



International Applied Phytotechnologies Conference

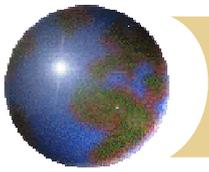
March 3-5, 2002 Chicago, USA



Advances in Phytoremediation Technology in China

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**Soil and Environment Bioremediation Research Center
Institute of Soil Science, Chinese Academy of Sciences**

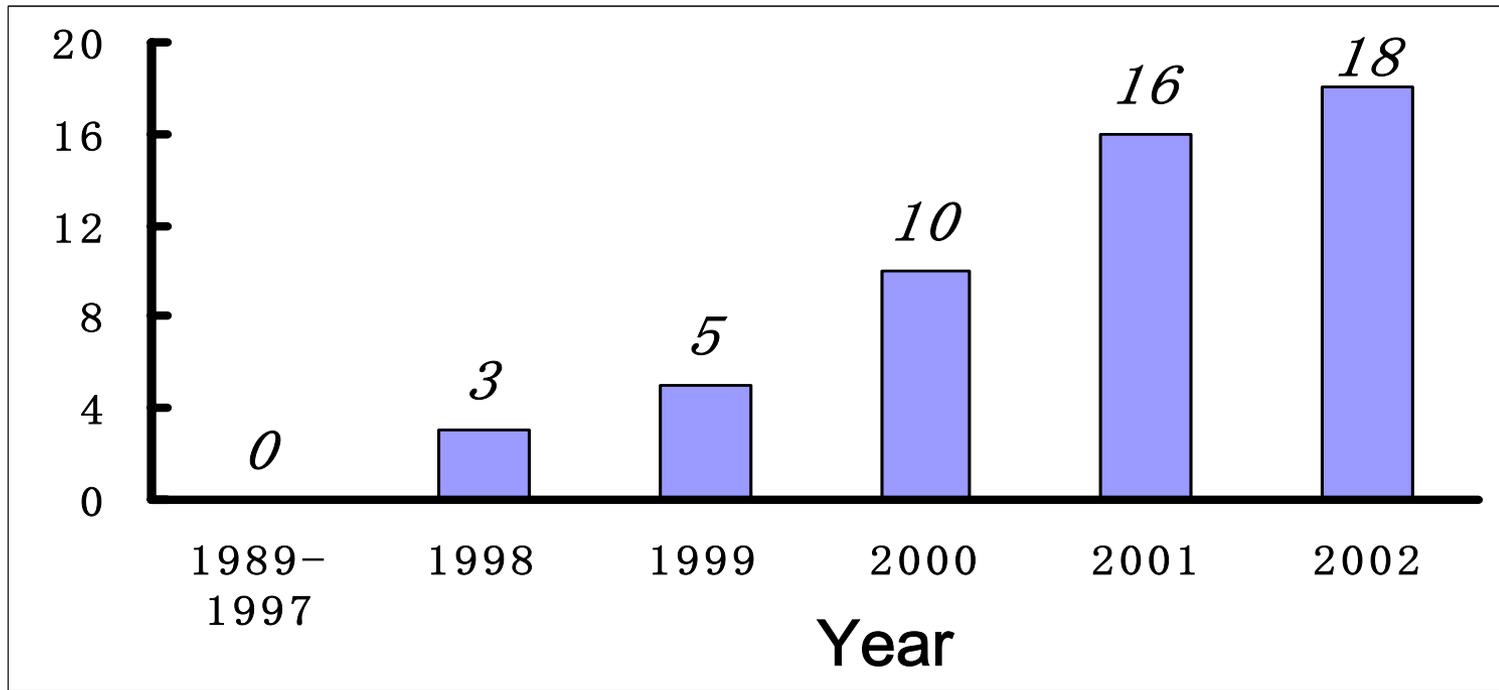
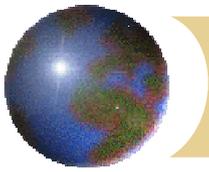


Three Main Contents

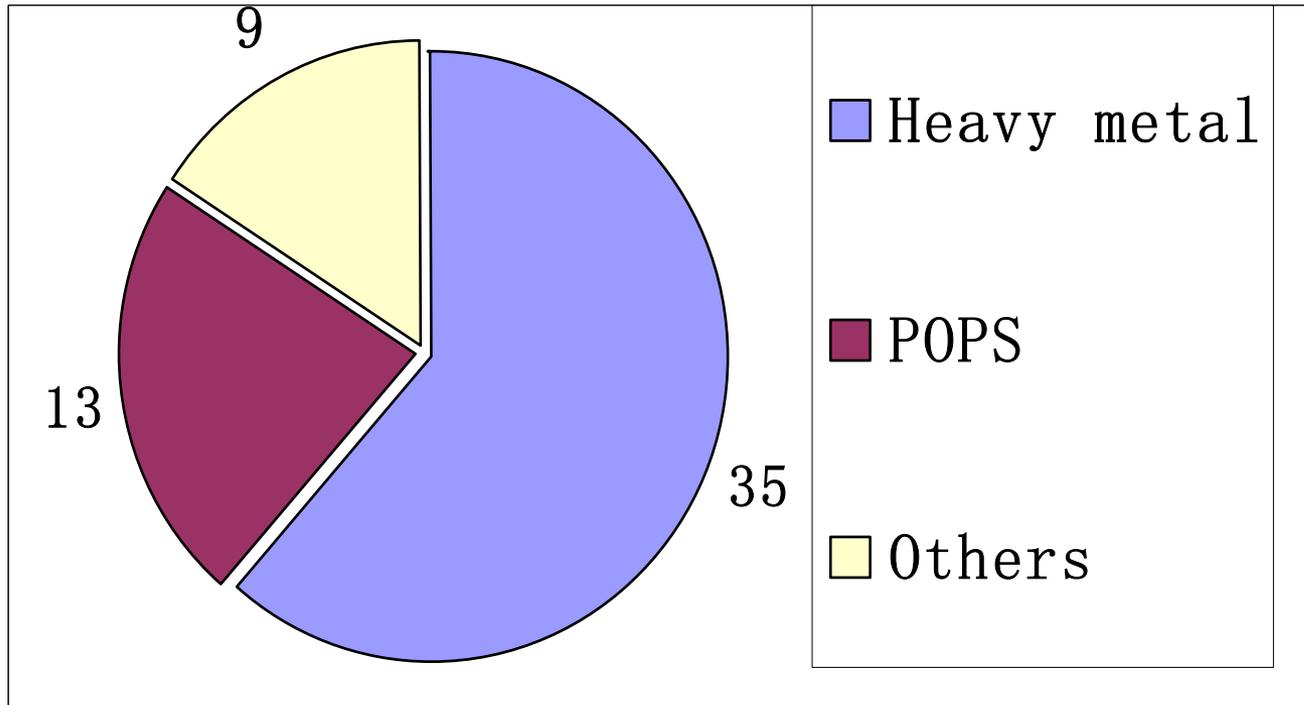
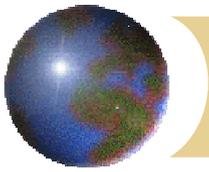
✚ **General State**

