

The 6th International Conference on Vetiver ICV-6

VETIVER SYSTEM
EMPOWERING SUSTAINABLE DEVELOPMENT



CENTER OF EXCELLENCE FOR SUSTAINABILITY OF HEALTH, ENVIRONMENT, AND INDUSTRY
NARESUAN UNIVERSITY
Working Together Towards Sustainable Development

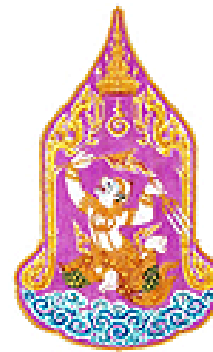


Community-based Remediation of Water and Soil Contaminated with Phenol By

DEVELOPMENTS AND FIELD-SCALED IMPLEMENTATIONS OF USING VETIVER GRASS TO REMEDIATE WATER AND SOIL CONTAMINATED WITH PHENOL AND OTHER HAZARDOUS SUBSTANCES FROM ILLEGAL DUMPING AT NONG NEA SUBDISTRICT, PHANOM SAKHAM DISTRICT, CHACHOENGSAO

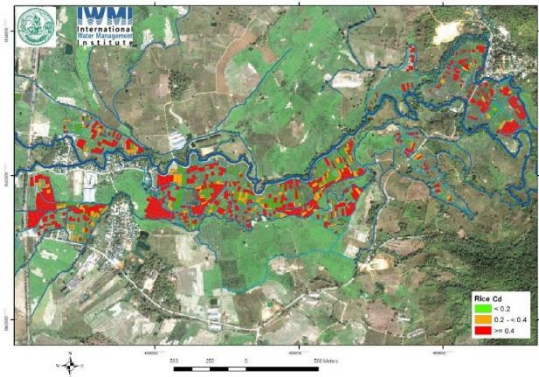
Tanapon Phenrat, P. Teeratitayangkul, T. Imthiang, Y. Sawasdee, S. Wichai, T. Piangpia, J. Naowaopas, and W. Supanpaiboon

ACKNOWLEDGI

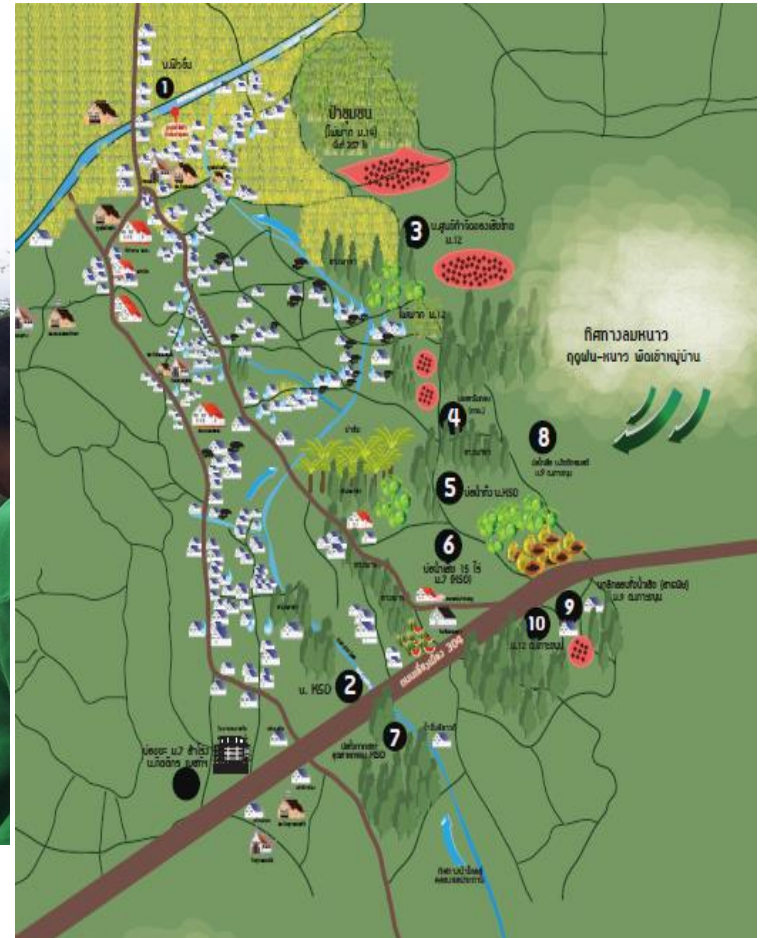


- ❖ Funding from Office of the Royal Development Projects Boards through Naresuan University (Grant nos. R2555B098 and R2557A057)
- ❖ His Majesty the King of Thailand's Chaipattana Foundation and The King of Thailand Vetiver Awards
- ❖ Excellent advice and continuous support from our expert consultants, including Dr. Weerachai Nanakorn, Dr. Narong Chomchalow, Ms. Suwanna Pasiri, and Dr. Pittayakorn Limthong.
- ❖ Trust and involvement from the Nong Nea community who welcomed our research team like a family
- ❖ Chachoengsao Development Station, Land Development Department, Ministry of Agriculture and Cooperatives, Thailand, for supporting vetiver grass for our research
- ❖ Channel 3 and volunteers for field scaled implementation of

