Mobility, Chemical Lability, and Bioavailability of PAHs in Contaminated Soils Amended with Biosolids.

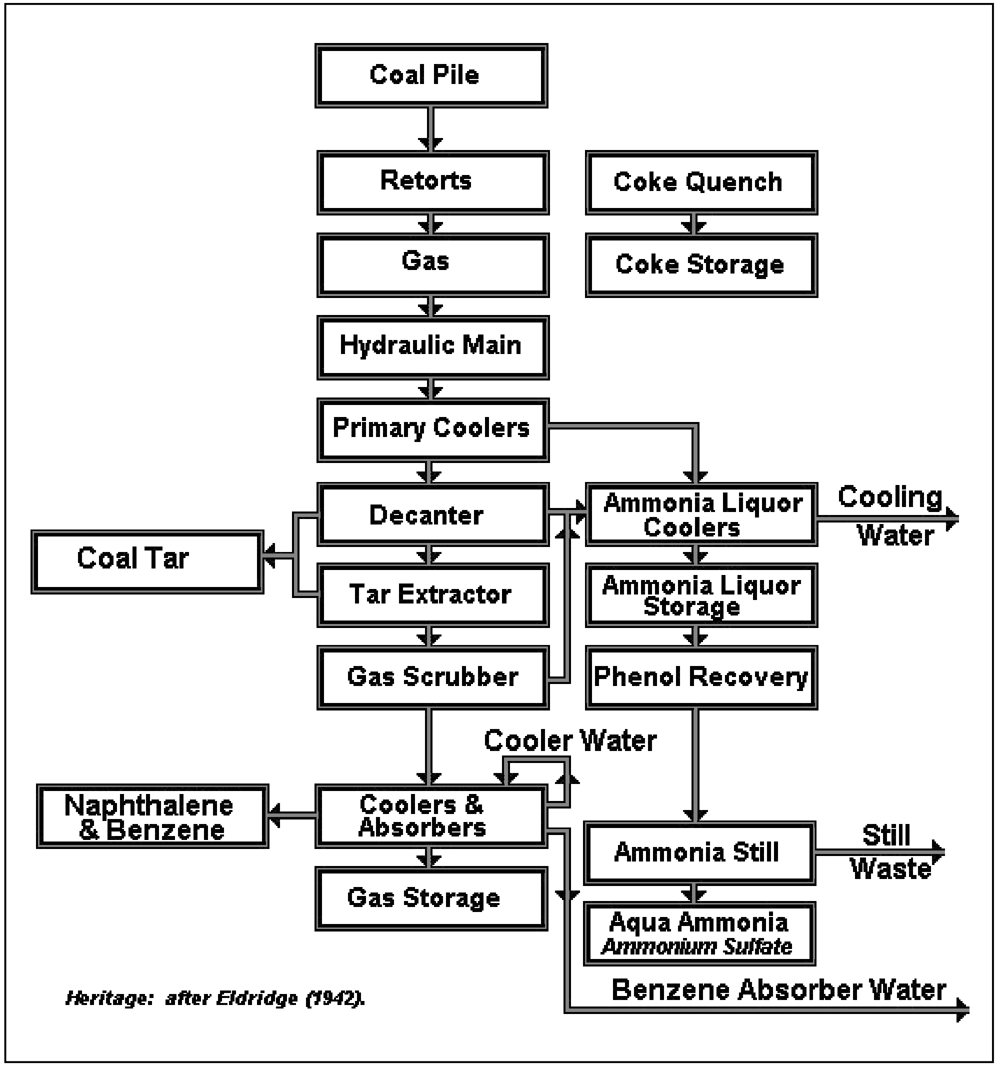
Paul Schwab, Kathy Banks, Naressa Cofield, and Zakia Parrish