✚ **Research and Development**

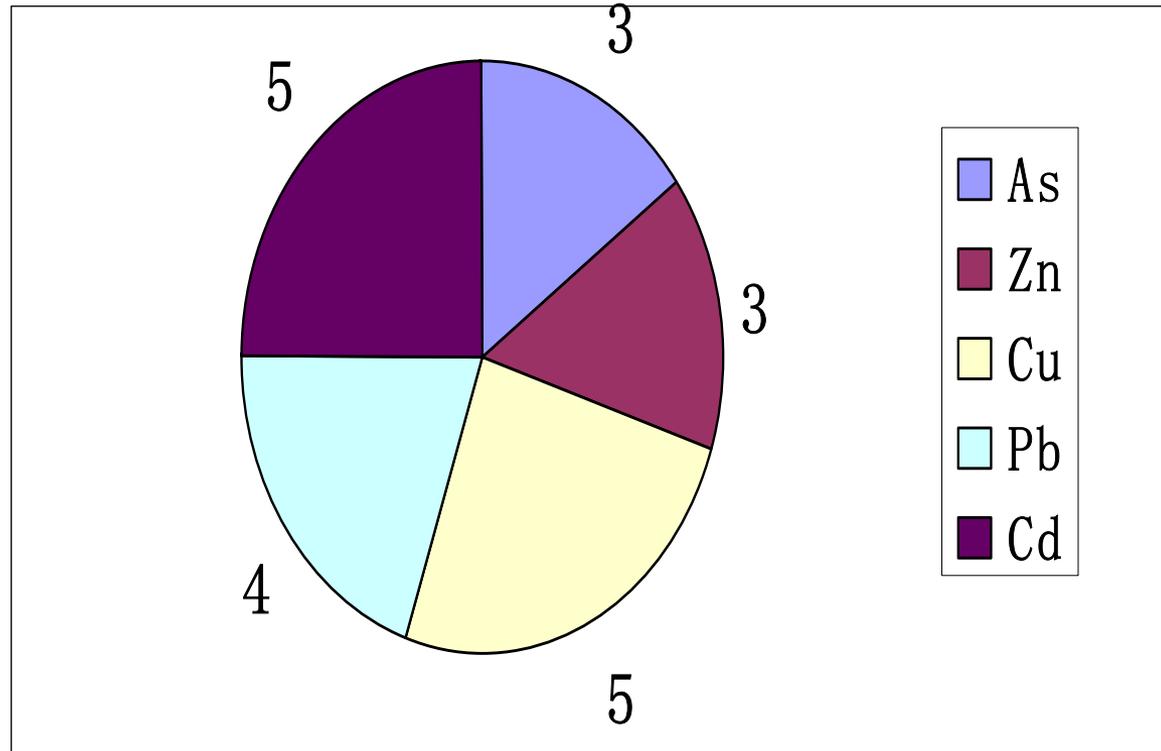
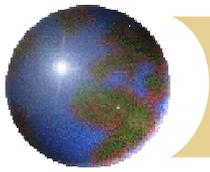
✚ **Tendency in Phyto-technology**



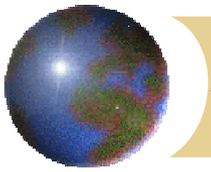
**Published papers in relation to phytoremediation
in China during 1989/2002.6**



Distribution of the published papers among the pollutants in China during last 5 years



**Distribution of the published papers
among heavy metals in China**



Phytoremediation Research in China

- ✚ **Limited experimentally-based work, but increasing with time;**
- ✚ **At very early developing stage.**

**Phyto-
tech.
Study
in
China
(I)**

Phytoextraction

**Hyperaccumulation
(As/Zn/Pb/Cu/Cd)**

**Enhanced
Phytoextraction**

**Phytoaccumulation
(Cu/Zn/Cd/Pb)**

Phytofiltration

**Root Concentration
(Cu/Pb/PAHs)**

Phytovolatilization

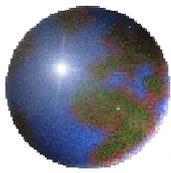
Volatilization (Hg)