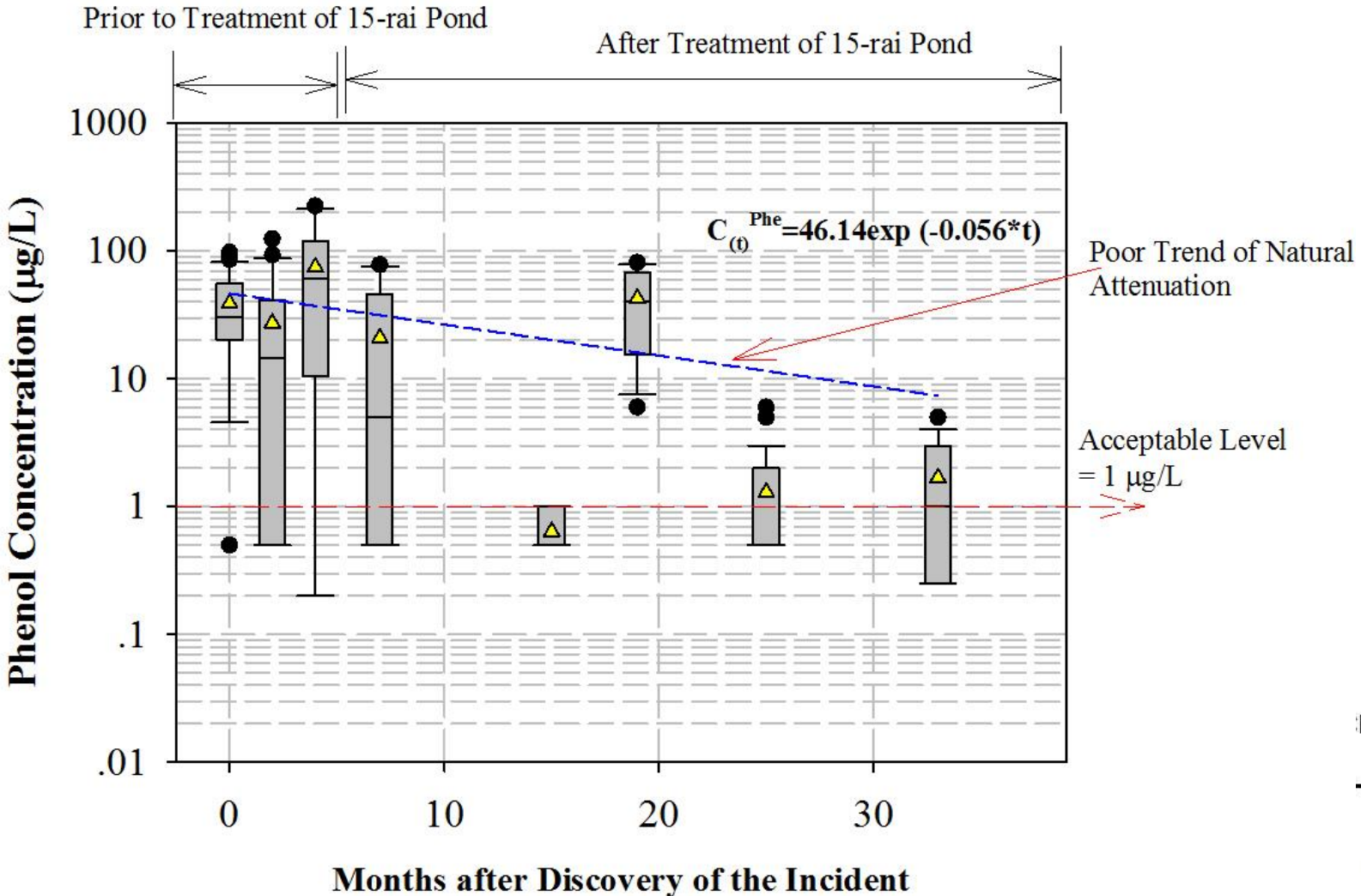
CONTAMINATION OF HAZARDOUS SUBSTANCES IN THAILAND



ILLEGAL DUMPING OF INDUSTRIAL WASTE AND WASTEWATER AS CONTAMINATION

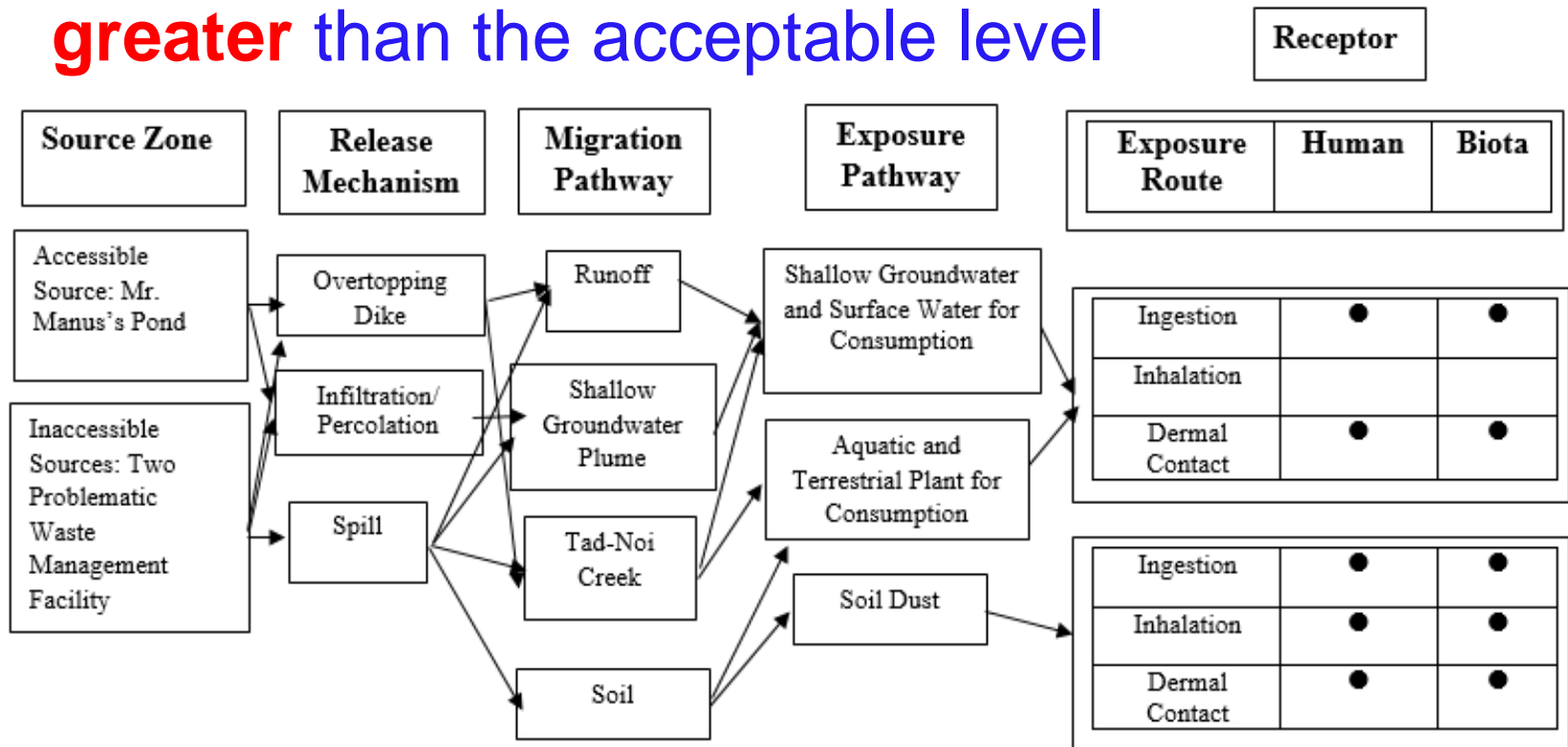


COMMUNITY CALLS FOR RISK MITIGATION MEASURES WAS ONLY SOURCE ZONE REMOVAL ENOUGH?