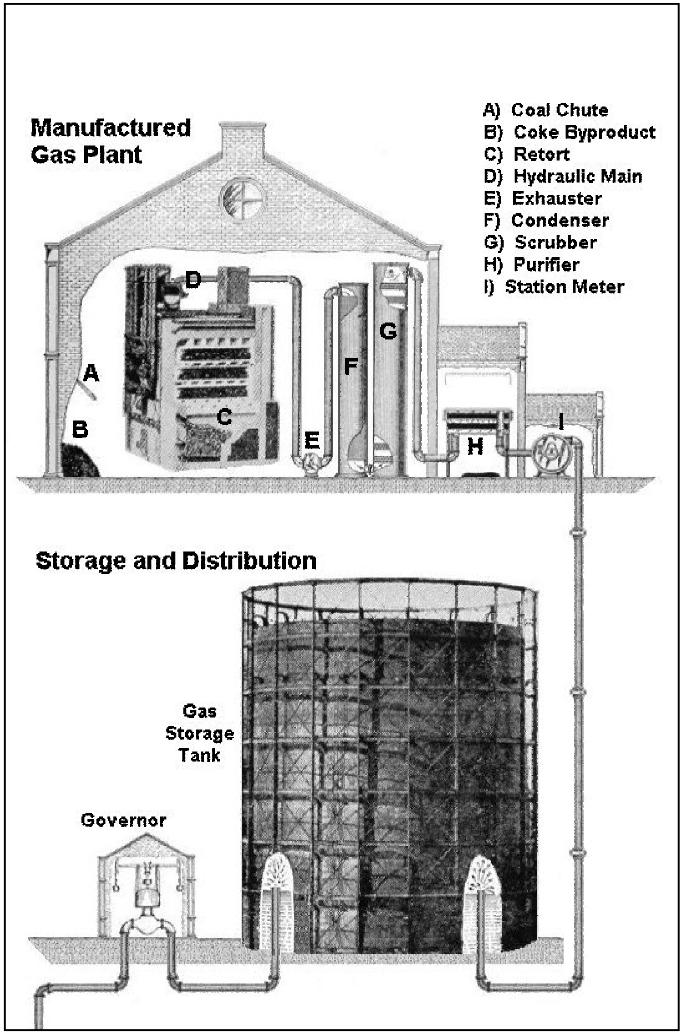
Purdue University

PAH Contamination in MGP Soils

- Manufactured gas plants: Brief history
  - Coal gas was first manufactured in the U.S. in the late 1790s.
  - By 1816, this gas was seen as a promising way of bringing illumination to homes and businesses.
  - By 1859, nearly 300 companies were serving over 4 million customers.
  - Most plants were small and served neighborhoods, but advances in high-pressure pipes made changes
  - By 1960, the plants had all but disappeared
  - The legacy was vast quantities of coal tar, highly contaminated with PAHs

Manufactured Gas Plant





MGP Site in Bedford, Indiana

- Nearly 100 years of coal gas production
- The waste tar was put in a small silo that had no bottom
- Over the decades, the tar contaminated the soils and an adjacent wetland
- In the late 1990s, US EPA and Indiana DEM decided to take action.
- Comparative remediation technologies: land treatment, composting, phytoremediation.

Phytoremediation of MGP Soils: Challenges

- The bulk of the contamination was found below the shallow water table.
- The tar-laden soils also contained free phase organics that were toxic to plants.
- The soils were elevated in salinity and highly hydrophobic.
- Establishing rigorous plant growth on these soils was very difficult.
- An amendment of some sort was required.

Approach

- Greenhouse study to test amendments on soil properties, plant viability
- Ultimate goal is to test phytoremediation on these recalcitrant contaminants
- The amendment chosen was biosolids – locally available, high organics
- Step one: test the rates of amendment application on soil/plant response
- Step two: Determine the efficacy of phytoremediation on total and chemically labile contaminants

Methods and Materials

- MGP soil obtained from the Bedford site
- Biosolids from local municipal wastewater treatment plant (anaerobic digestion)
- Organic amendment applied at rates up to 50% by mass.
- Moisture retention, seedling emergence, plant biomass, earthworm toxicity, and hydrophobicity were measured after 6 weeks.
- The most promising rate was chosen for a 12-month study.

Methods and Materials (cont'd)

- Moisture retention was measured at 33 kPa
- Lettuce germination and emergence was measure after 2 weeks (US EPA protocol)
- Earthworm mortality and biomass measured after 2 weeks
- Hydrophobicity determined water/ethanol penetration test
- Plant biomass determined after 6 weeks of growth in the amended soil.

Methods and Materials (continued)

- Phytoremediation study:
  - Standard phytoremediation approach (greenhouse)
  - 12 months of growth
  - Switchgrass, fescue for plants
  - Unplanted controls, fertilized and unfertilized
  - Monitored changes in total PAHs, labile, earthworm toxicity, lettuce, nematodes

Results – Testing Amendment Rates

- Two primary objectives:
  - Find the minimum rate of amendment (biosolids) to allow plant growth.
  - Test the impact of amendment on rates of degradation and toxicity.
- Rates: 0, 5, 10, 25, 50% biosolids.
- The impact of biosolids immediately after application was an increase in water holding capacity (25%) and increased earthworm toxicity (10%) but had no effect on lettuce germination.