**Phyto/microbial
degradation**

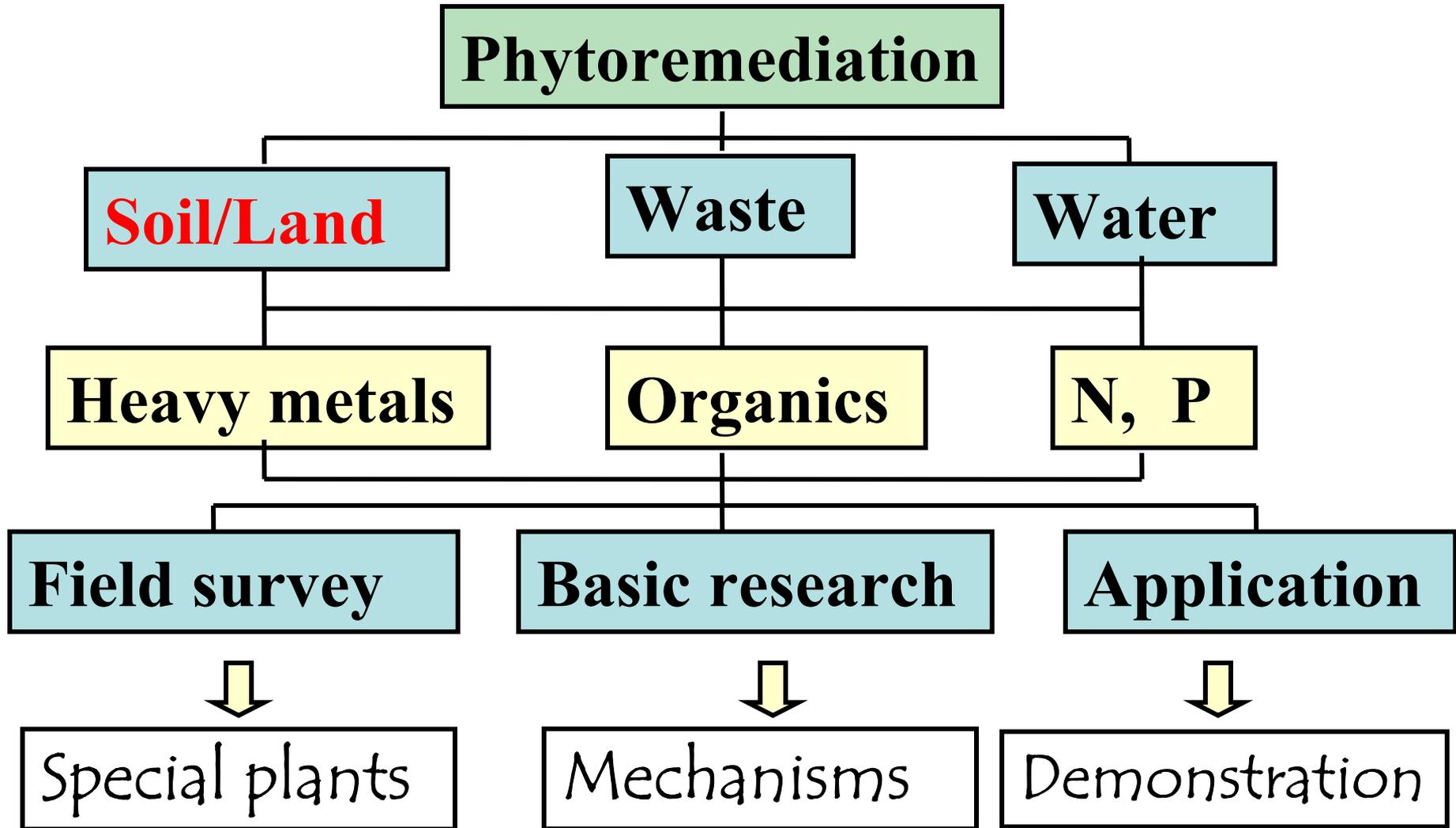
**Biodegradation
(Pesticide/PAHs)**

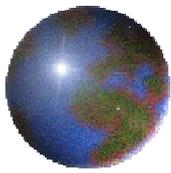
Phytostabilization

**Root Retention
(Zn/Pb/Cu)**



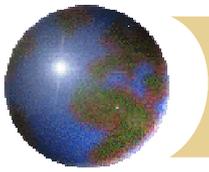
Phytoremediation Research in China (II)





Hyperaccumulator plants

- As: *Pteris vitatta* (Chen et al., 2000/02,), **>0.1%**;
Pteris cretica (Wei et al., (2002), **>0.05%**
- Zn: *Sedum alfredii* H (Yang et al., 2001), **0.4%**
- Pb: *Brassica pekinensis* ruciferae (Xiong, 1998),
>0.2% (experimentally)
- Cu: *Elshohzia splendens* (Yang et al., 1998);
Commelina communis (Shu et al., 2001),
>0.1%
- Cd: Chinese oilseed rape (*Brassica Juncea*) (Su et al., 2001), **>0.01%** (experimentally)

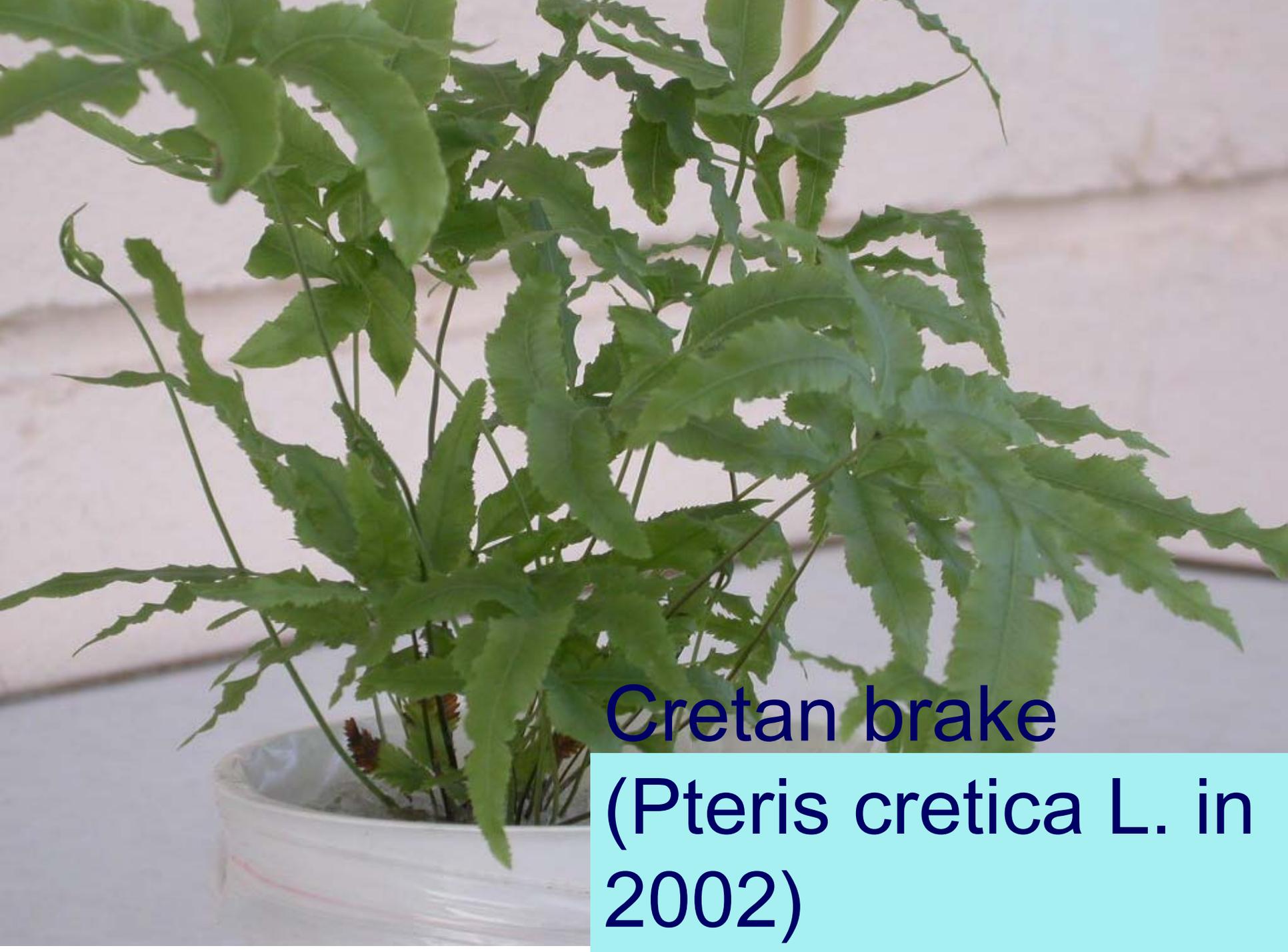


Research and Practice (1)

- ✦ **As** by Prof. Chen and colleague in Beijing Institute of Geographical Science and Resources, CAS, China



Brake fern (*Pteris vittata* L. in 2000)