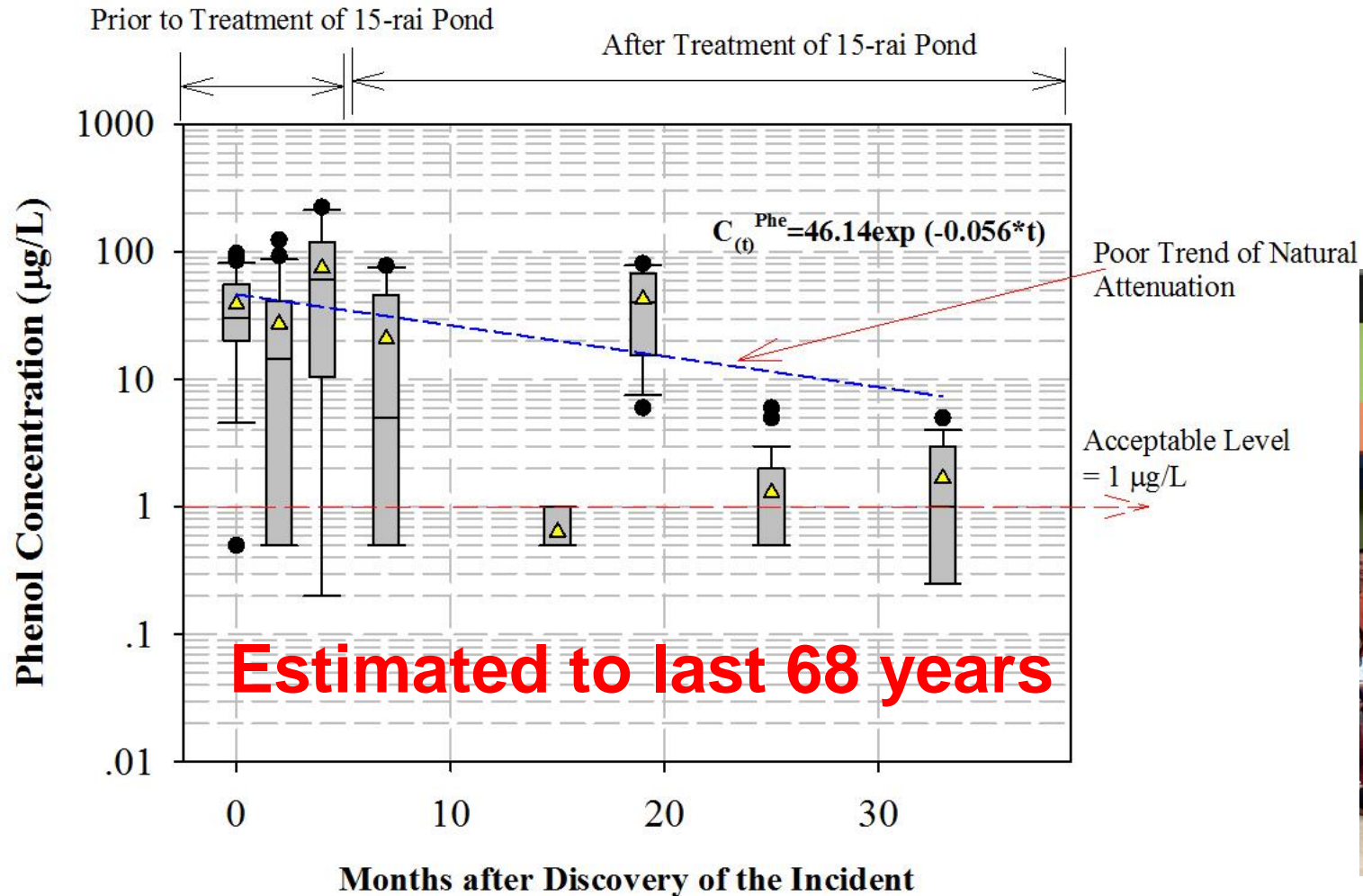


RISK: EXPOSURE MODEL

Phenol Concentration in Water **250 times greater** than the acceptable level

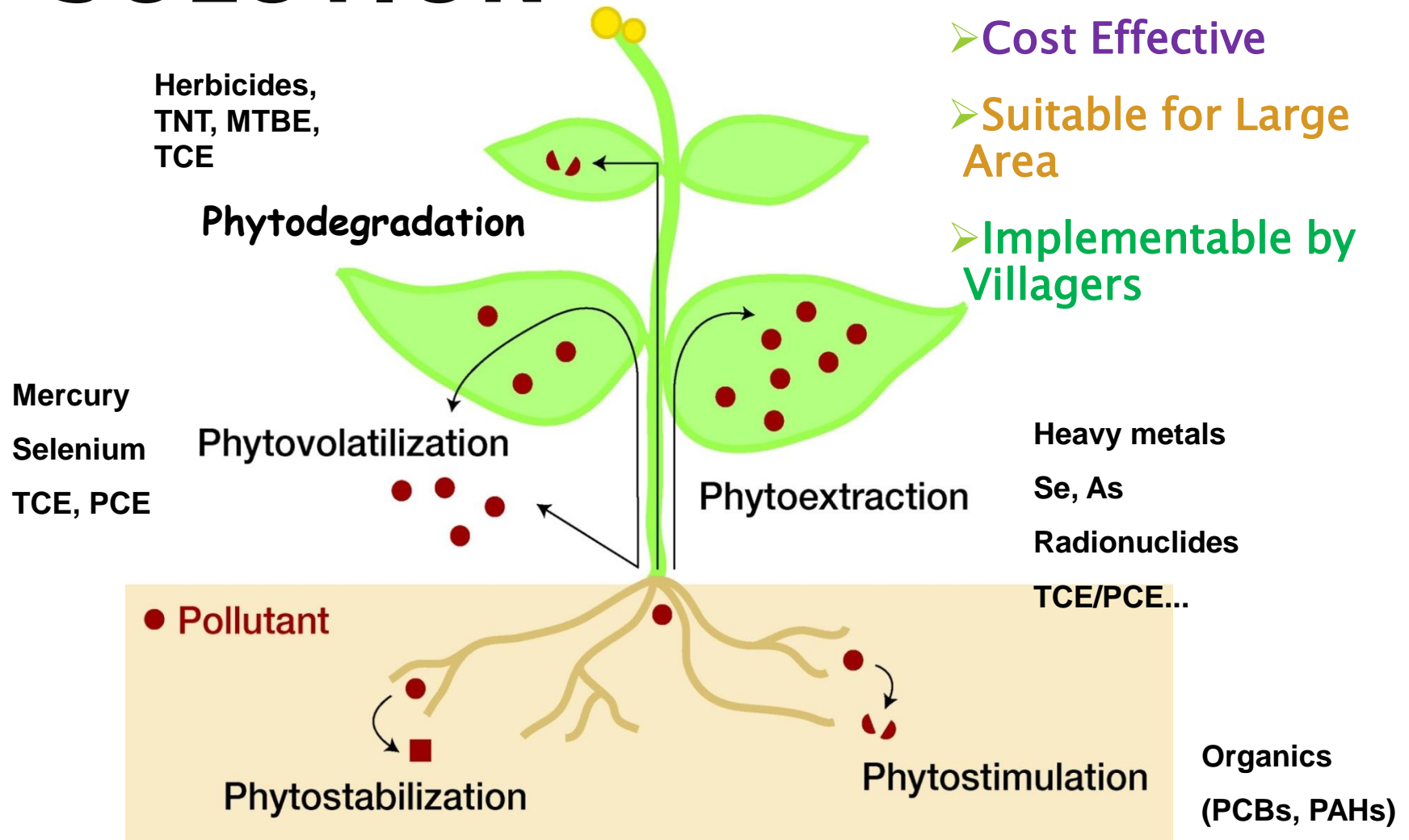


POINT-OF-USE TREATMENT USING OZONE IS UNDER OPERATION BUT IS NOT AN ABSOLUTE SOLUTION



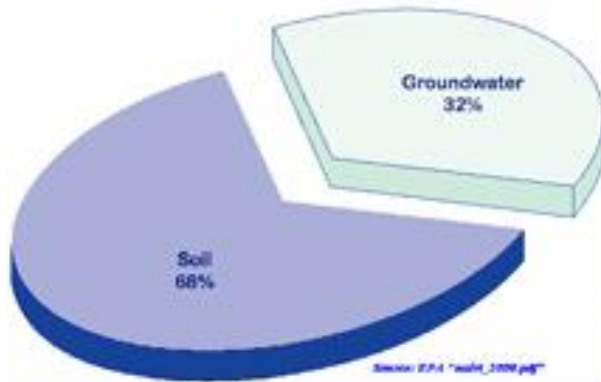
PHYTOREMEDIATION IS THE SUSTAINABLE SOLUTION

- Cost Effective
- Suitable for Large Area
- Implementable by Villagers

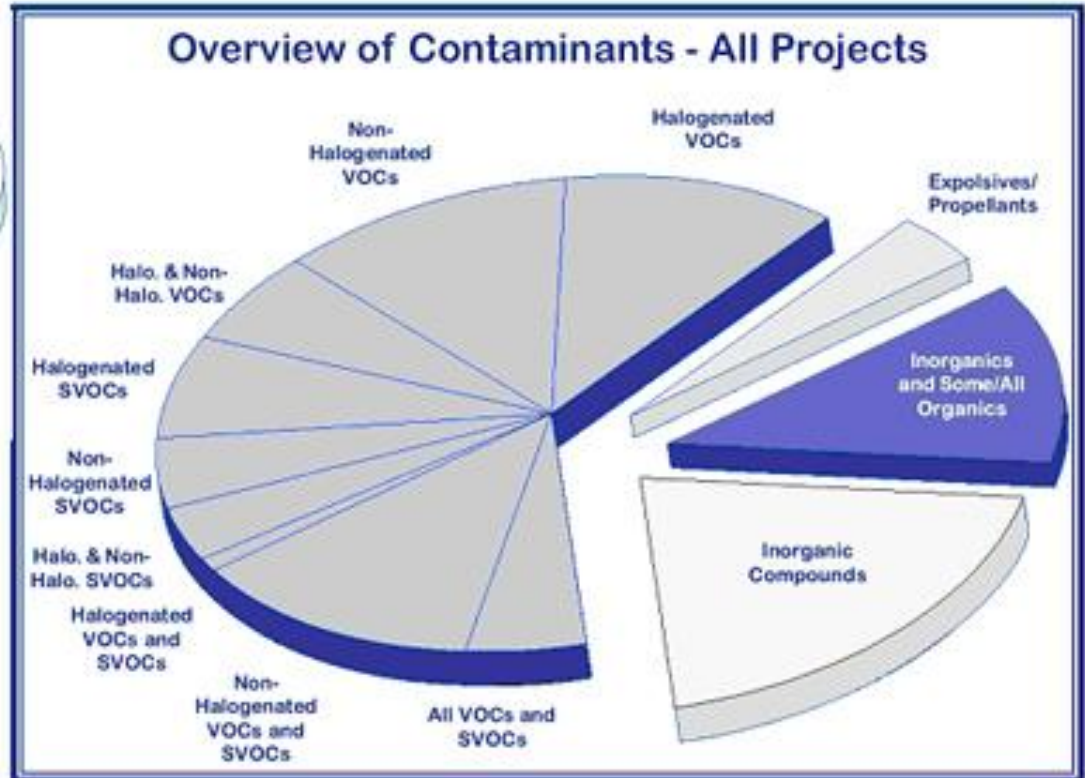


WHILE AROUND THE WORLD >75% CONTAMINATED BY HAZARDOUS ORGANICS

Overview of Demonstrations by Media



Overview of Contaminants - All Projects



http://www.ewmgroup.net/serving_mining_industry.asp

ONLY 10% RESEARCH USING VETIVER FOR PHYTOREMEDIATION OF HAZARDOUS ORGANICS

As of May, 4, 2015

Only 6 papers on the topic of vetiver and organic contaminants

52 papers on vetiver and metals

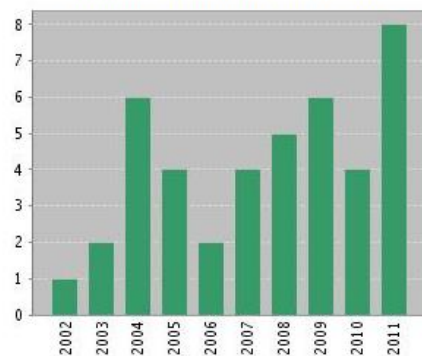
Web of ScienceSM

[<< Back to previous results list](#)

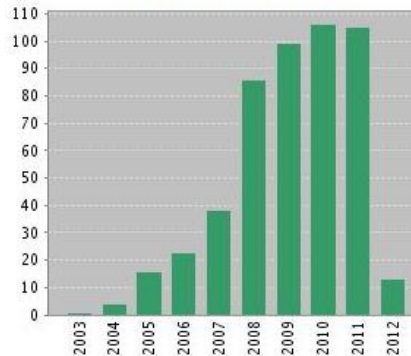
Citation Report Topic=(vetiver metals)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.