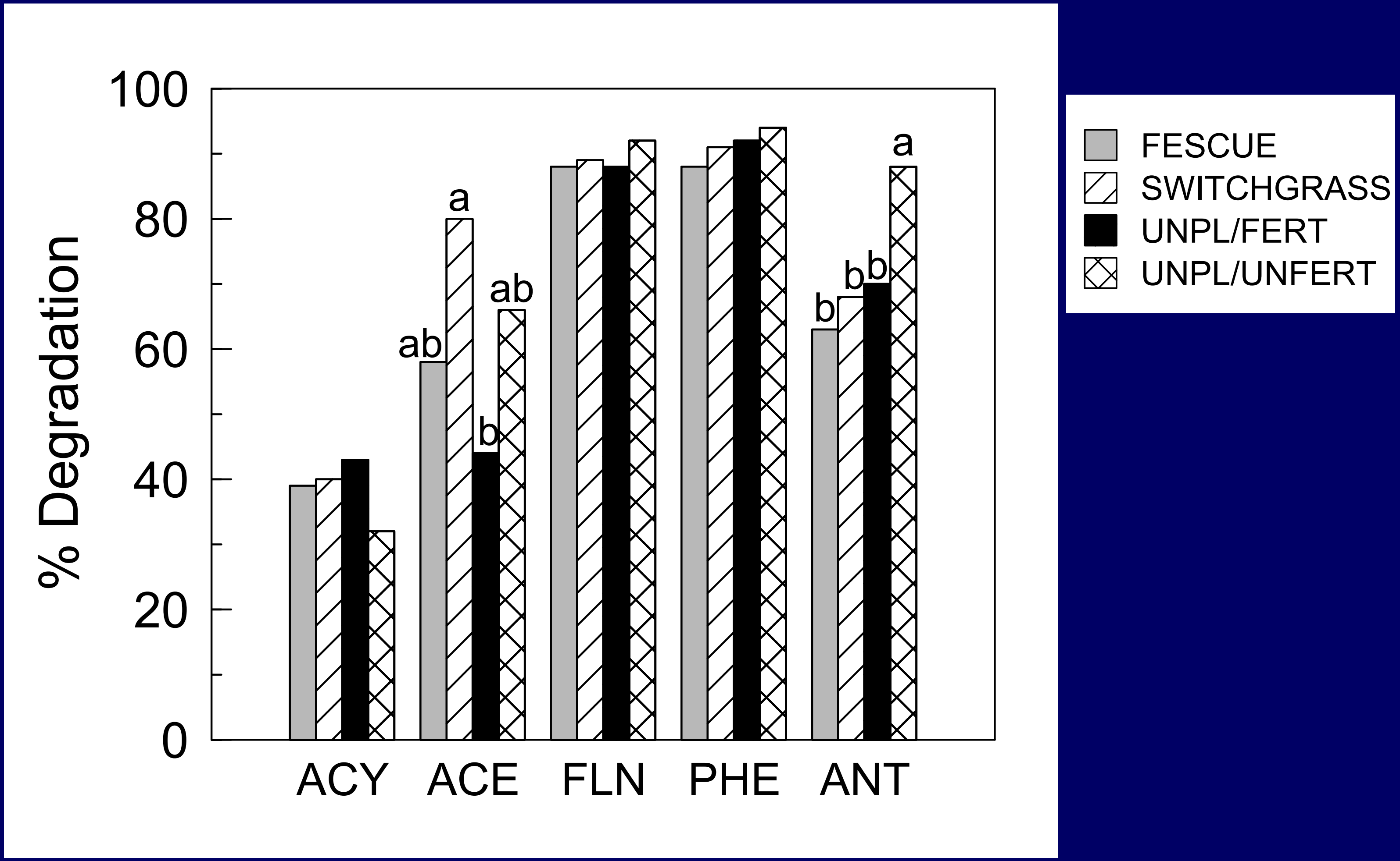
Effects of Amendment – 6 week expt.

