PHYTOREMEDIATION OF ILLEGALLY DUMPED PETROLEUM HYDROCARBON-CONTAMINATED WASTEWATER USING VETIVER (VETIVERIA ZIZANIOIDES (L.) NASH)

Tanapon Phenrat,

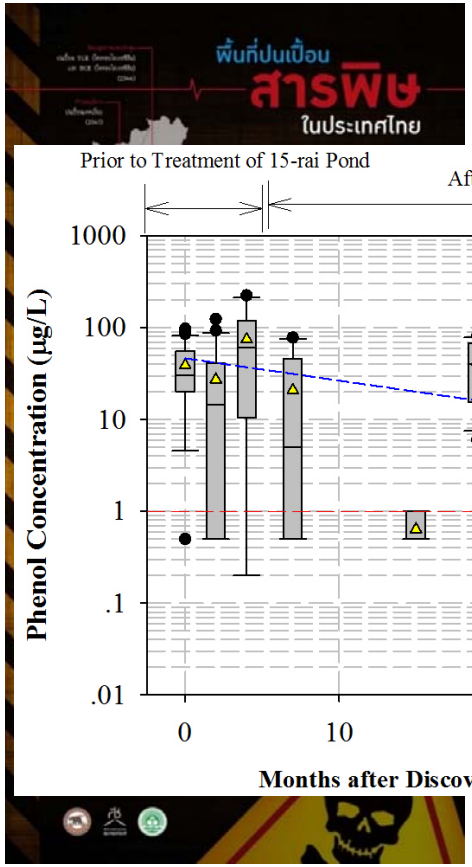
Pimpawat Teeratitayangkul,

Naresuan University

Faculty of Engineering

Thailand

ILLEGAL DUMPING OF PHENOL- AND TPH-CONTAMINATED WASTEWATER



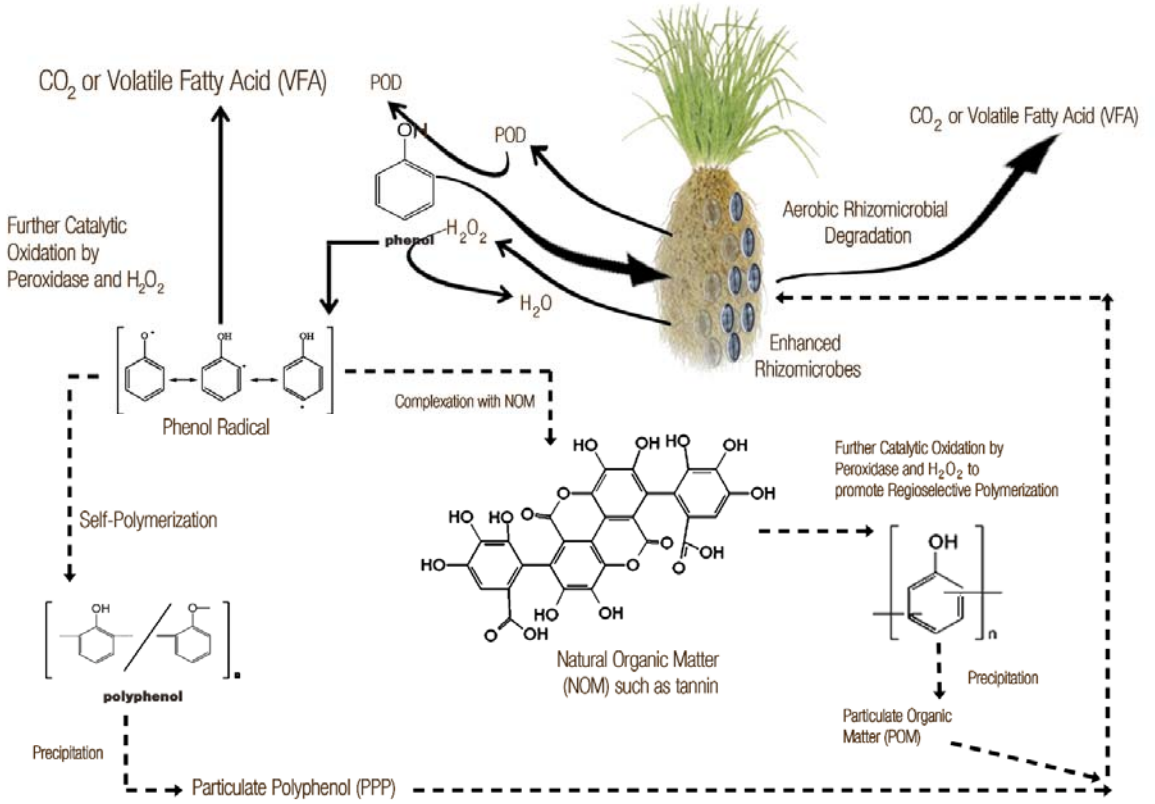
PAST KING BHUMIBOL ADULYADEJ PIONEERED AND CONTINUOUSLY PROMOTED RESEARCH AND APPLICATION OF VETIVER IN THAILAND SINCE 1991