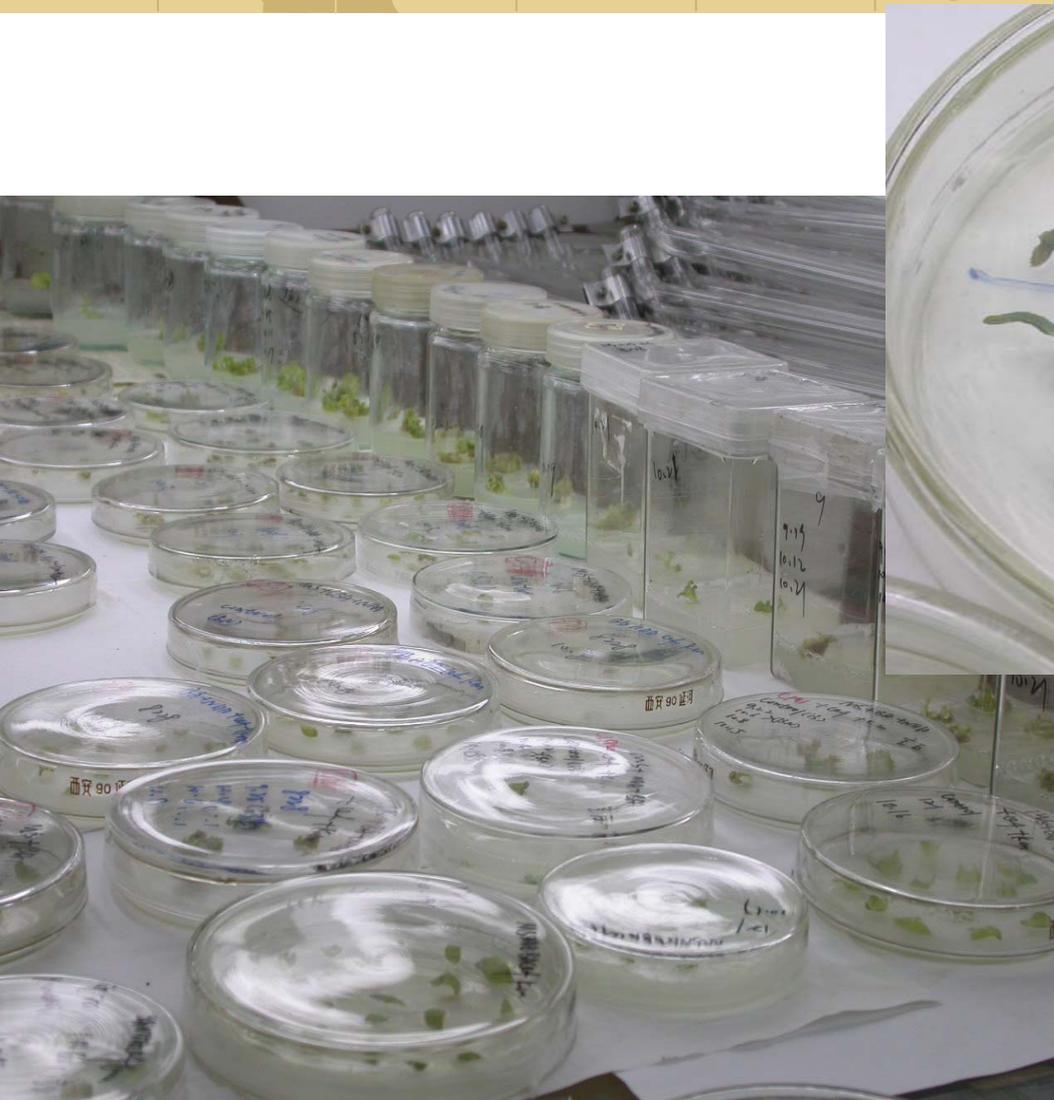


**Cretan brake
(*Pteris cretica* L. in
2002)**

Greenhouse experiment



Tissue culture of *P. Vittata*





Field management for seedlings of *P. vittata*

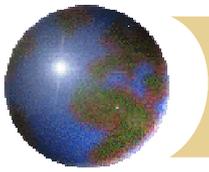


Phytoremediation demonstration site

Plant biomass about 30 t/ha
8 months after transplanting

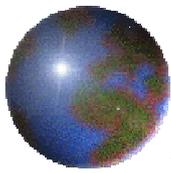


Cut and regeneration

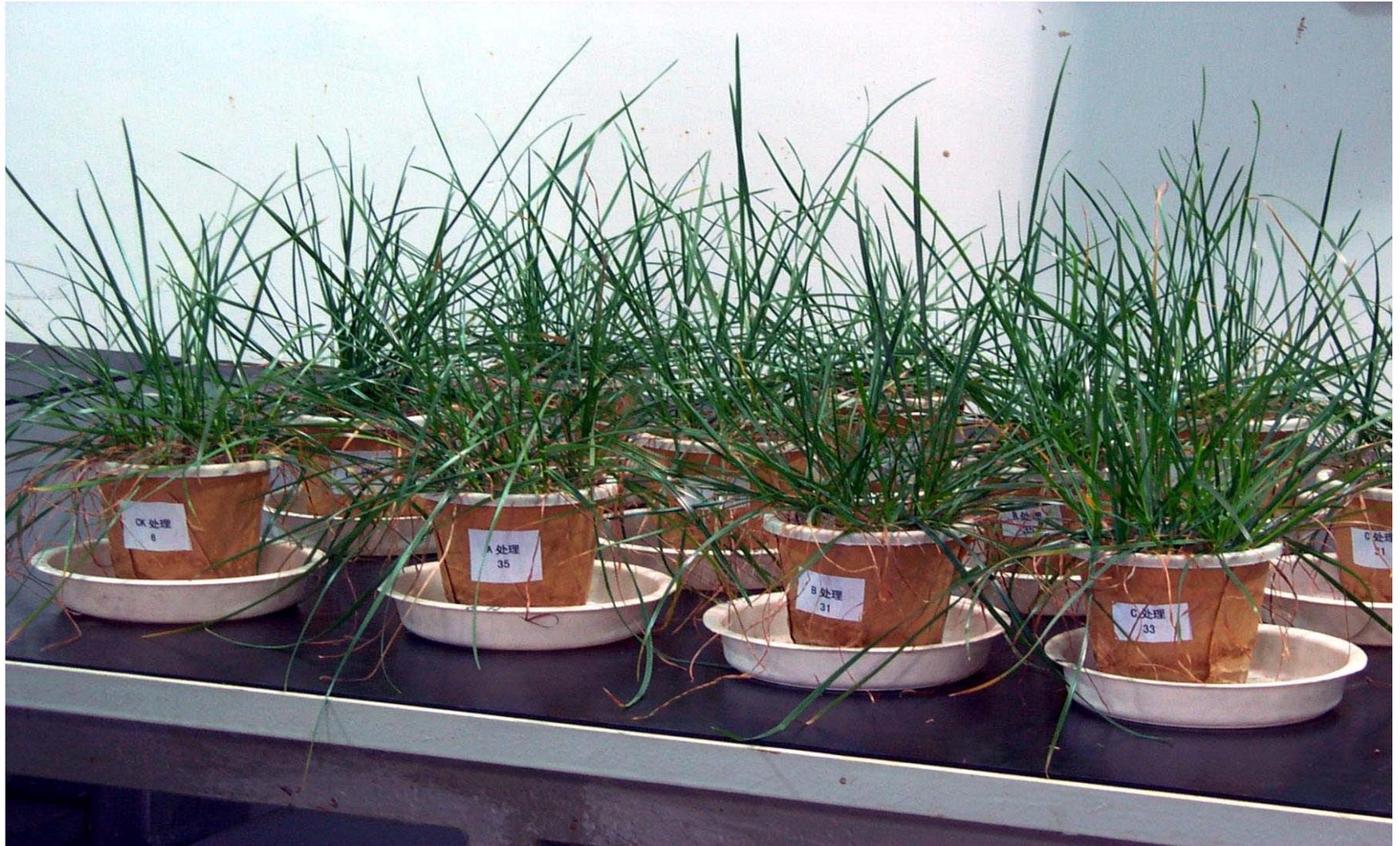


Research and Practice (1)

