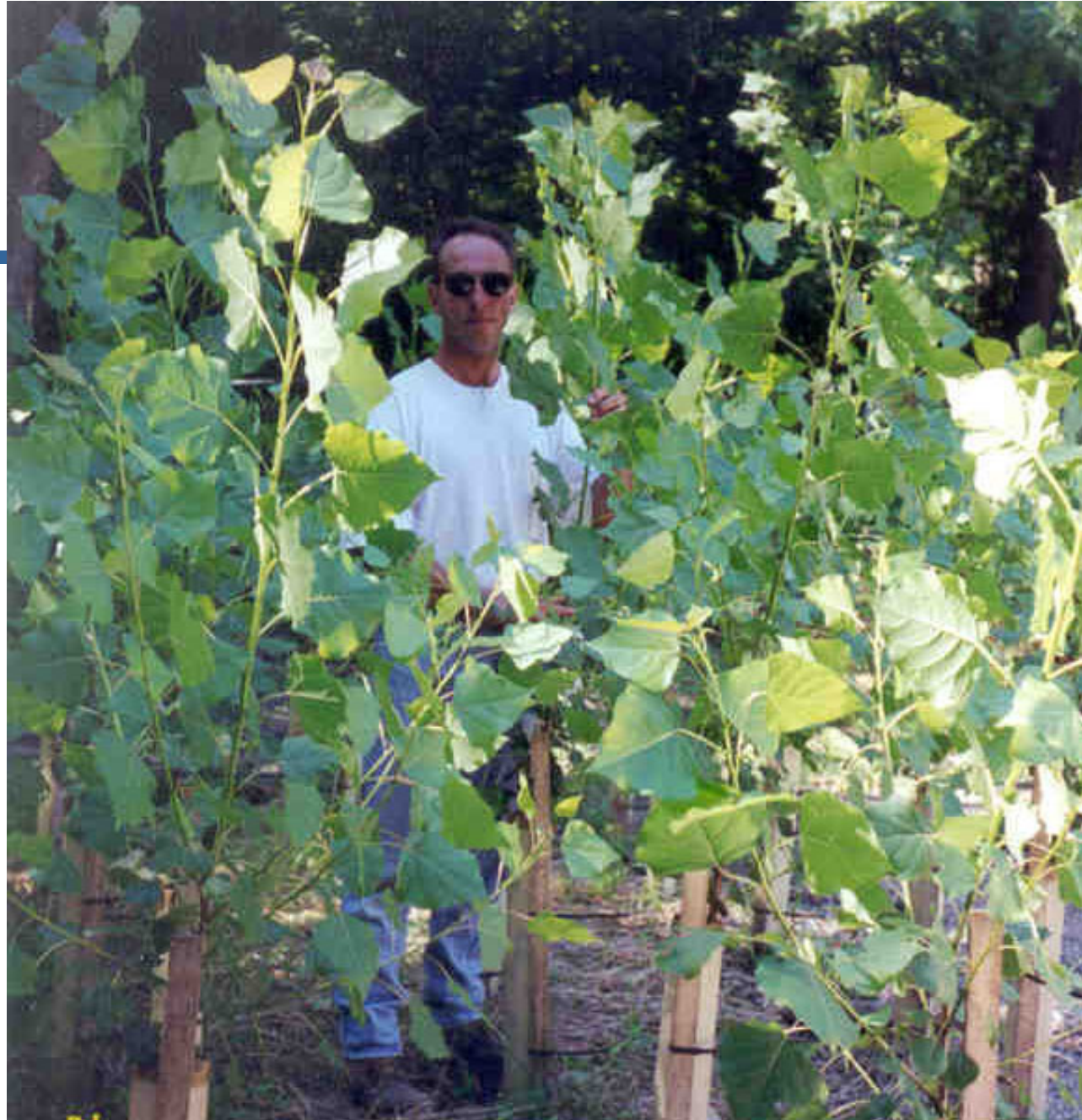
Bedford Site (1999-2002)