Internationally Recognized

2015
International
Year of Soils

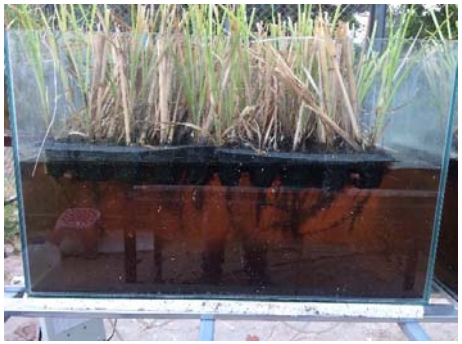
WITH AERATION, VETIVER PLANTLET ON A FLOATING PLATFORM CAN EFFECTIVELY DETOXIFY PHENOL

- Two-Phase Behavior
- Phenol = 500 mg/L
- Phenol = 100 mg/L inhibits microbial growth and activity
- Using aeration alone, it will take 235 days to degrade phenol
- With vetiver plantlet (57% plant coverage), it takes 31 days

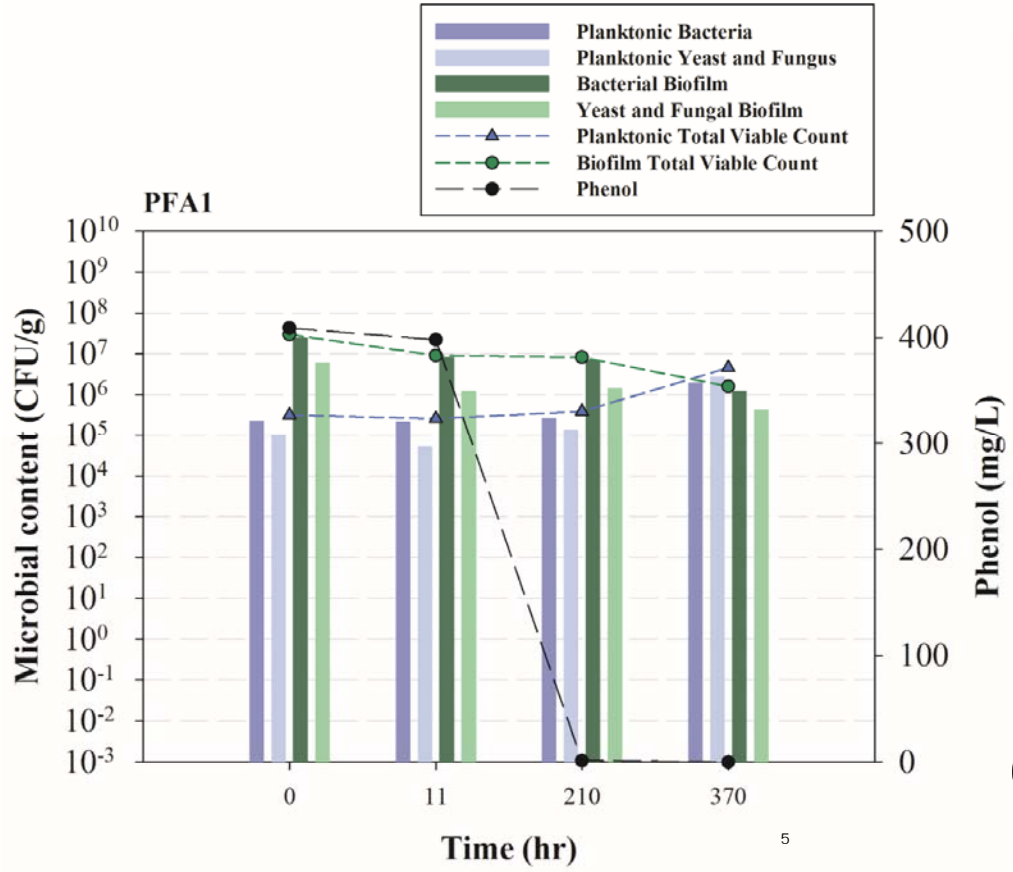


Phenrat, T.; Teeratitayangkul, T.; Prasertsung, I.; Parichatprecha, R.; Jitsangiam, P.; Chomchalow, N.; Wichai, S.(2017). Vetiver Plantlets in Aerated System Degrade Phenol in Illegally Dumped Industrial Wastewater by Phytochemical and Rhizomicrobial Degradation. Environmental Science Pollution Research. Volume 24, Issue 15, pp 13235–13246

WELL-DEVELOPED VETIVER RHIZOSPHERE COATED WITH BIOFILM ENHANCES PHENOL DEGRADATION EVEN MORE

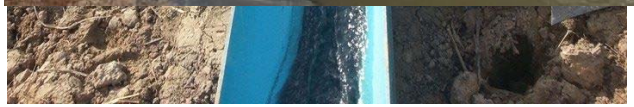


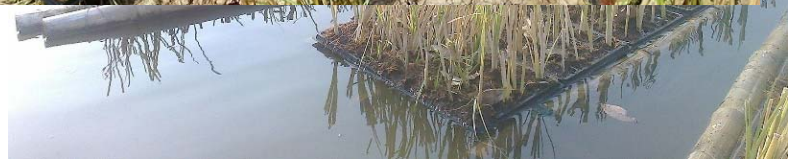
- Two-Phase Behavior
- 2 times faster in Phase I if with biofilm and well-developed rhizosphere
- 5 to 10 times faster in Phase II if if with biofilm and well-developed rhizosphere
- With vetiver +biofilm (57% plant coverage), it takes 7.8 days in comparison to 31 days without biofilm and 235 days without vetiver.