- **PAHs** by Soil and Environment
Bioremediation Center, Nanjing
Institute of Soil Science, CAS,
China



Ryegrass assisted rhizo-remediation

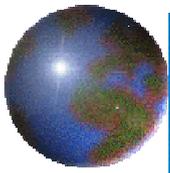


Under different concentrations of PAHs

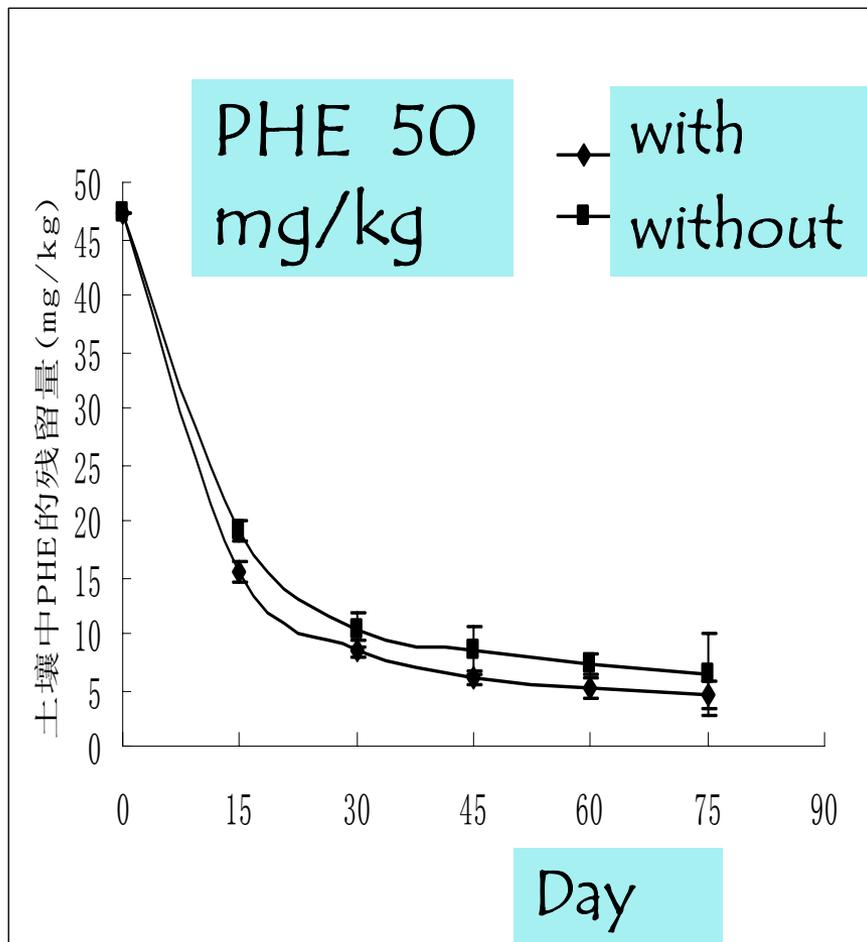
Clover assisted rhizo-remediation



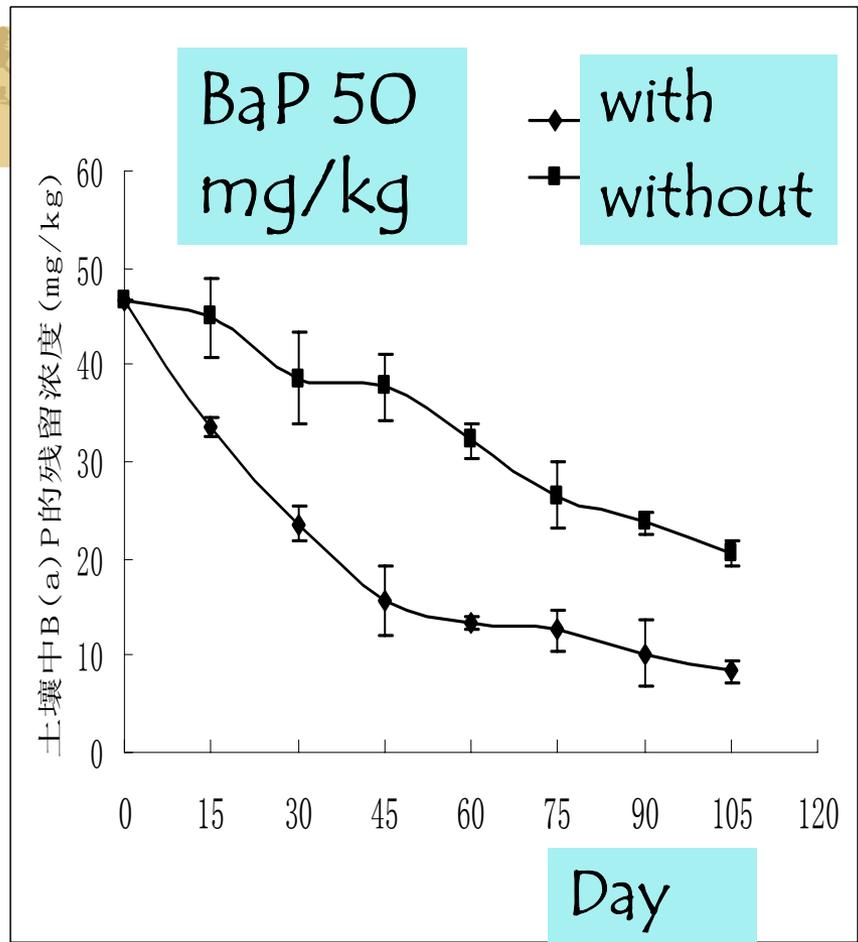
Under different concentrations of PAHs (BaP)



Clover plants inoculated with VAM



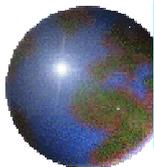
Phenanthrene (PHE)
 concentrations in soil with
 and without ryegrass
 plants



Benzo- α -pyrene (BaP)
 concentrations in soil with
 and without ryegrass
 plants

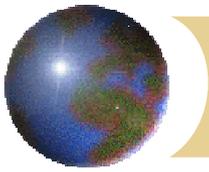
B[a]P concentrations (mg/kg) in Cu and B[a]P mixed contaminated soil grown with and without clover plants