- **MGP site with PAH contamination at depths between 3 and 6 feet.**
- **Two treatments are being compared; hybrid poplar/grass cover and natural attenuation.**
- **Fertilization and irrigation is used as needed.**
- **Soil from three depths are being analyzed for contaminant concentration, microbial characteristics, and toxicity over the three year study.**

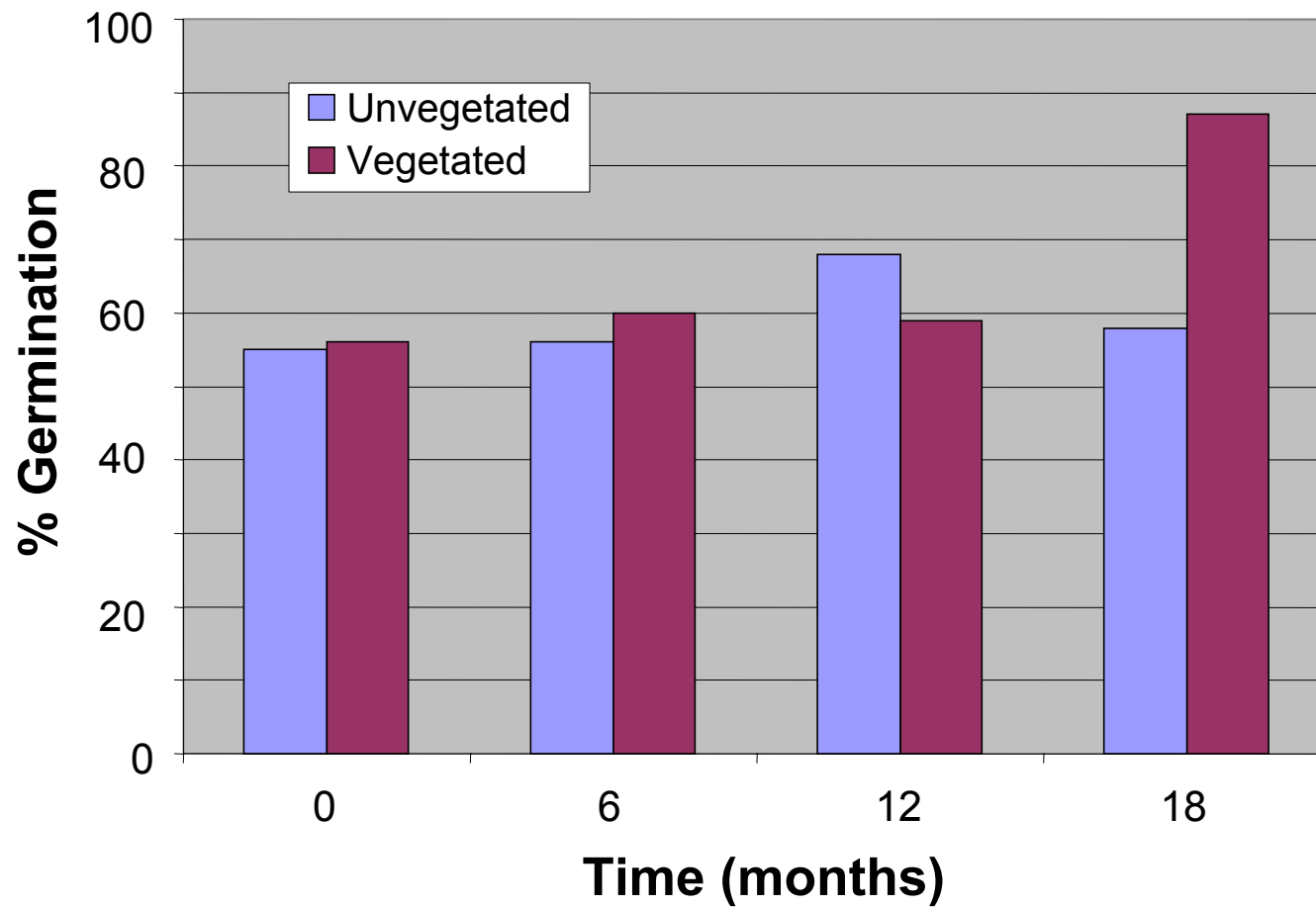


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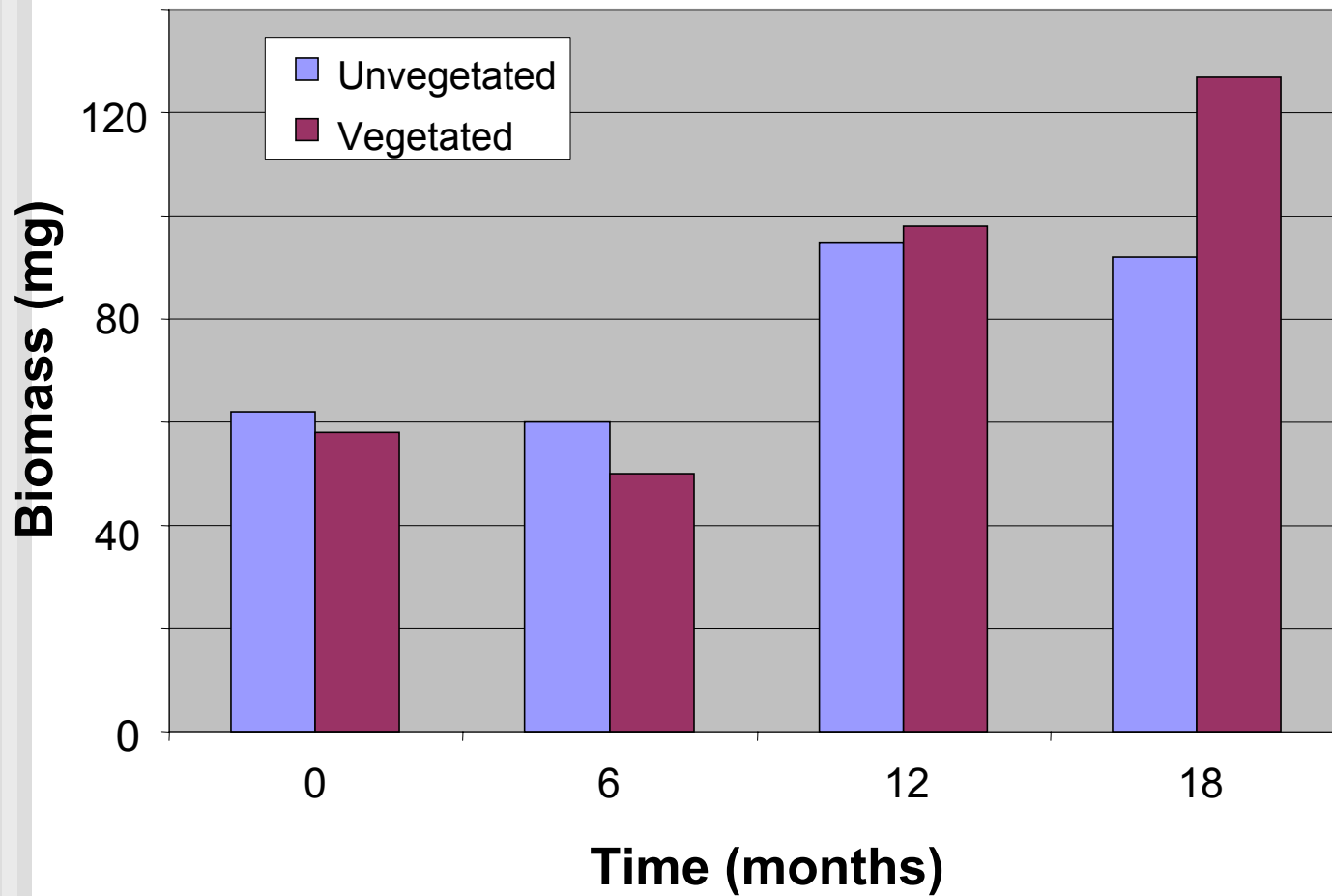