TPH CONTAMINATED WATER AND SEDIMENT: FIELD-SCALED TREATMENT

FROM LAB TO LIFE WITH SOCIAL ENGAGEMENT



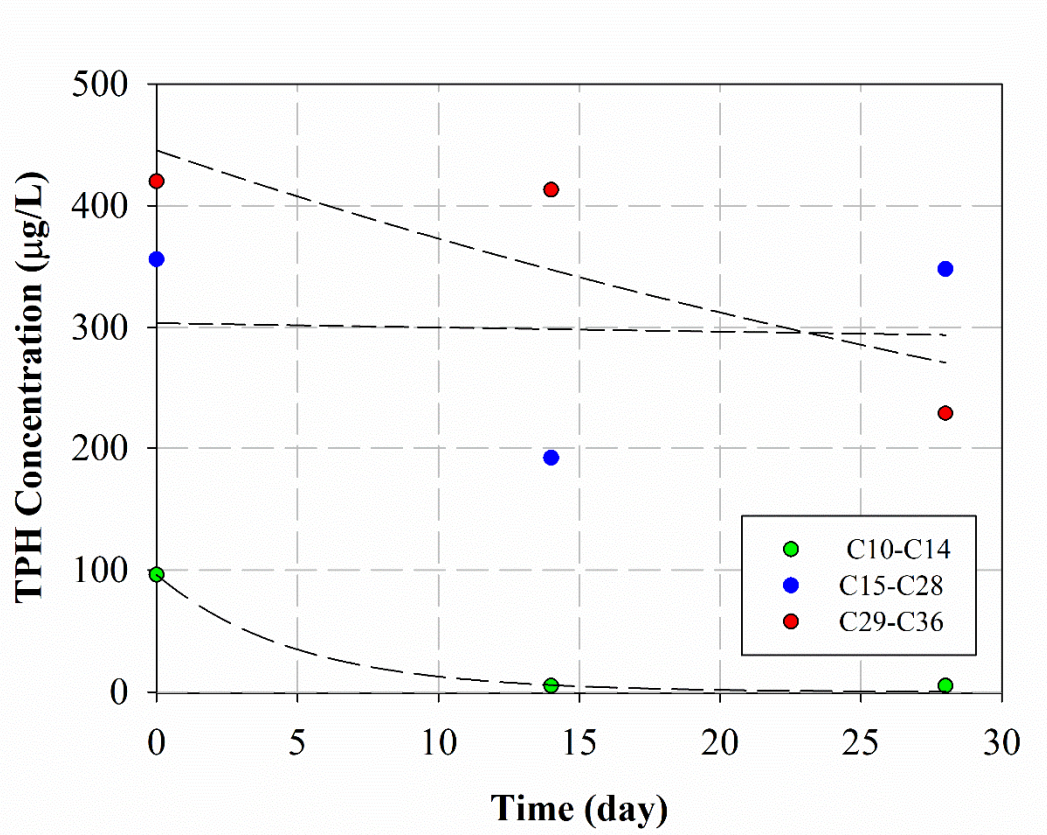


SUCCESSFUL FIELD-SCALED APPLICATION OF WATER TREATMENT ALL BY COMMUNITY

NATURAL ATTENUATION: TPH DEGRADATION IN WATER WITHOUT VETIVER

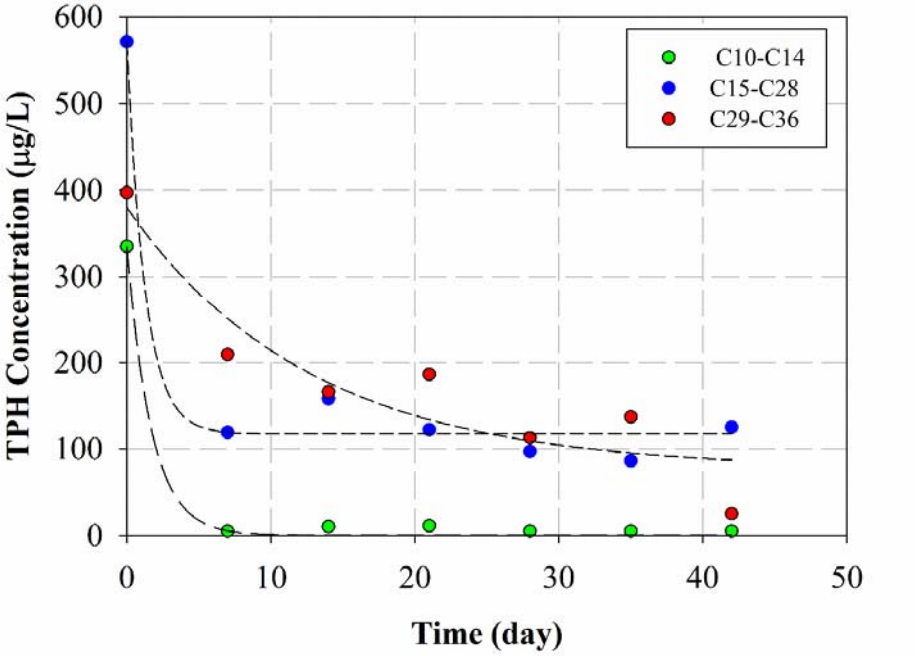
$$TPH_{final} = TPH_{std} + A \exp(-B*t)$$

TPH	A (µg/L)	B Day^{-1}	TPH_{std} (µg/L)	R^2
C10-C14	335	0.204	95.98	0.9960
C15-C28	303	0.0012	0	0.0023
C29-C36	445.55	0.018	0	0.7140
Overall	239	0.159	578	0.9779