Treatment	Concentration in soil		Concentration in plants	
	With	Without	Root	Stem/leaf
CK	0.02 ± 0.00	0.02 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
1	0.14 ± 0.01a	0.21 ± 0.01b	0.57 ± 0.04aA	0.16 ± 0.03bB
10	1.57 ± 0.02A	2.47 ± 0.05B	0.84 ± 0.13cC	0.21 ± 0.04bBD
100	60.16 ± 3.56A	88.71 ± 2.36B	0.85 ± 0.12cC	0.60 ± 0.03eE



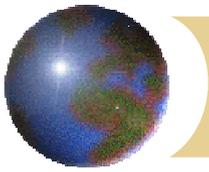
Difference in soil degraded B[a]P concentration (mg/kg) between treatments with and without VAM inoculation

B(a)P Added (mg/kg)	Treat ment	Day					
		0	30	40	50	60	90
1	—	0	0.19	0.26	0.18	0.17	0.18
	VA	0	0.30	0.26	0.22	0.24	0.28
10	—	0	2.24	2.71	2.45	2.43	2.40
	VA	0	3.53	3.32	3.2	3.47	3.20
100	—	0	8.11	19.47	22.96	21.13	18.73
	VA	0	24.63	25.33	21.6	27.47	23.33



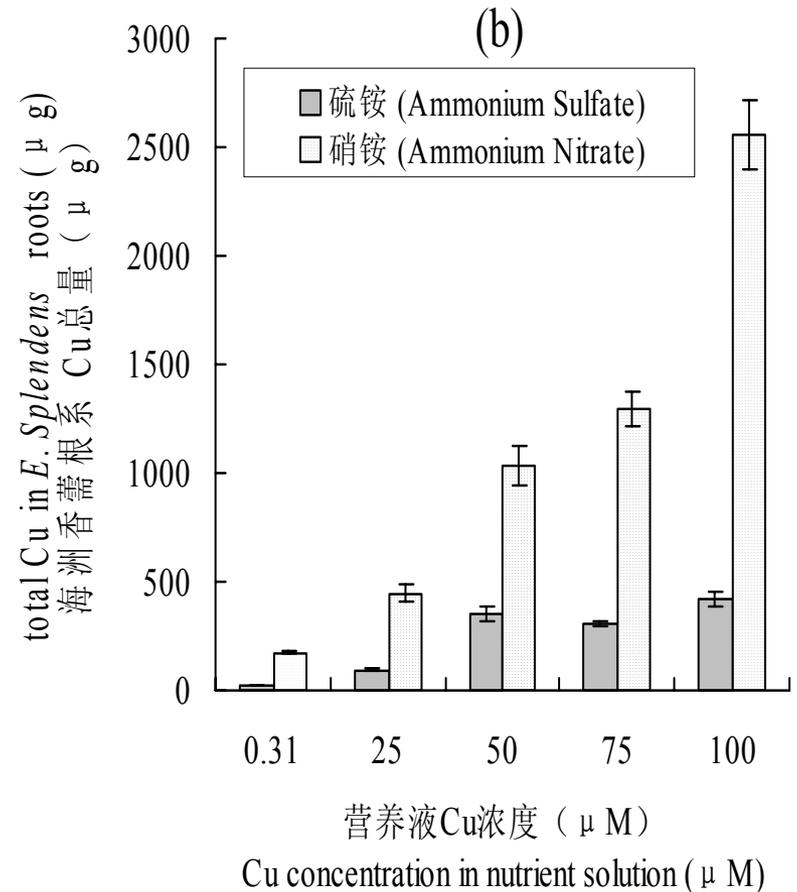
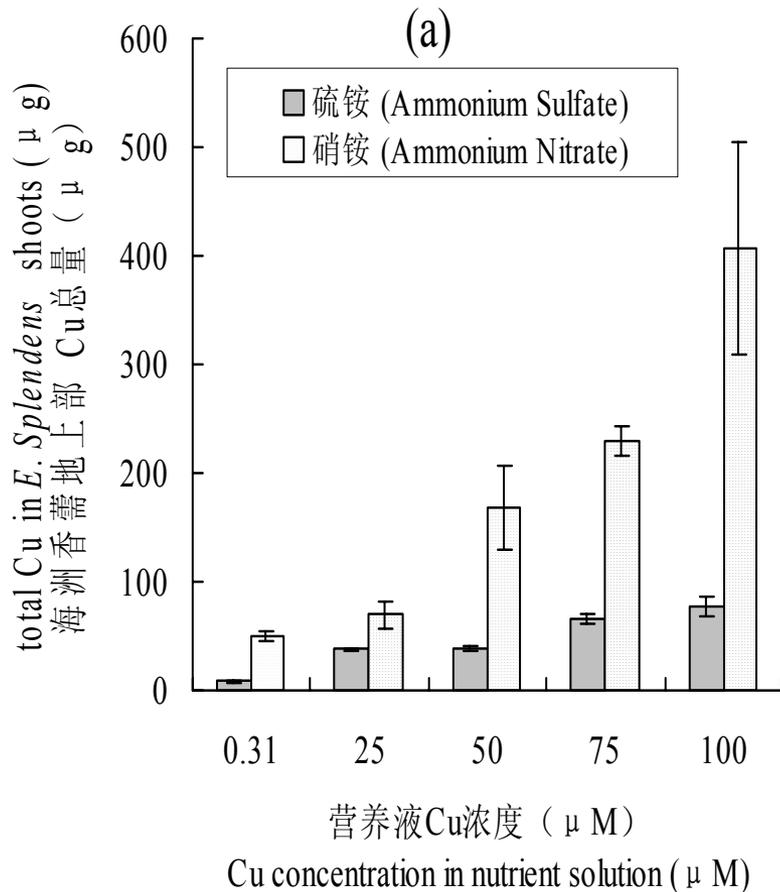
Summary

- **Phytoremediation of POPs is indirect **and/or direct****
- **Planting with inoculum enhances rhizo-remediation**
- **A cost effective 'green phyto-technology'**
- **Engineered rhizo-remediation could be a new approach**



Phytotechnology and restoration of metal contaminated wetland and eutrophied lake in China

Cu Concentrations in above-ground (a) and in roots (b) of *E. splendens*

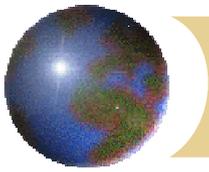


Phytotechnology for restoration and reconstruction of Wetland near mined areas



Using water plants for phytoremediation and restoration of contaminated lake





Phytotechnology of contaminated estuary in China



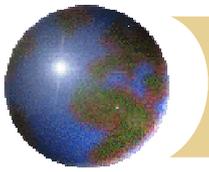
A Solution Approach to Eutrophication in Mariculture Areas by Applying Technology of Large-scale Cultivation of Seaweeds (*Gracilaria lemaneiformis*) in Chinese Coastal waters (By YANG Yu-Feng, FEI Xiu-Geng)