Treatment	Amend.	Moisture	Biomass	Lettuce	Worm
	% (v/v)	% (m/m)	g	% germ	% change
Preplant	0	5	-	0	-64
	5	6	-	0	-31
	10	5	-	1	20
	25	12	-	2	34
	50	26	-	1	33
Clover	5	4	1.0	22	-48
	10	5	2.5	15	44
	25	15	4.6	14	49
	50	25	5.3	14	21
l.s.d.		16	4	7	51

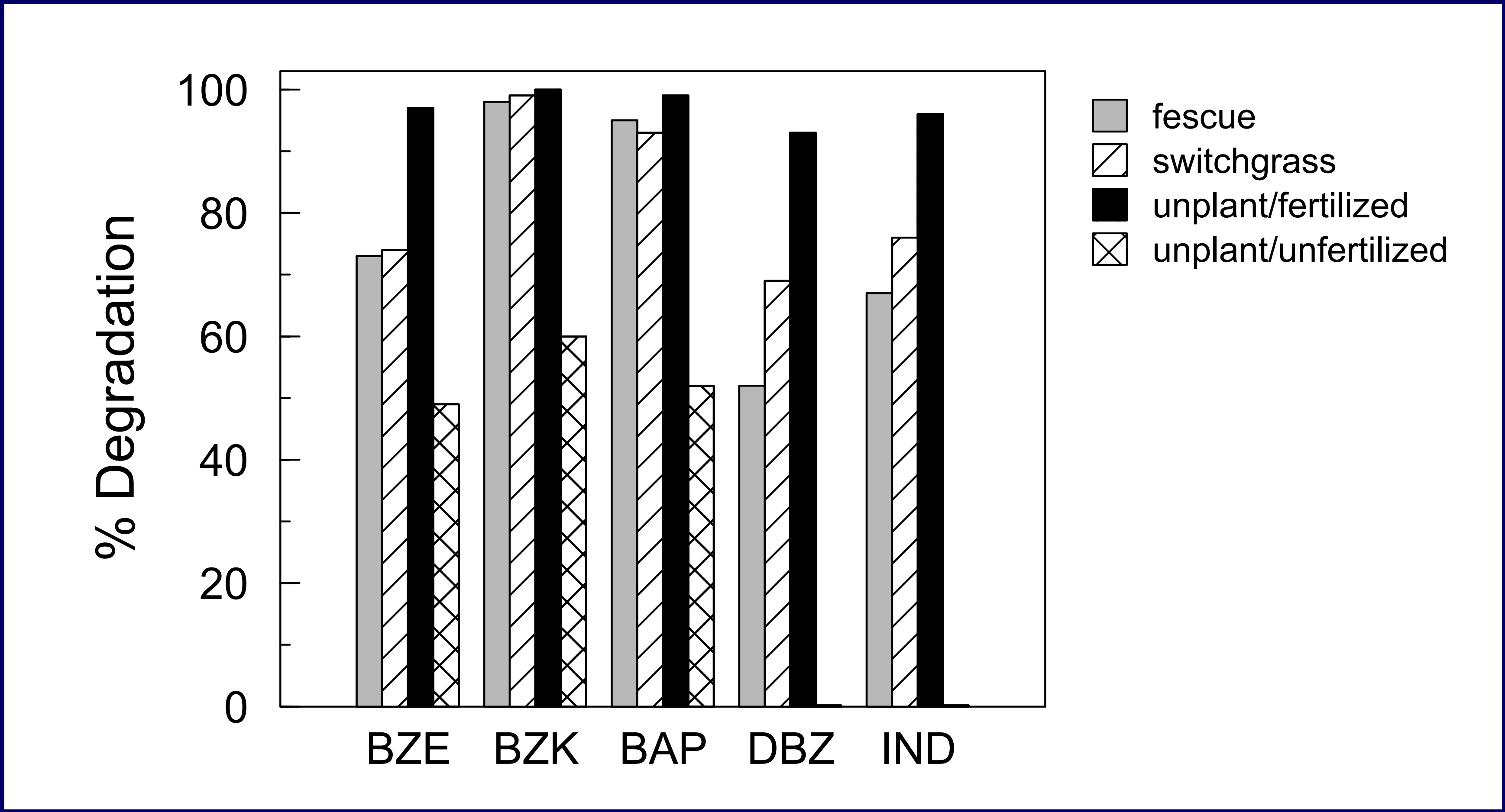
Results – Phytoremediation

- Biosolid additions were able to eliminate phytotoxicity and allow phytotoxicity to proceed.
- However, phytoremediation had little impact on degradation of the total PAHs in the soil
- This is most likely due to the heavy tar matrix containing the PAHs and greatly reducing the availability of the compounds.
- Using phytoremediation as a polishing step was far more successful