PHYTOREMEDIATION: TPH DEGRADATION IN WATER WITH VETIVER

$$TPH_{final} = TPH_{std} + A \exp(-B*t)$$



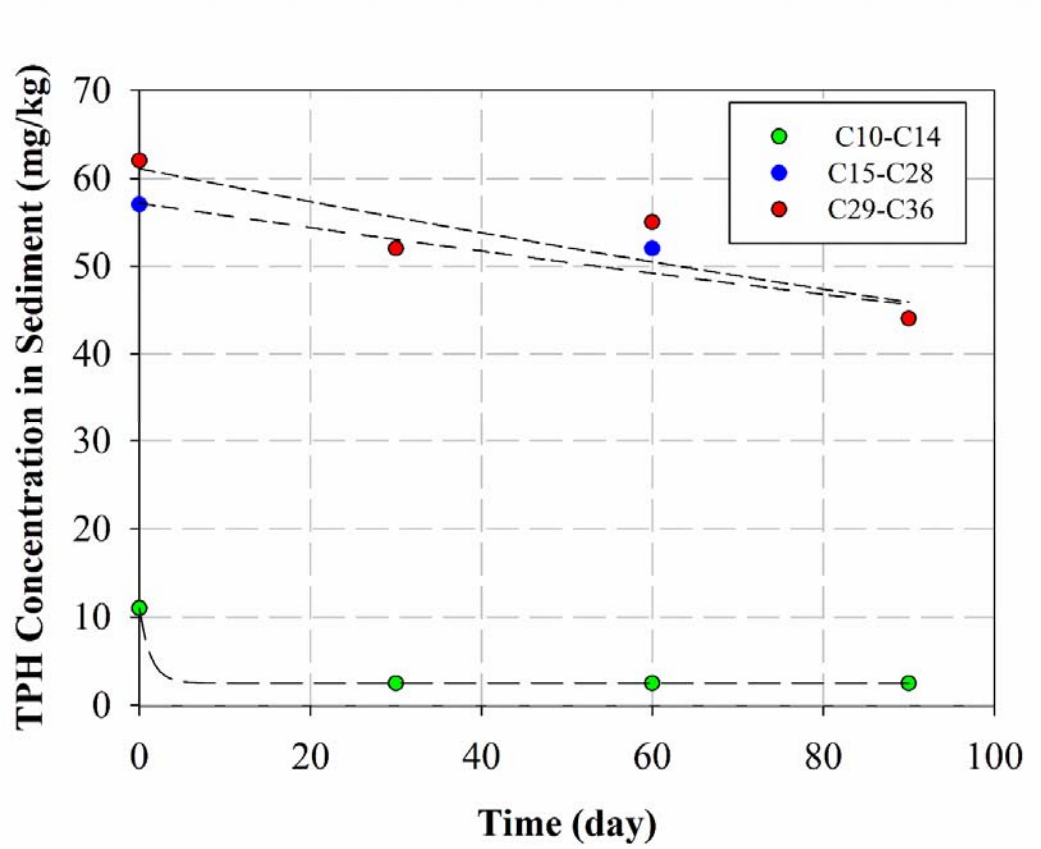
TPH	A (µg/L)	B Day^{-1}	TPH_{std} (µg/L)	R^2	Enhanced Removal Rate Constant
C10-C14	335	0.592	0	0.9968	2.90
C15-C38	453.46	0.791	118	0.9825	659
C29-C36	303.95	0.079	76.25	0.8663	4.38
Overall	1058	0.328	244	0.9779	2.06