Harvest of seaweeds

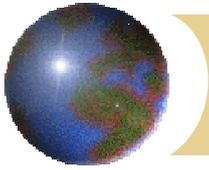




- * **Efficient removal of N and P**
- * **High biomass**
- * **Easy harvest**

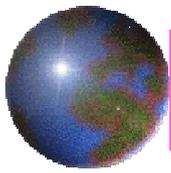


Future initiative and prospect for phytoremediation in China

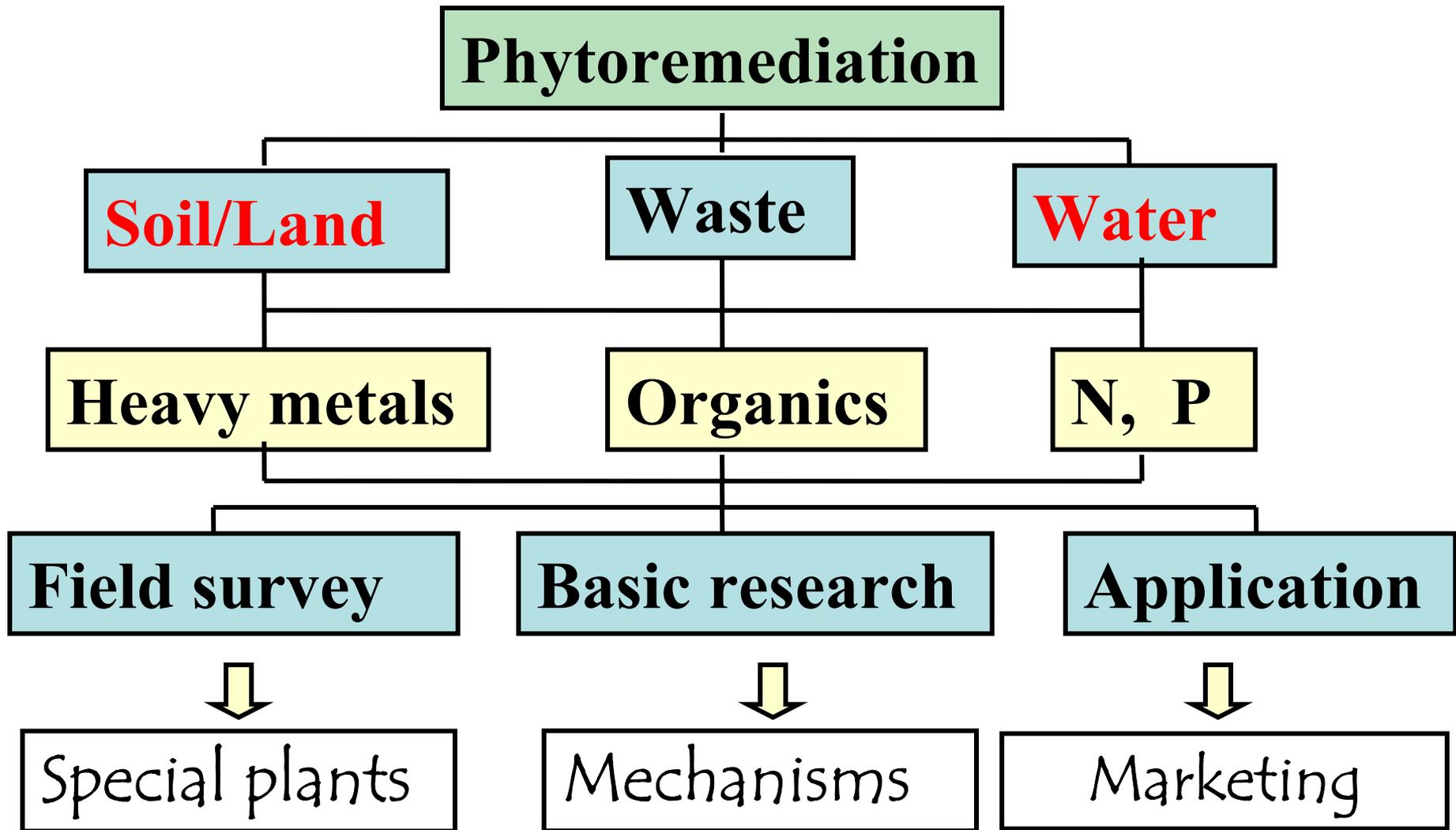


On-going project in China

- **Phytoremediation** of soils contaminated with heavy metals (As, Cu and Zn etc.)
- **Phyto-technology** of soils contaminated with POPs (Pesticides, PAHs, PCBs etc.)



Future Phytoremediation Research in China



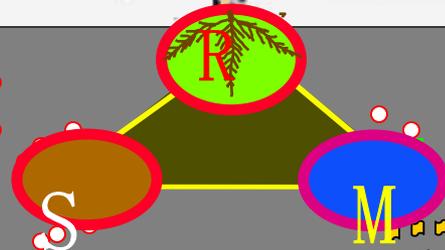
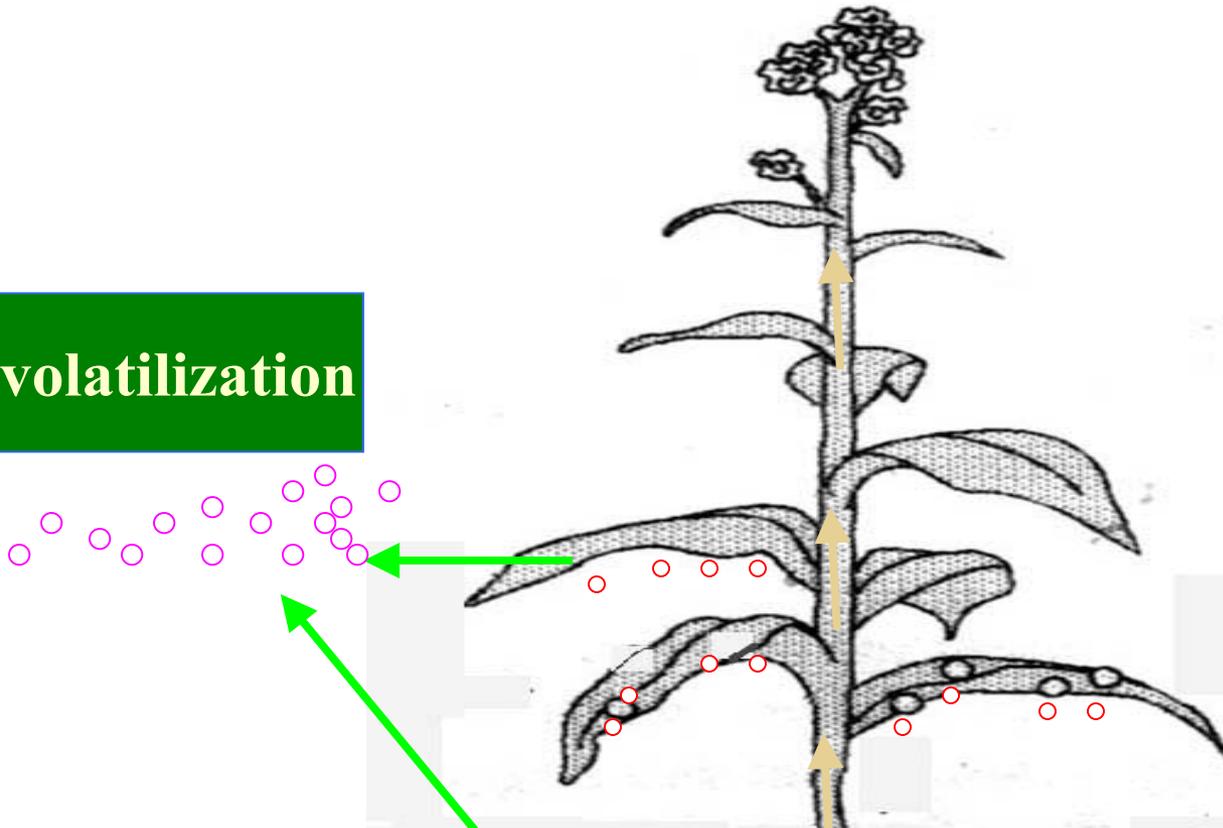
Phytoremediation of polluted environment