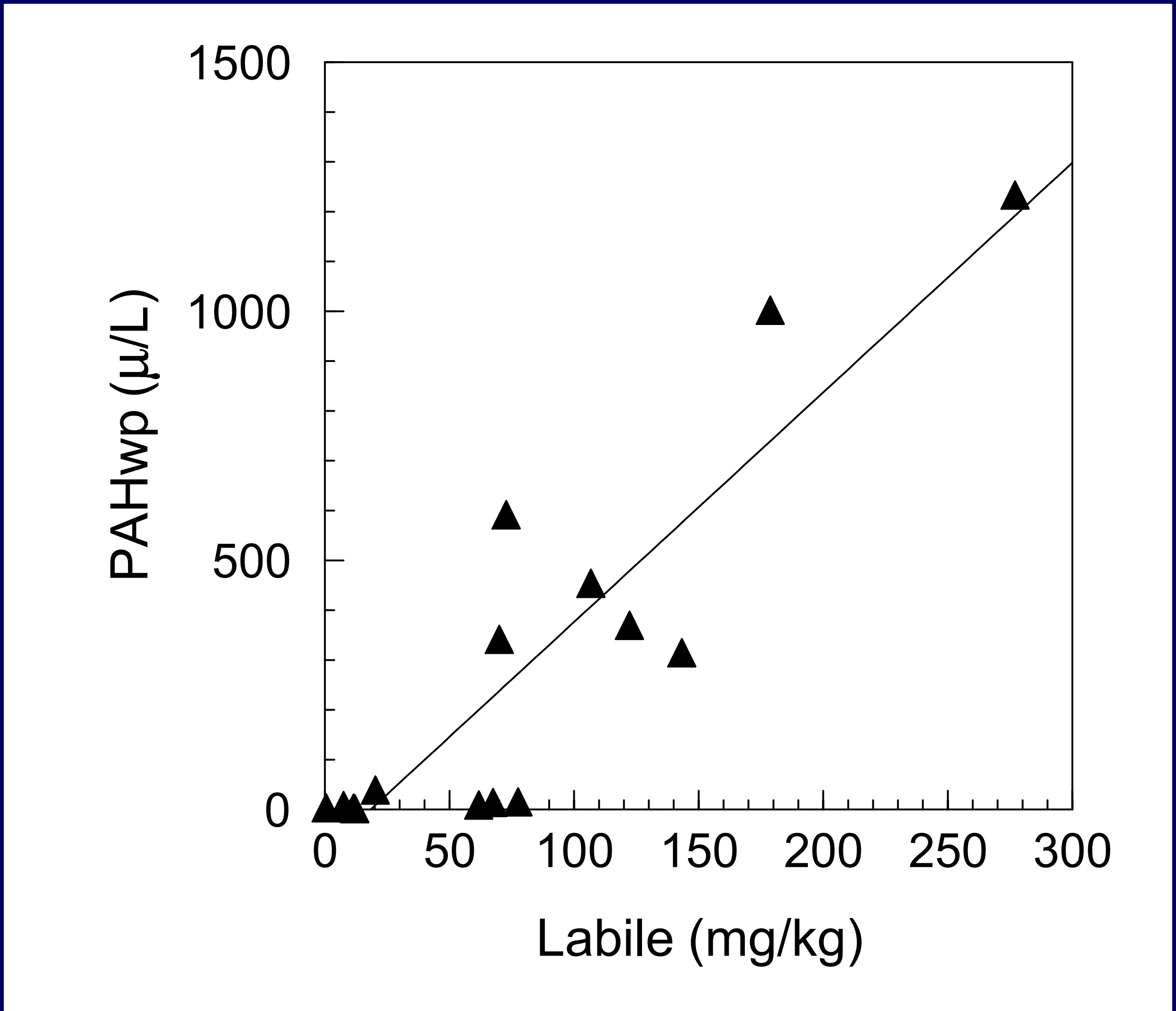
Degradation of PAHs



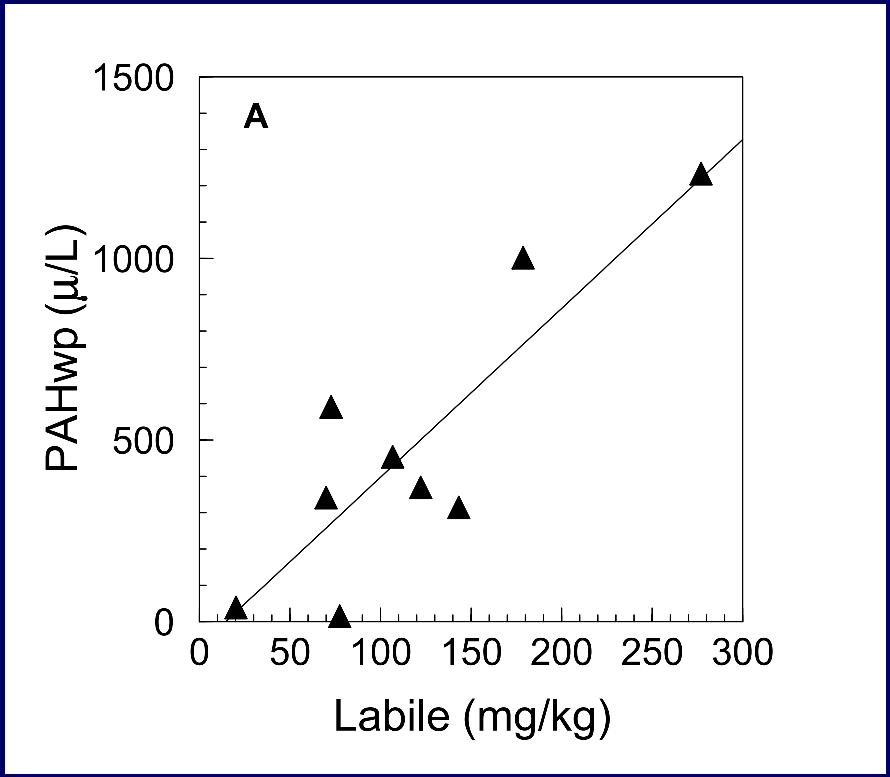
Dissipation of labile PAHs

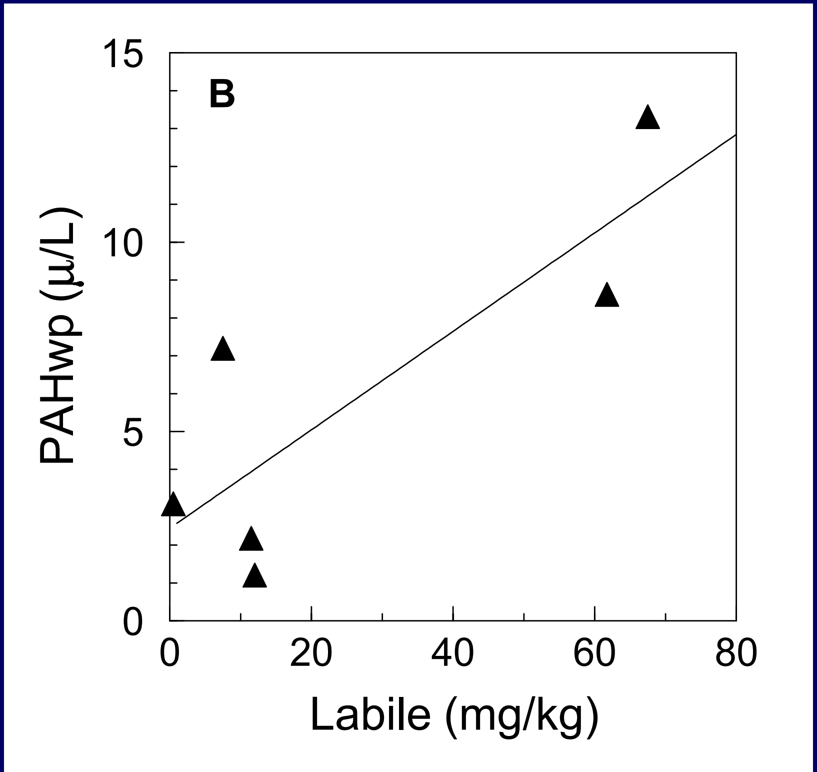


Relationship between labile and aqueous phase PAHs in treated soil



Labile vs. soluble, more detail





CONCLUSIONS

- Degradation of neither total nor labile PAHs neither were impacted by the presence of plants
- Likewise, plants did not strongly influence the changes in biological toxicity indicators
- No question, though, that the presence of the biosolids enhanced recovery of the health of the soil
- Plants would undoubtedly be an critical part of reclamation of MGP soils (stabilization, moisture control) despite the negative results from phytoremediation