FIELD-SCALED APPLICATION FOR SEDIMENT TREATMENT ALL BY COMMUNITY

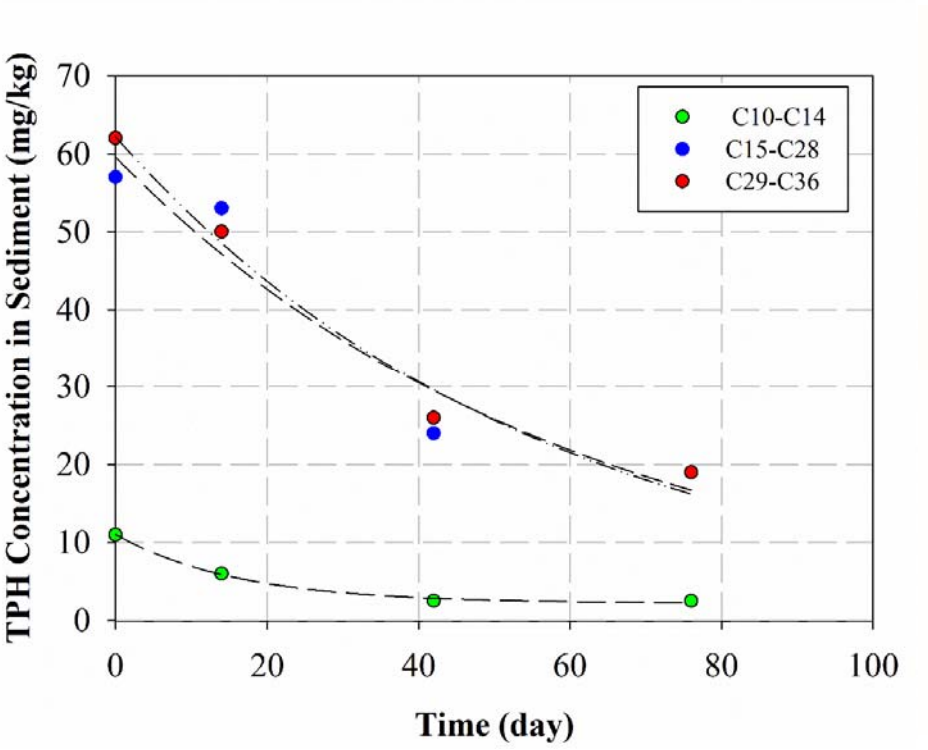
NATURAL ATTENUATION: TPH DEGRADATION IN SEDIMENT WITHOUT VETIVER

$TPH_{final} = TPH_{std} + A \exp(-B*t)$

TPH	A (mg/kg)	B Day^{-1}	TPH_{std} (mg/kg)	R^2
C10-C14	8.5	0.774	2.5	1
C15-C38	57.17	0.0025	0	0.859
C29-C36	61.10	0.0032	0	0.7763
Overall	127.16	0.0036	-	0.8506