This report reflects citations to source items indexed within Web of Science. Perform a Cited Reference Search to include citations to items not indexed within Web of Science.

Published Items in Each Year



Citations in Each Year



Results found: 42

Sum of the Times Cited [?]: 491

Sum of Times Cited without self-citations [?]: 386

Citing Articles [?]: 356

Citing Articles without self-citations [?]: 327

Average Citations per Item [?]: 11.69

h-index [?]: 12

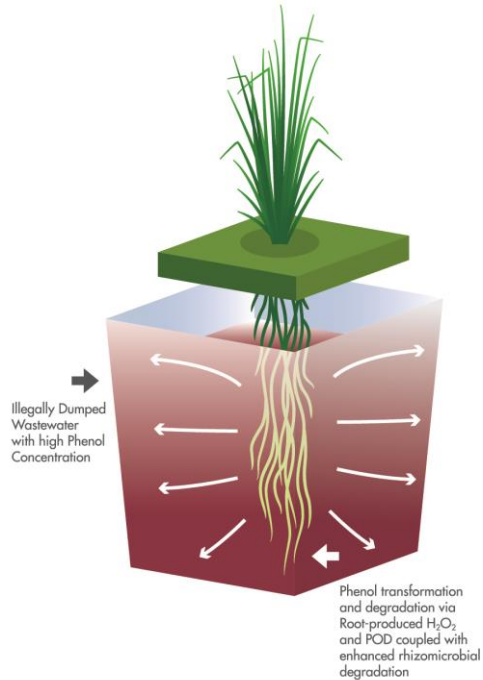
THE KING OF THAILAND AND THE MIRACLE VETIVER GRASS

His Majesty's remark to His Excellency Mr. Ampol Senanarong (Privy Councilor) and the Committees of National Research Council of Thailand, given at Kaikung Won Palace on 22 November, 2002 in that “Vetiver is a versatile plant capable for various applications. In addition to the main benefit of soil erosion prevention, vetiver root penetrating into soil can remove toxic substances flowing into the soil” (2002-2011)

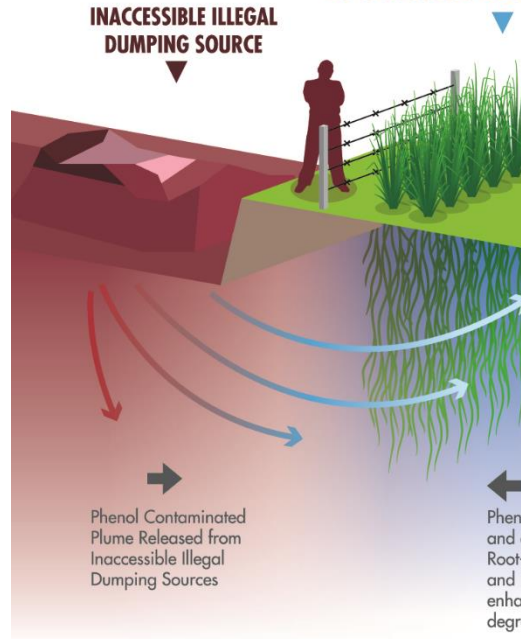


RISK REDUCTION STRATEGY: FROM THE LAB TO THE LIFE

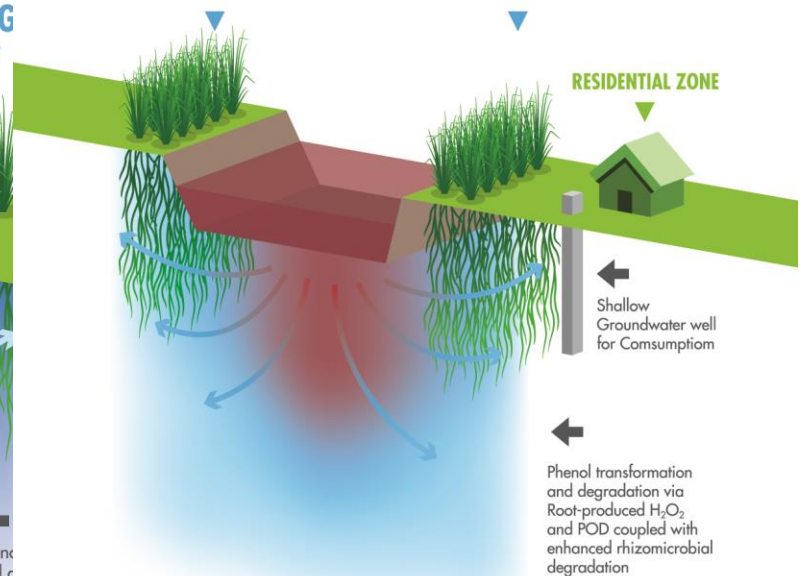
VETIVER ON A FLOATING PLATFORM DEGRADES PHENOL IN CONTAMINATED WATER



PERMEABLE REACTOR OF VETIVER ROOTS CAPABLE OF PHENOL DEGRADATION

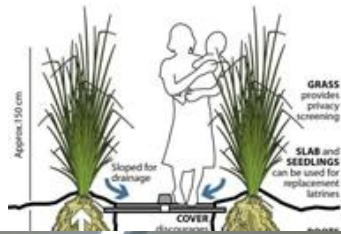


VETIVER HEDGEROWS ALONG TAT NOI CREEK WITH ROOTS CAPABLE OF PHENOL ELIMINATION



SUGGESTION FROM EXPERT CONSULTANTS OF RDPB DURING FIELD VISIT

www.krobkruakao.com/video.php?type=videoDetail&video=19&path=22032&year=2013&month=08