Toxicity Analysis (Germination) Bedford Site

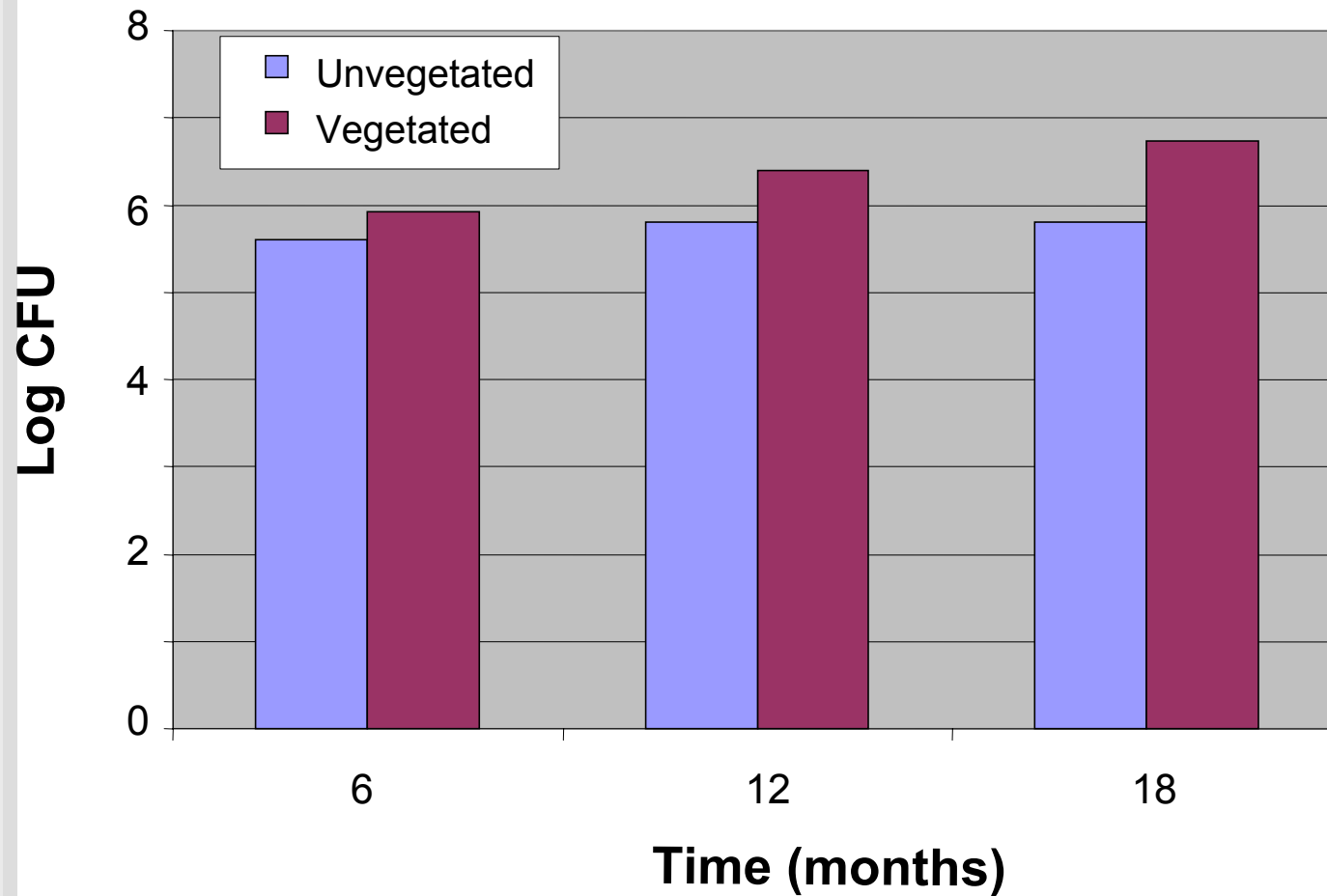


Toxicity Analysis (Earthworm)