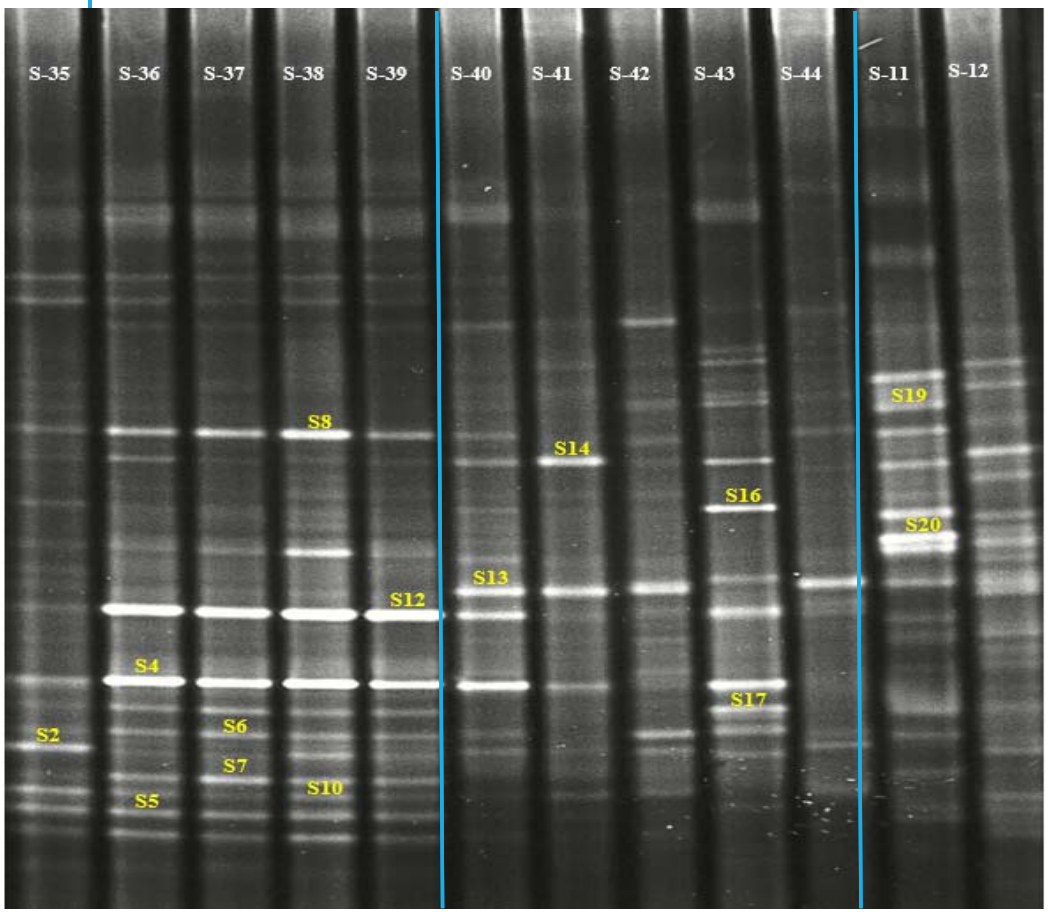
PHYTOREMEDIATION: TPH DEGRADATION IN SEDIMENT WITH VETIVER



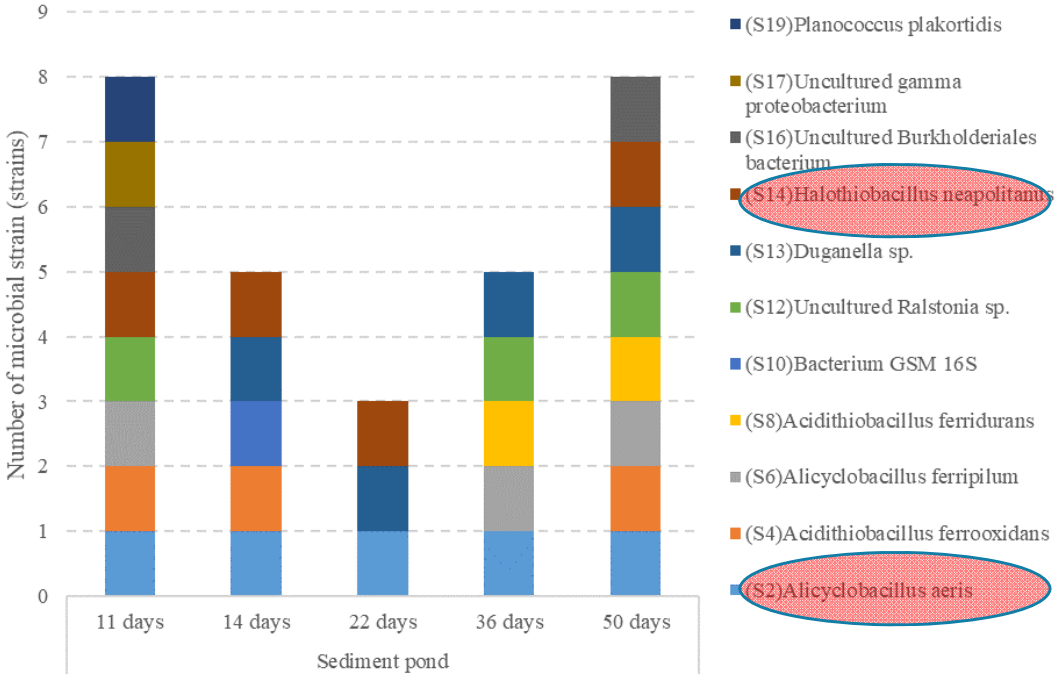
$$TPH_{final} = TPH_{std} + A \exp(-B*t)$$

TPH	A (mg/kg)	B Day^{-1}	TPH_{std} (mg/kg)	R^2	Enhanced Removal Rate Constant
C10-C14	8.83	0.06	2.20	0.9963	-
C15-C38	59.57	0.017	0	0.9825	6.8
C29-C36	62.17	0.018	76.25	0.9831	5.6
Overall	131.89	0.018	0	0.9676	4.95