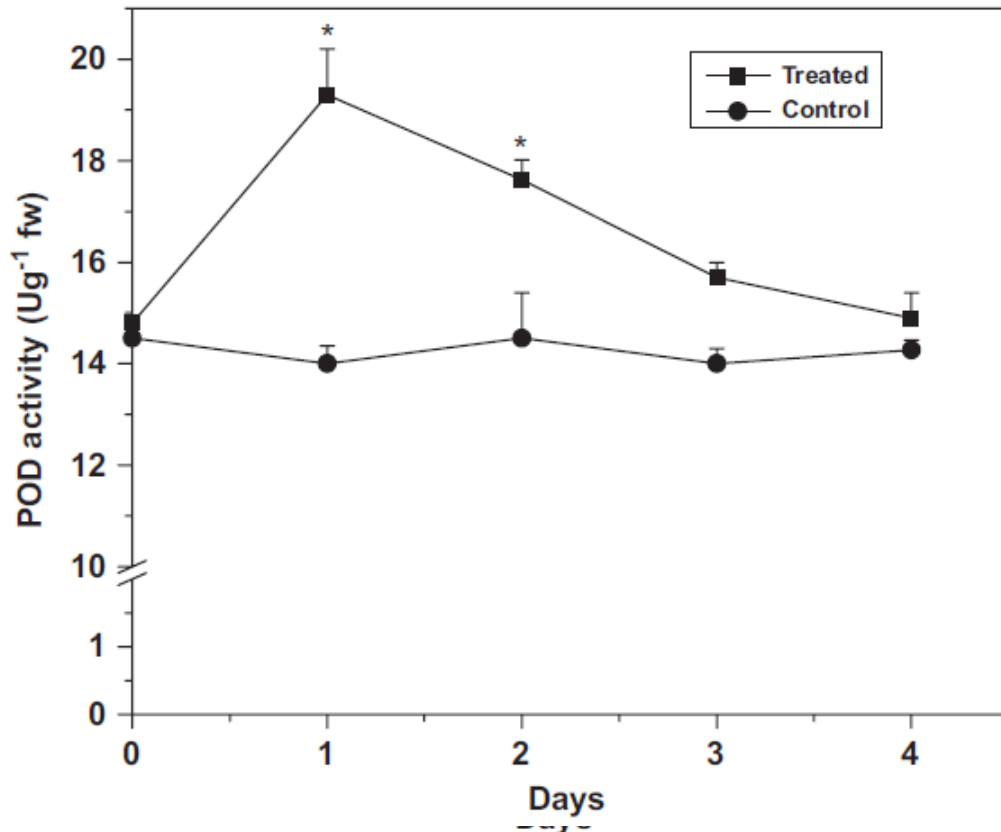


THE LAB



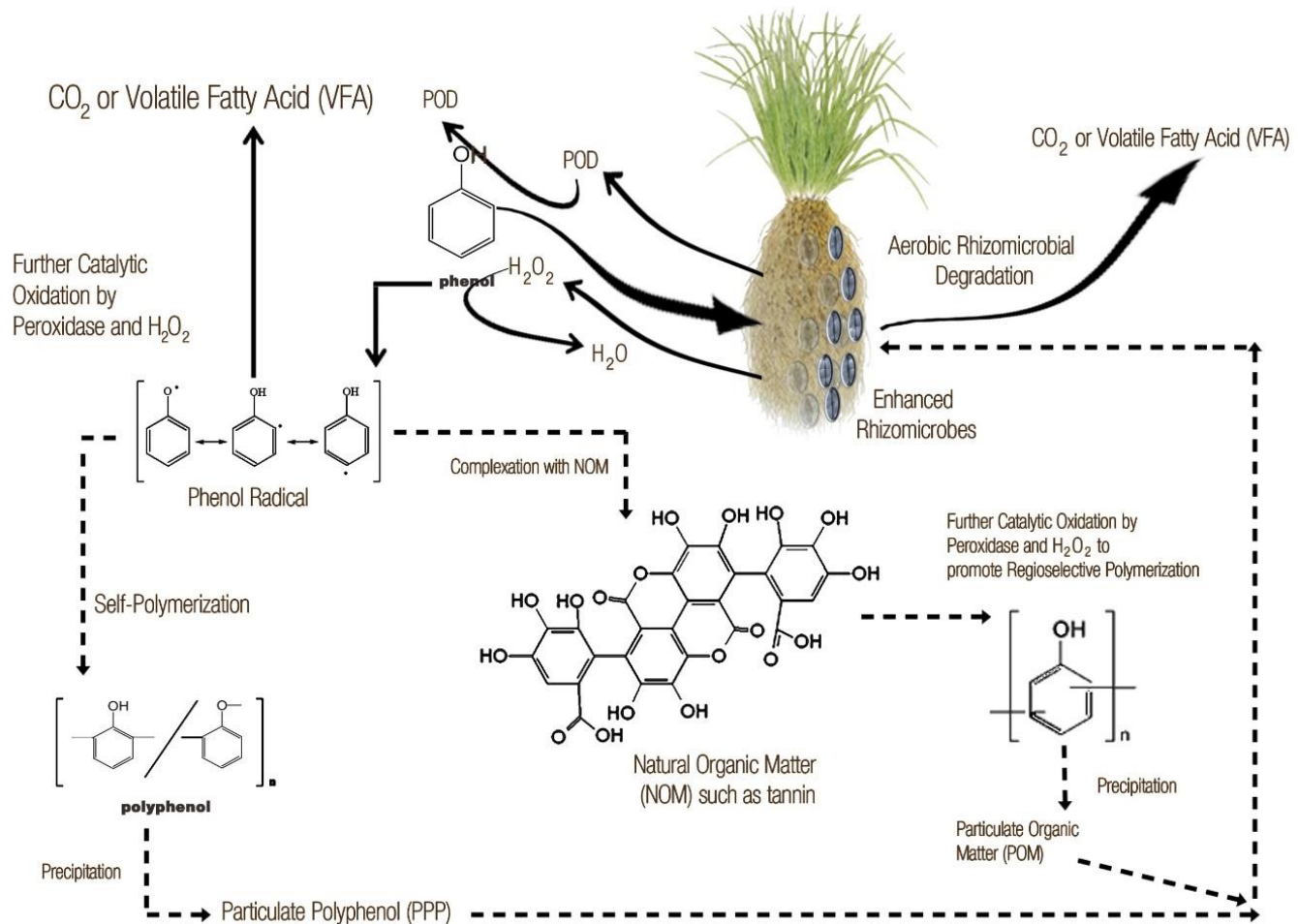
LITERATURE: PHYTODEGRADATION OF PHENOL BY VETIVER

Source: Singh et al.(2008)Ecotoxicology and Environmental Safety 71 (2008) 671–676

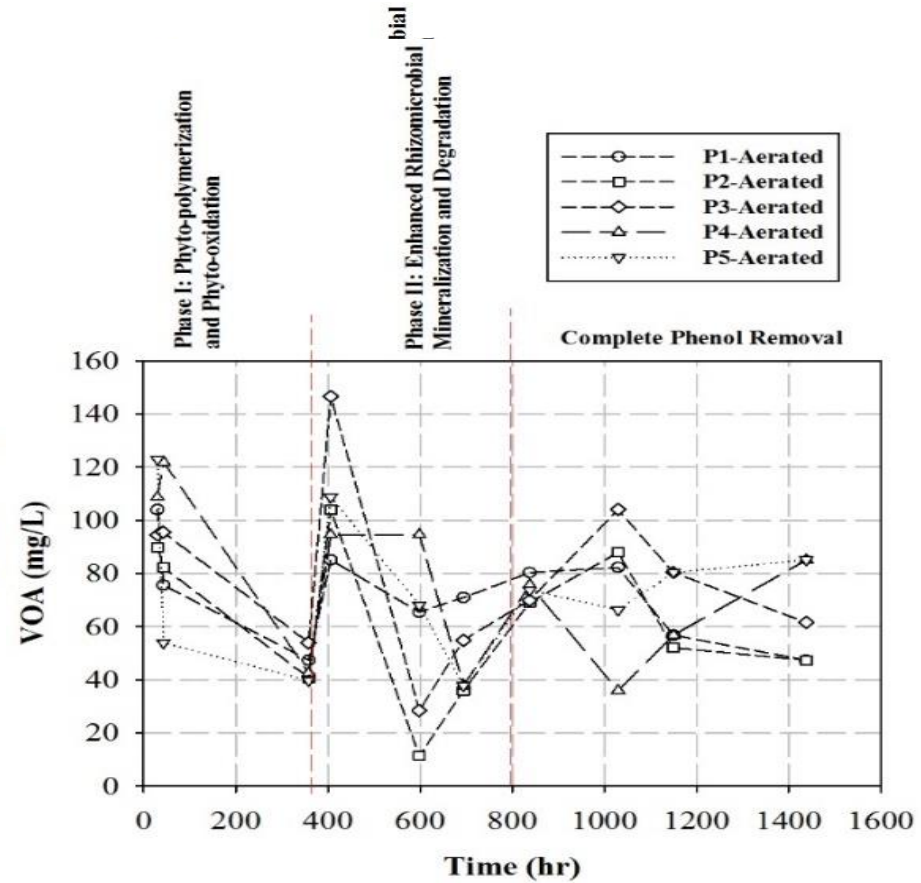
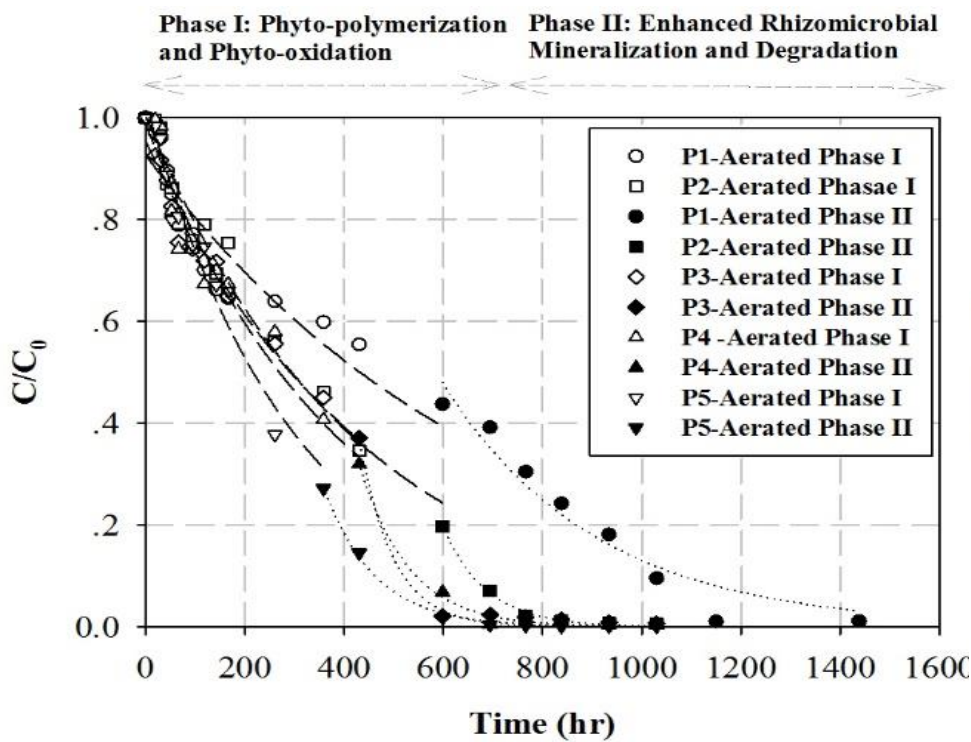