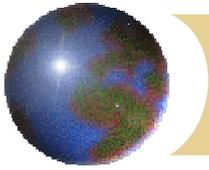
Phytovolatilization

Phytoextraction

Phytostabilization

Phytodegradation





Phytotechnology for Air Pollutant ???

- 1. Hyper-metabolism**
- 2. Super-transformation**

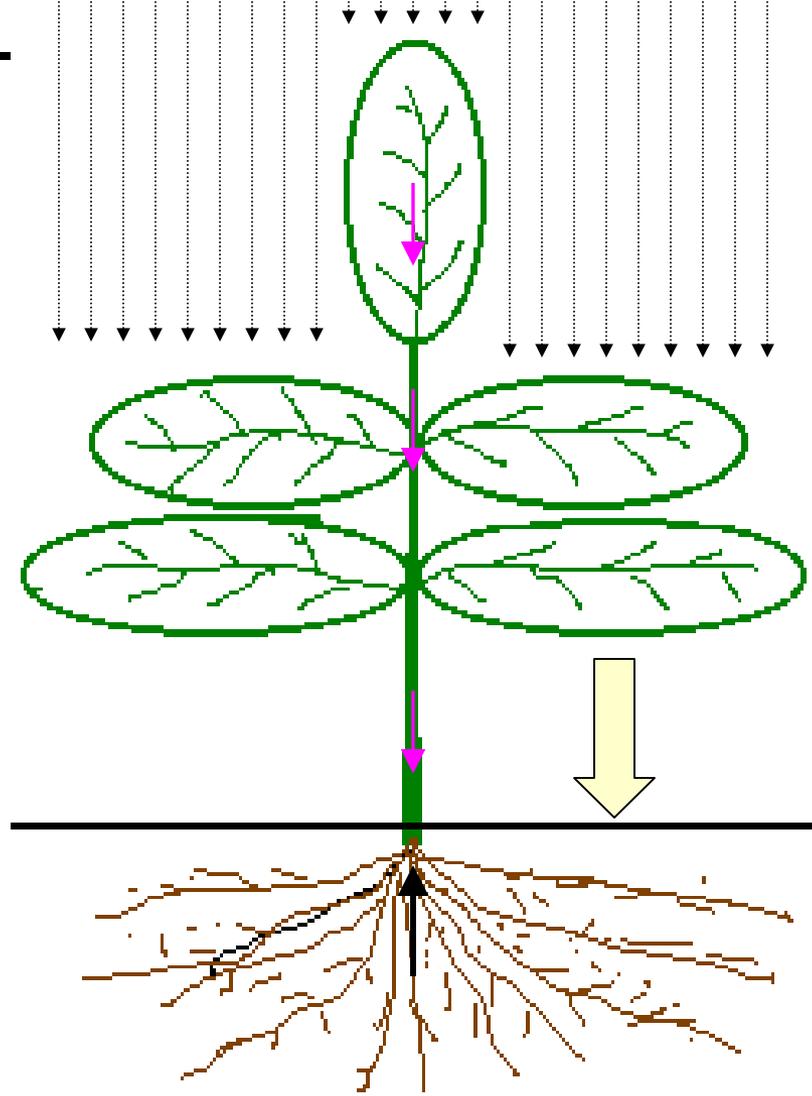
NO_x, SO_x, VOCS, POCS, PTEs, TSPs

Biomass ←

Concentration

Mechanism

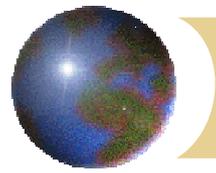
Processes



- Adsorption
- Absorption
- Degradation
- Metabolism
- Transformation

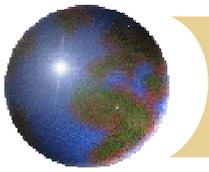
**Plant/Soil
Interaction**

Air Phytoremediation and Eco-environmental Safety



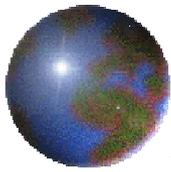
General summary

- 1. Research and development of phytoremediation are just beginning;**
- 2. Advances in phytoremediation appear in several aspects: Theory, Research and Practice;**
- 3. Using natural green resources to tackle natural environmental pollution will be encouraged.**



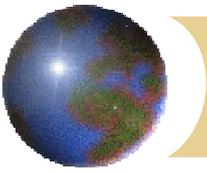
Needs for phytoremediation in China

- Cooperation between regions: Forum, Network and funding mechanisms
- Promote public awareness
- Guidelines and legislation enforcement
- **Applied phytotechnology development**
- Environmental monitoring and assessment
- Management of phytoremediation sites
- Marketing Strategy



Applied Phyto-technology

- **High efficient,**
- **Cost-effective**
- **Easy operation (large-scale suitability)**
- **Risk-free or minimum**
- **Profitable**
- **Legislative**
- **Hybrid (for multiple-pollutants or mixed polluted environment)**



Plant physiology

Hydrology

Physics

**Multi-
disciplinary
Research**

Agronomy

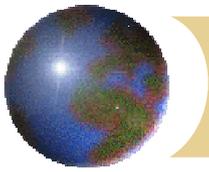
Chemistry

Engineering

Microbiology

Mineralogy

Biochemistry



Acknowledgements

Many thanks for those who provided with information and allowed me for using their materials, and also for Prof. Alan Baker's recommendation and for Jennifer Musella's efficient work.

**INSTITUTE OF SOIL SCIENCE
CHINESE ACADEMY OF SCIENCES**



Thank you !