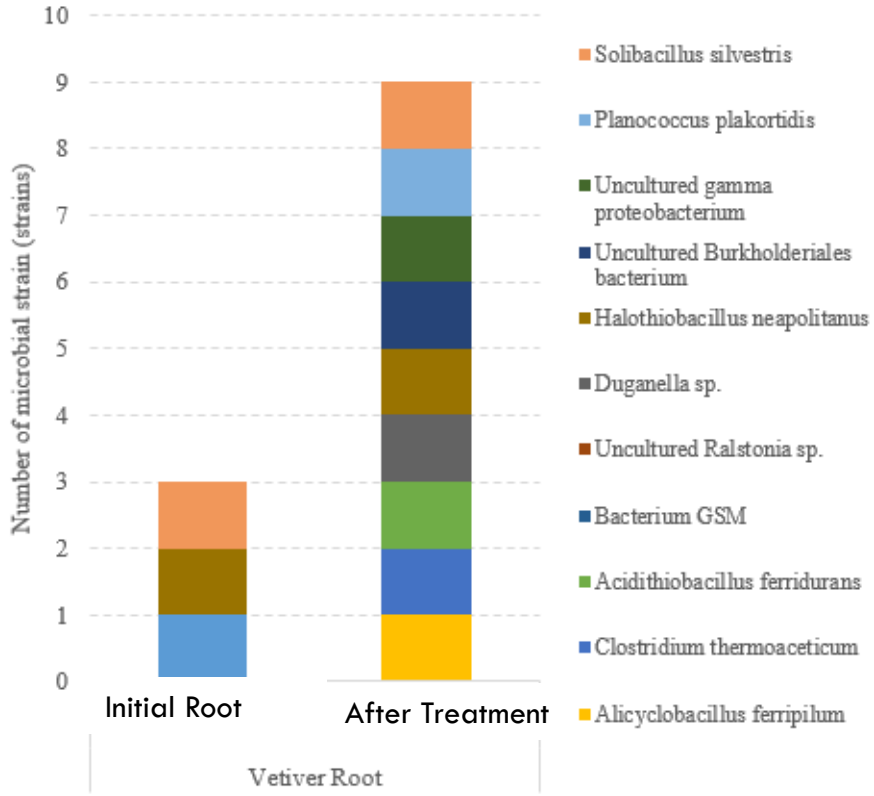
MICROBIAL DIVERSITY IN SEDIMENT

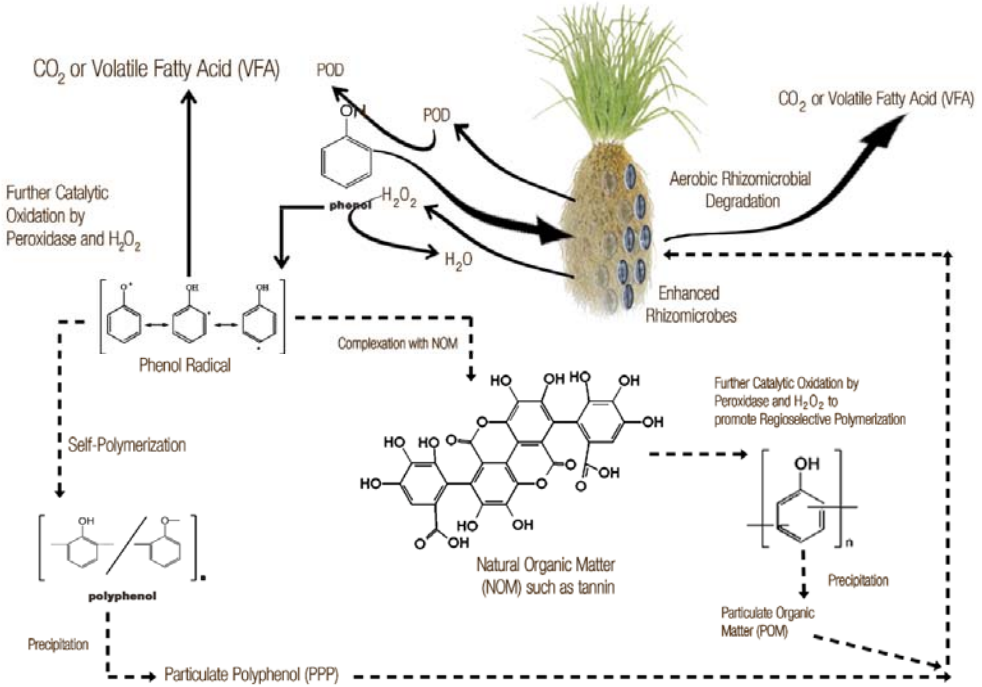


PCR-DGGE: universal primers 5'-CCT ACG GGA GGC AGC AG-3' and 5′-ATT ACC GCG GCT GCT GG-3'



MICROBIAL DIVERSITY ON VETIVER ROOT





Shekoohiyan et al (2016) J Hazard Mater. doi: 10.1016/j.jhazmat.2016.03.081.

Al-Baldawi et al (2015). Ecological Engineering Volume 74, January 2015, Pages 463-473

CONCLUSION

- ✓Natural attenuation alone cannot degrade TPH in contaminated water and soil to the cleanup level in the treatment period.
- ✓Vetiver speeded up TPH degradation to comply with the cleanup levels in both contaminated water and soil.
  - ❖28 days for water.
  - ❖76 days for soil.
- ✓ Presumably, H_2O_2 and POD together with rhizomicrobes enhanced TPH degradation.
- ✓Phytoremediation using Vetiver is easy and can be implemented by affected villagers.

POMPHENRAT@GMAIL.COM