- Hypothesis of Phytooxidation by H₂O₂ and Peroxidase
- Vetiver degrades phenol faster than other plant (such as alfalfa bean) around 7–8 times
- No Complete Mechanistic Understanding
- No Field Scaled

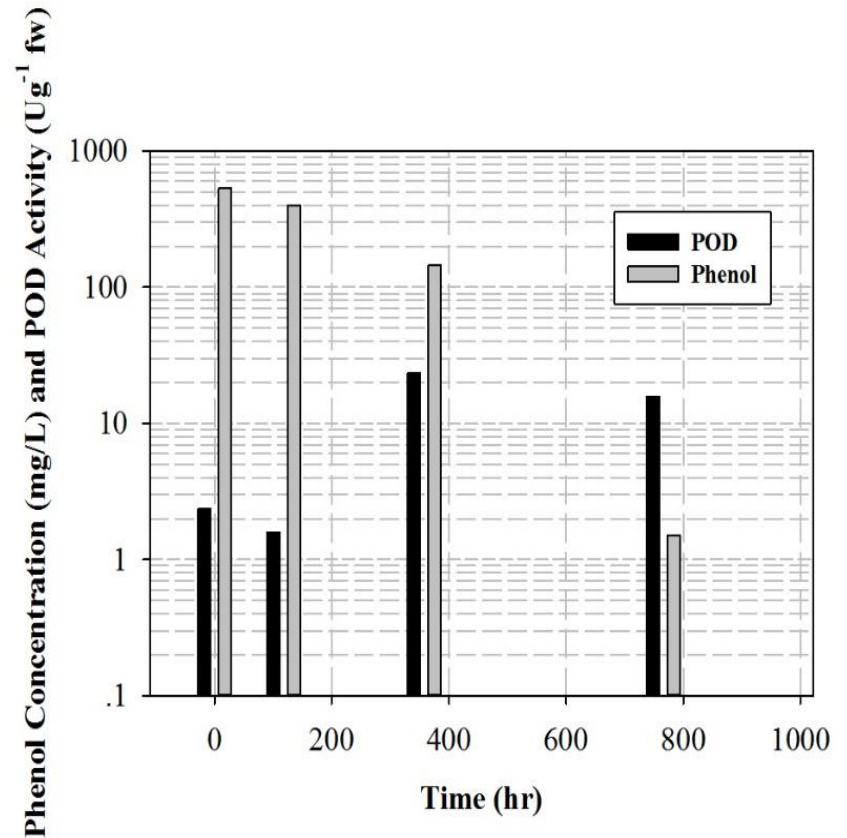
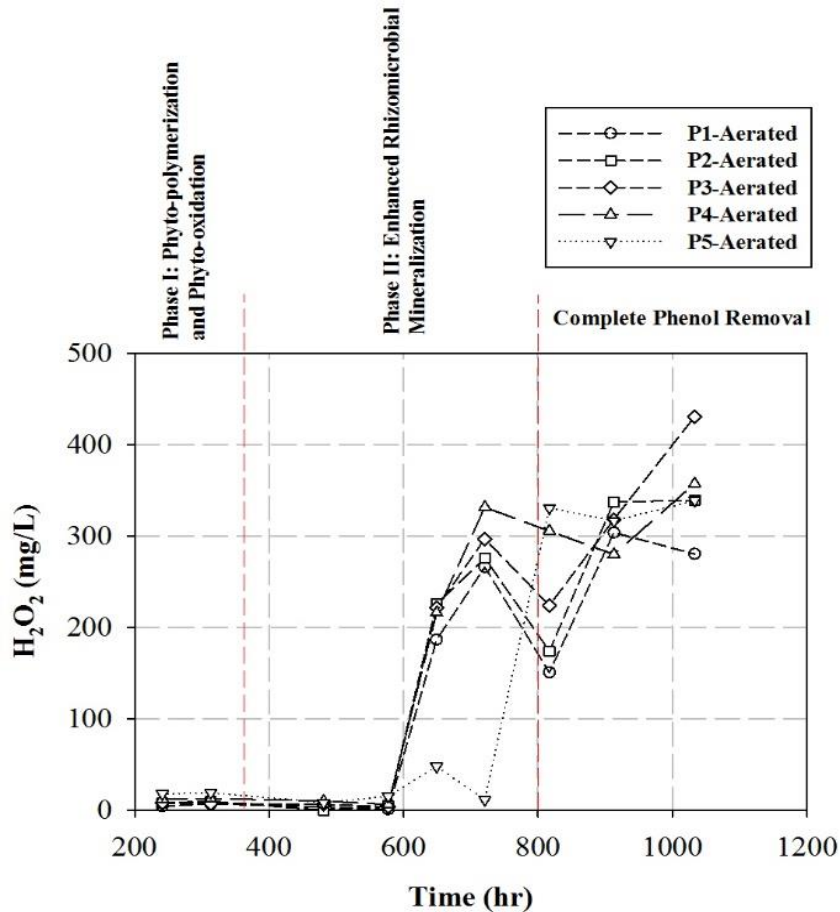
PHYTOREMEDIATION MECHANISM: PHYTOOXIDATION, PHYTOPOLYMERIZATION, AND RHIZOMICROBIAL DEGRADATION



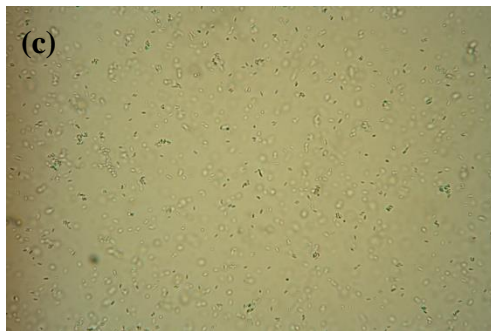
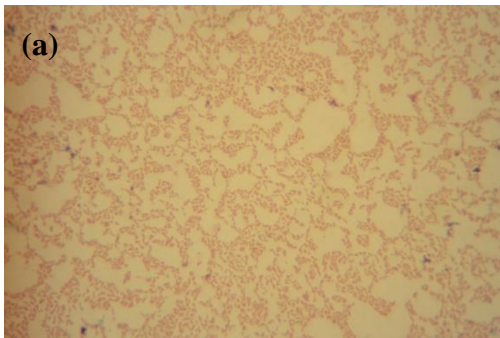
PHENOL DEGRADATION KINETICS: 2-PHASE PROCESS



PHYTOCHEMICALS



RHIZOMICROBE



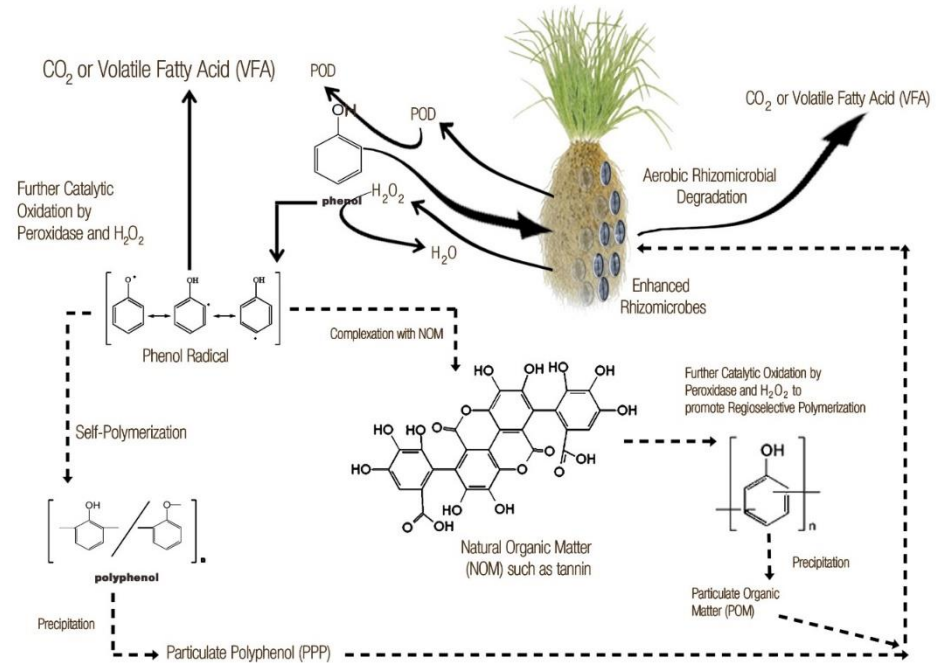
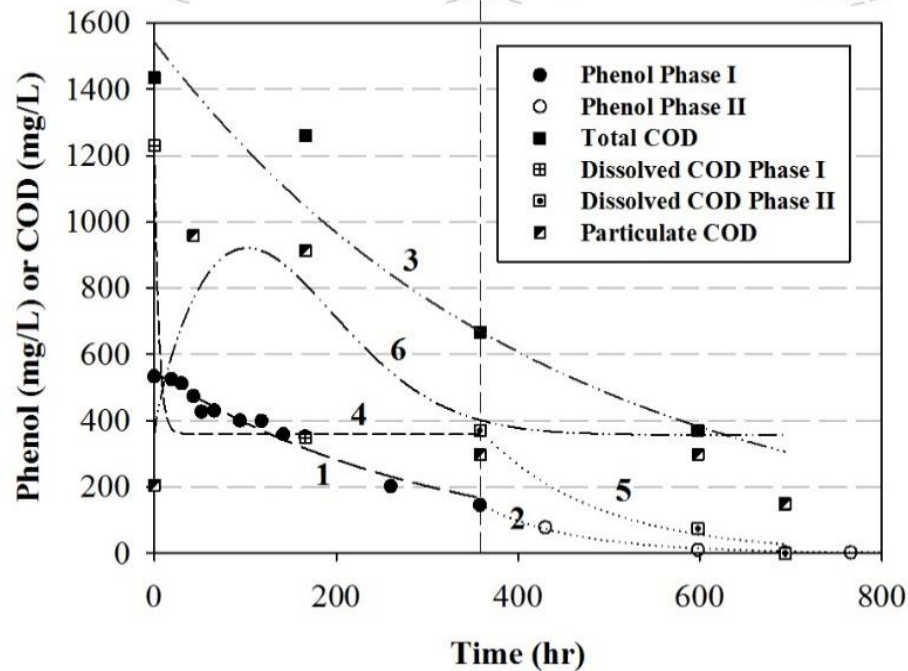
Isolated colonies from treated wastewater and vetiver roots, including (a) *Pseudomonas* spp., (b) *Micrococcus* spp. 1,000X magnification, (c) *Candida* spp. 400X, and (d) *Trichosporon* spp. 400X.