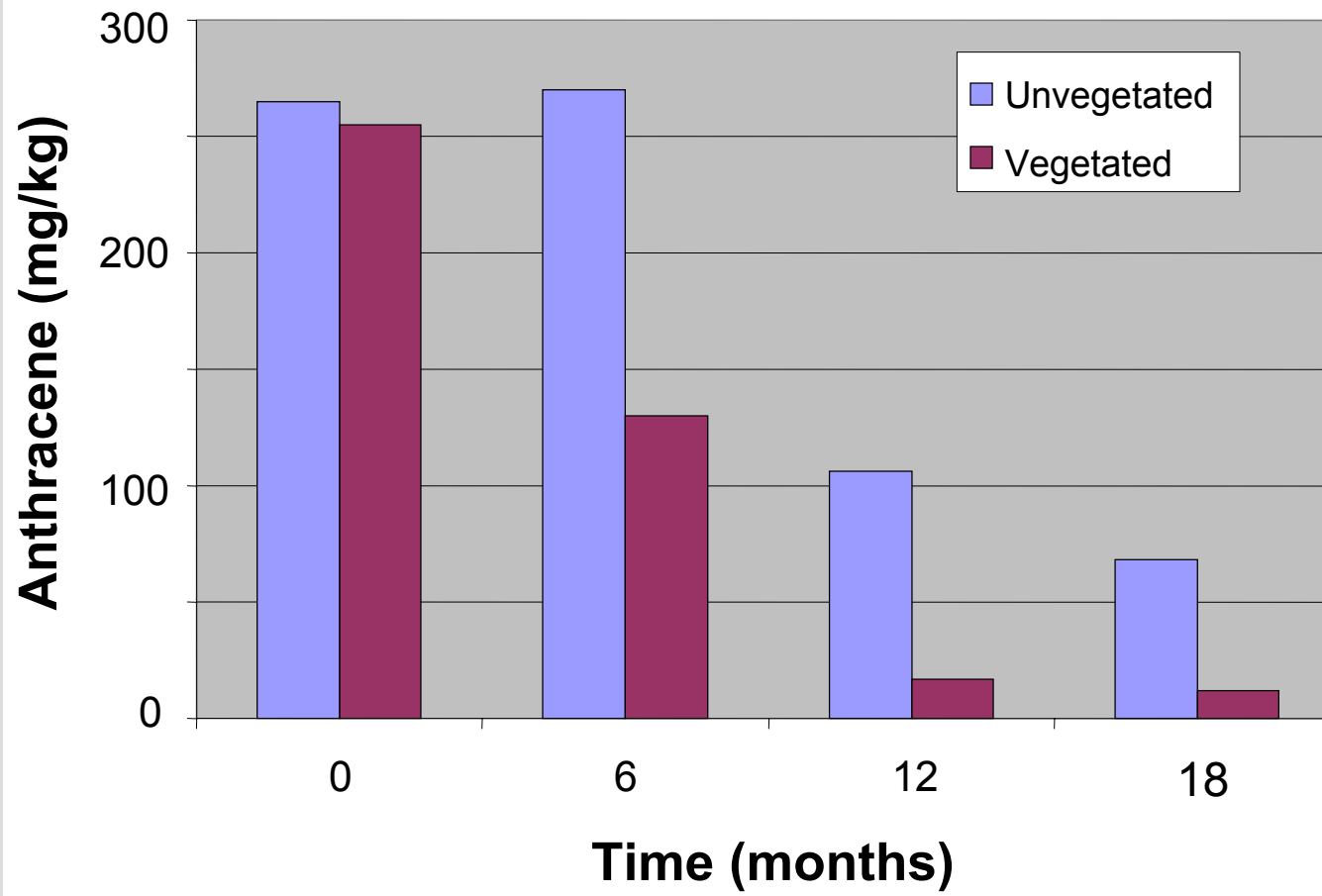
Bedford Site



Microbial Analysis (Petroleum Degraders) Bedford Site



Contaminant Analysis (PAHs) Bedford Site



Supporting Greenhouse Study

Bedford Site

- **Soil cores were taken in the field and placed in the greenhouse.**
- **Trees (ash, poplar, and willow) were established in the columns with two takedowns (9 and 18 months).**
- **Water was added to the columns from the bottom to simulate field conditions.**
- **Contaminant concentrations, microbial characteristics, and toxicity was assessed.**