50 TO 500 TIME INCREASE OF MICROBE AT VETIVER ROOT

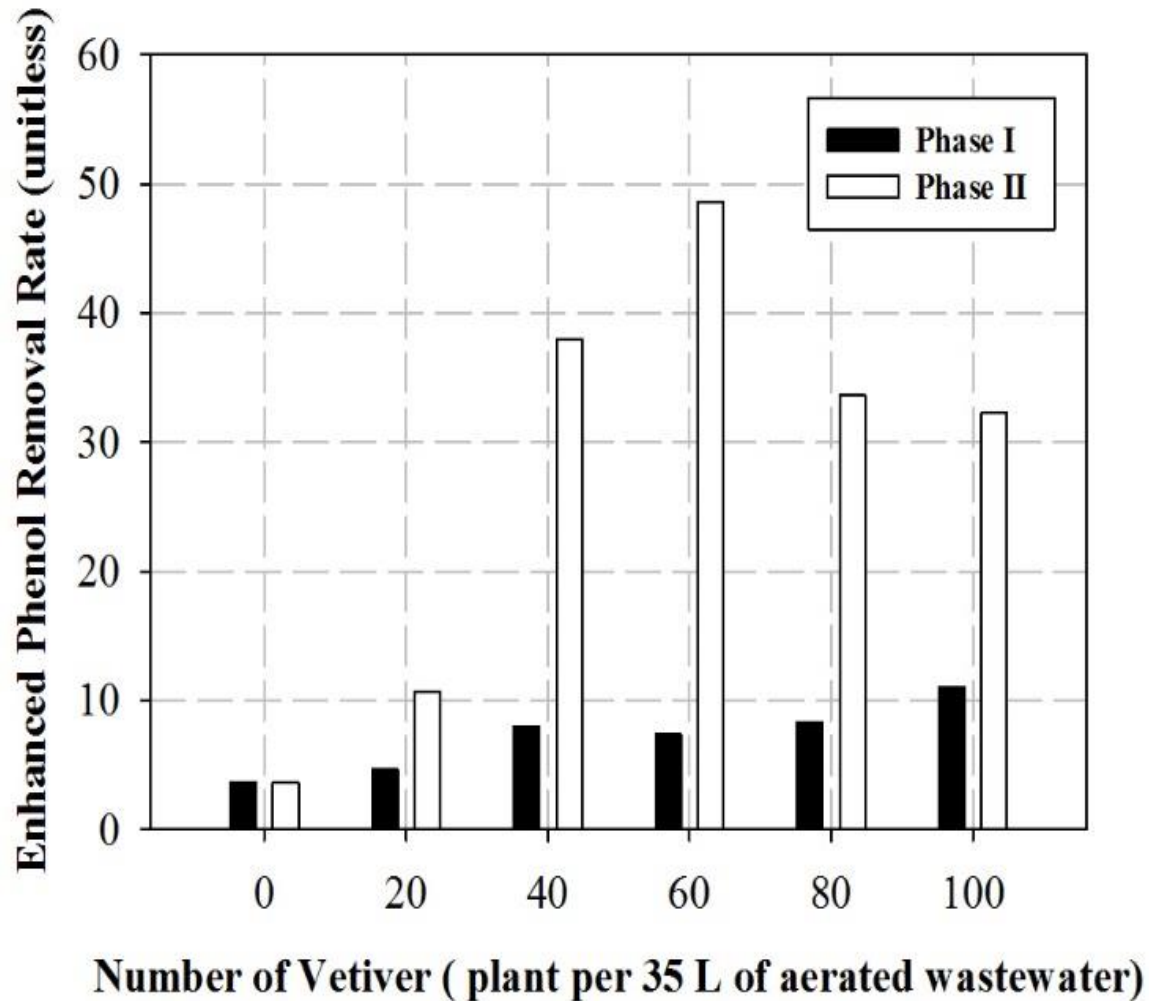
samples	Phenol waste treatment process				
	Lot PB	Lot P			
Water	PB1 430 hr (A1) TPC= 2.4×10^4 Y&M = <10	P1 272 hr (C1) TPC= 1.8×10^6 Y&M = 10	P1 416 hr (C2) TPC= 8.7×10^6 Y&M = 20	P1 608 hr (C3) TPC= 6.8×10^7 Y&M = 30	P1 792 hr (C4) TPC= 3.4×10^8 Y&M = 30
	PB5 430 hr (B1) TPC= $<10^3$ Y&M = <10	P5 272 hr (D1) TPC= 6.3×10^6 Y&M = 30	P5 416 hr (D2) TPC= 8.5×10^6 Y&M = 30	P5 608 hr (D3) TPC= 8.3×10^6 Y&M = 20	P5 792 hr (D4) TPC= 3.0×10^7 Y&M = 30
Vetiver root	PB1 430 hr (RA1) TPC= 3.2×10^6 Y&M = 1.2×10^2	P1 272 hr (RC1) TPC= 3.6×10^8 Y&M = 3.0×10^2	P1 416 hr (RC2) TPC= 4.0×10^9 Y&M = 4.5×10^2	P1 608 hr (RC3) TPC= 8.7×10^{10} Y&M =	P1 792 hr (RC4) TPC= 9.5×20^{10} Y&M = 2.5×10^2
	PB5 430 hr (RB1) TPC= 5.1×10^5 Y&M = 1.0×10^2	P5 272 hr (RD1) TPC= 3.3×10^8 Y&M = 2.5×10^2	P5 416 hr (RD2) TPC= 3.1×10^9 Y&M = 2.3×10^2	P5 608 hr (RD3) TPC= 1.5×10^{10} Y&M = 2.8×10^2	P5 792 hr (RD4) TPC= 6.2×10^{10} Y&M = 2.0×10^2

SIMPLE TECHNOLOGY WITH COMPLEX BIOCHEMICAL PROCESSES

Phase I: Phyto-polymerization Phase II: Enhanced Rhizomicrobial and Phyto-oxidation



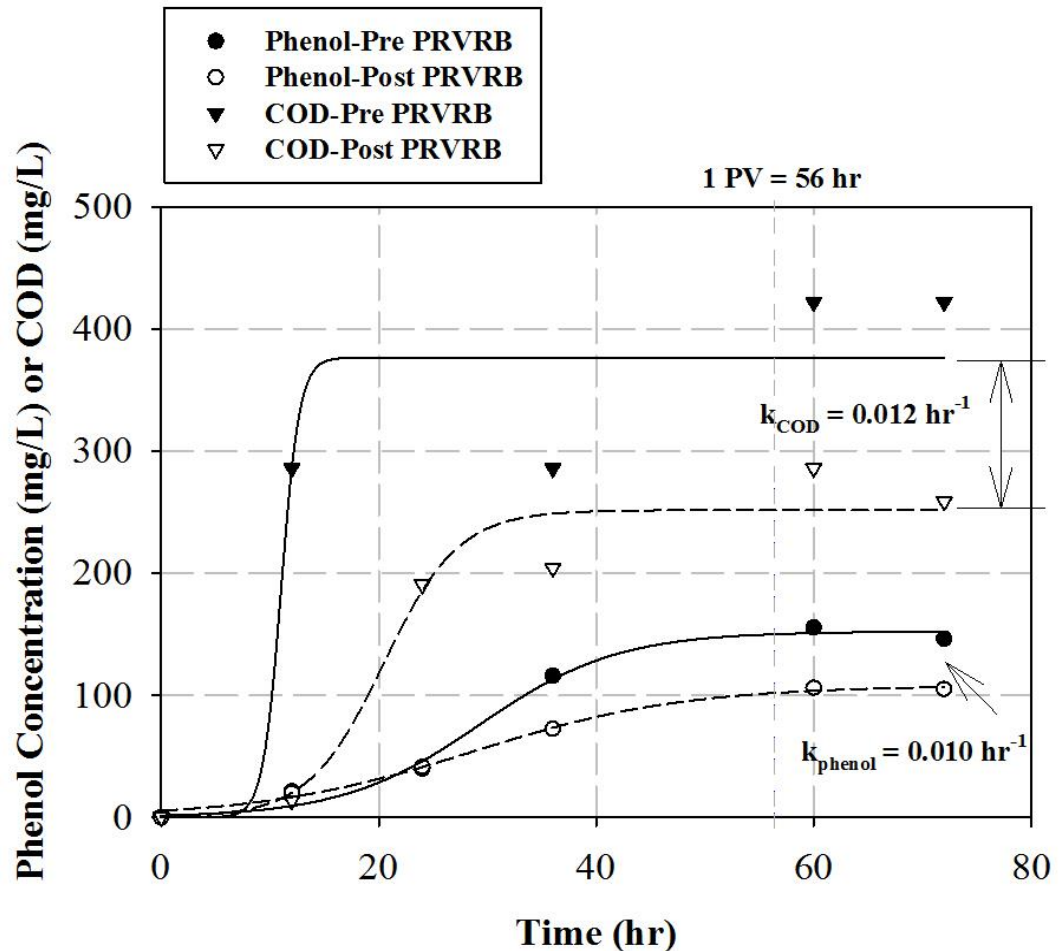
EFFICIENCY



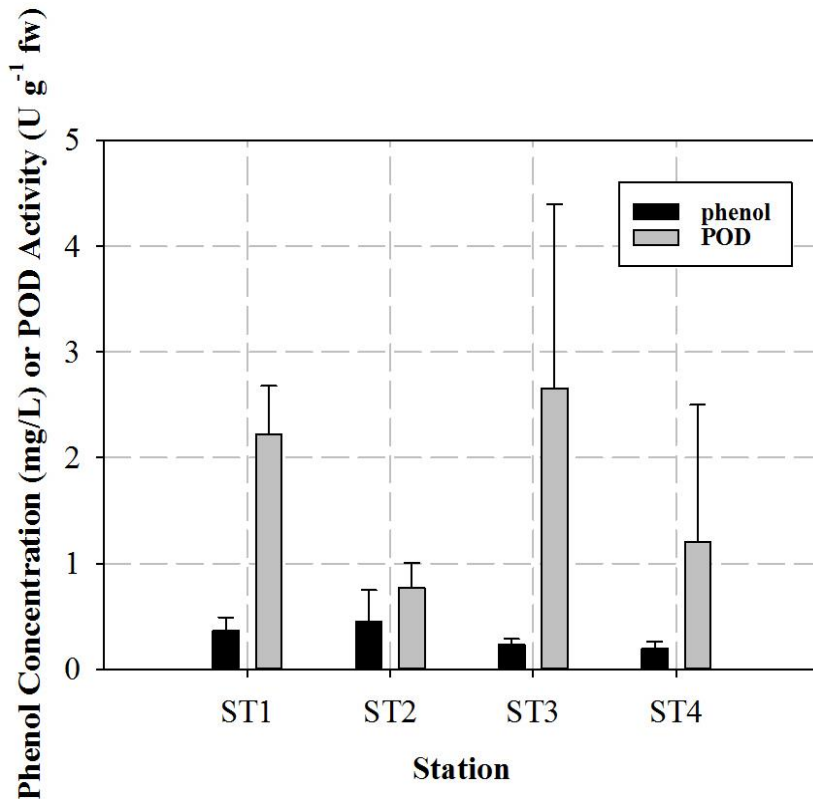
ROOT BARRIER

APPLICATION: ROLE OF MICROBE IN SOIL

- Phenol degradation rate faster than Phase I in wastewater treatment ($k_{\text{phenol}} = 0.0033 \text{ h}^{-1}$)
- but similar to that of Phase II ($k_{\text{phenol}} = 0.0097 \text{ h}^{-1}$), as the presence of soil presumably stimulates rhizomicrobial growth



FROM LAB TO FIELD



- Theoretical calculation suggests
- 1.5-km vetiver fences with a width of 1.5 m
- Decrease phenol transport along the 1.5-km creek banks at a removal efficiency of 40% (at a surface water flow velocity of 50 cm/min)
- Decrease phenol migration through soil (perpendicular to the creek) to the shallow wells at a removal efficiency of around 70% (at a seepage

FROM THE LAB TO THE LIFE WITH SOCIAL ENGAGEMENT



FIELD TREATMENT OF SOURCE ZONE

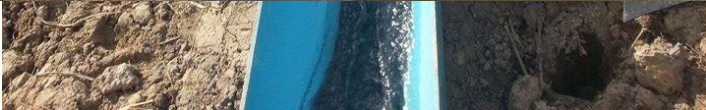
VETIVE
DEGRADES



enhanced rizomicrobial
degradation

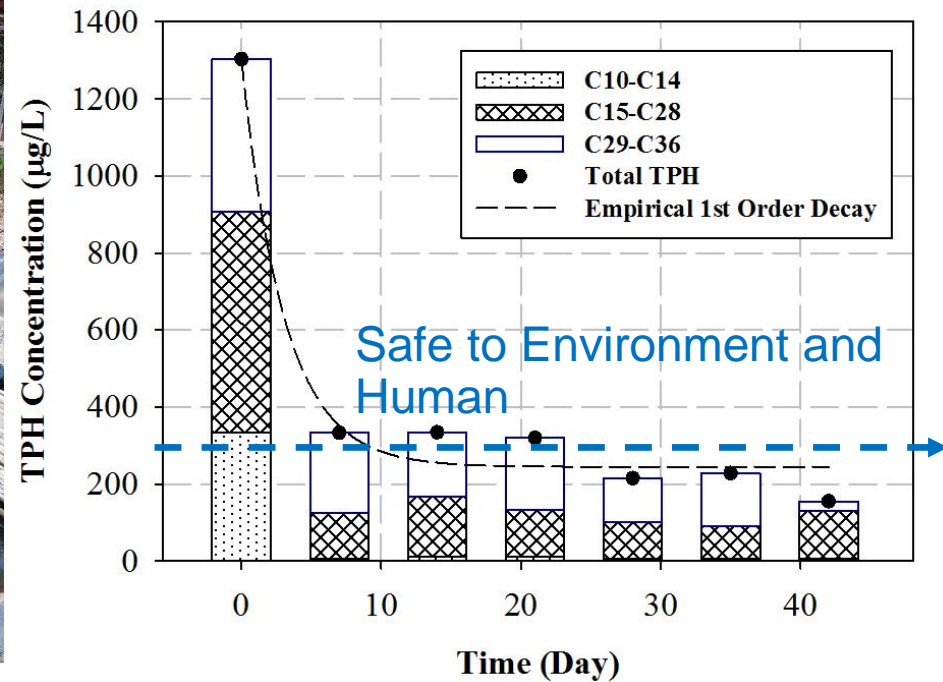


FROM LAB TO LIFE WITH SOCIAL ENGAGEMENT



SUCCESSFUL FIELD-SCALED APPLICATION ALL BY COMMUNITY

Around **50 times** faster than without vetiver



ON-GOING FIELD-SCALED APPLICATION ALL BY COMMUNITY



INSPIRED BY OUR INITIATIVE

- Non-hazardous Industrial contaminated by phenol and PAHs
- Promised with Community to make it better
- Proposed the use of vetiver covering the landfill to prevent dust

Simplicity with beautifully complex mechanisms to live with community sustainably



THANKS FOR YOUR ATTENTION

pomphenrat@gmail.com