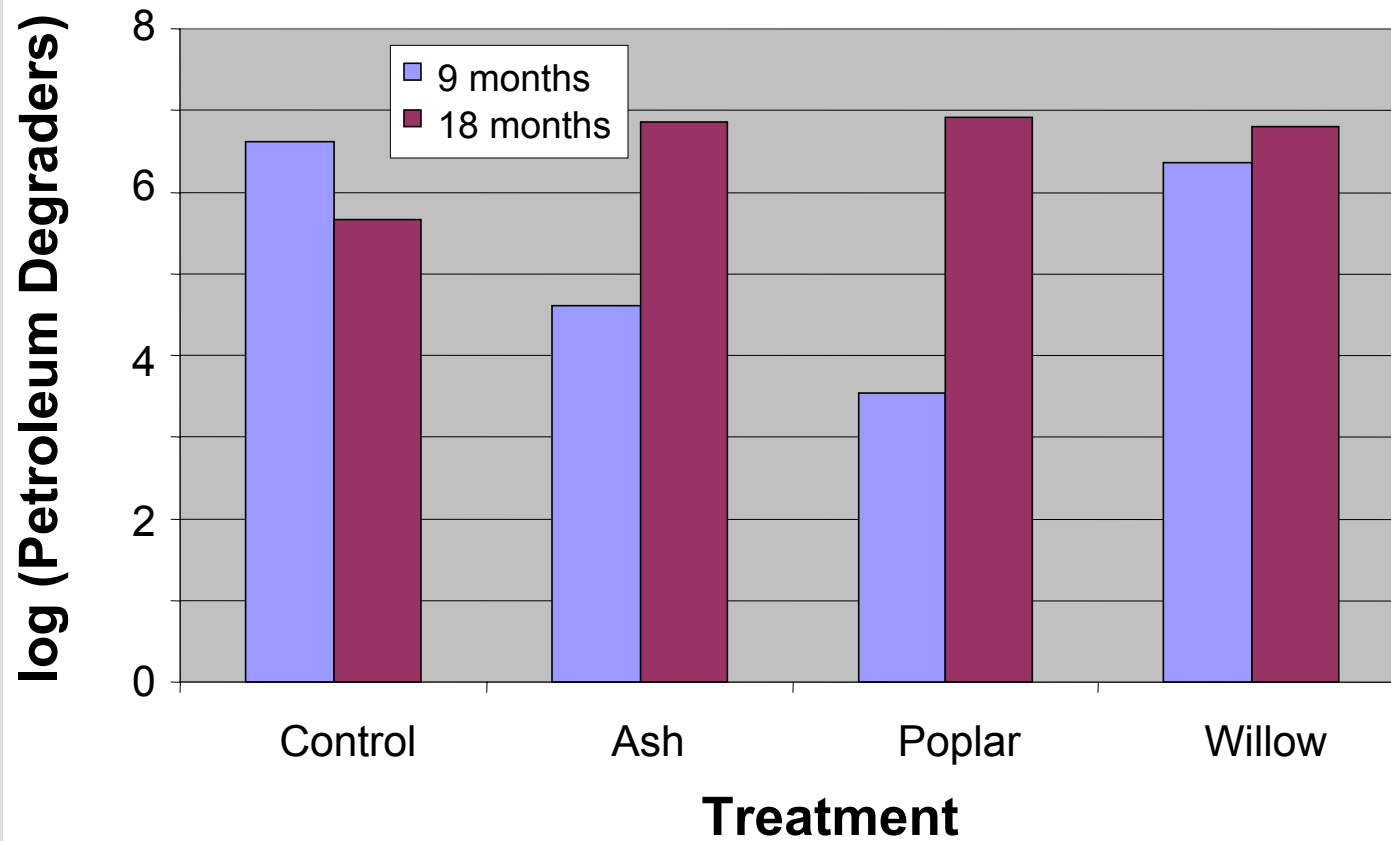


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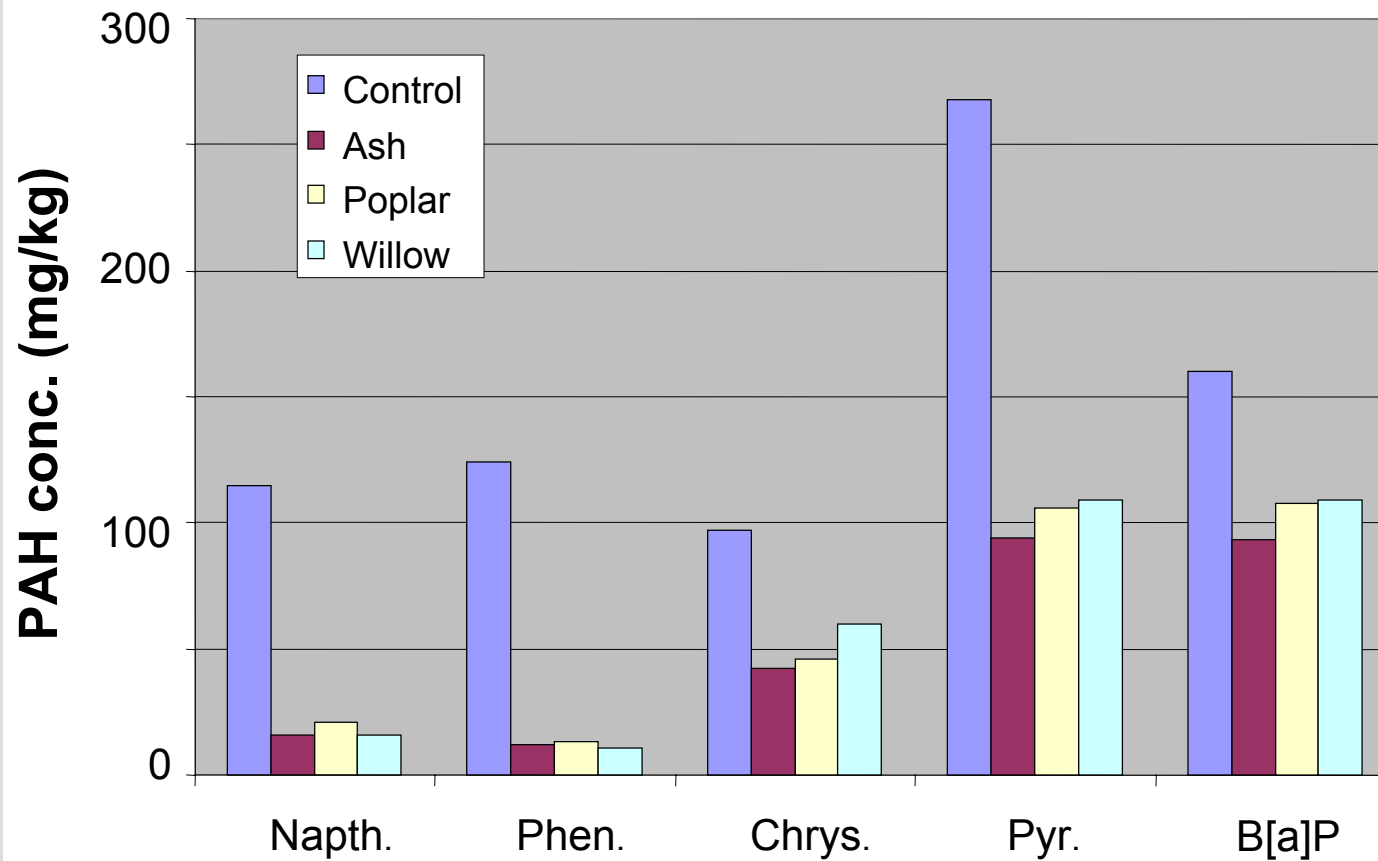
Microbial Analysis (Petroleum Degraders)

Bedford Greenhouse Study



Contaminant Analysis (PAHs)

Bedford Greenhouse Study



Summary and Outlook

Phytoremediation of Petroleum Contaminants

- Phytoremediation of petroleum contaminated soils has been successfully tested in the field.
- The impact of vegetation is related to the aging of the contaminants.
- Petroleum contaminated soil does not appear to be toxic to plants or invertebrates.
- PAH degradation parallels remediation of total petroleum hydrocarbons.
- The success of phytoremediation is closely related to the ability of roots to explore the soil.