

Degradation of TPHs and PAHs during bioremediation of an aged oil-contaminated soil



17 December 2017

SUMMARY

■ Introduction

- Definition of Soil Pollution and Polycyclic Aromatic Hydrocarbons (PAHs) Pollutant
- Causes/Effects of Soil Contamination by PAHs
- Methods for controlling PAHs contamination

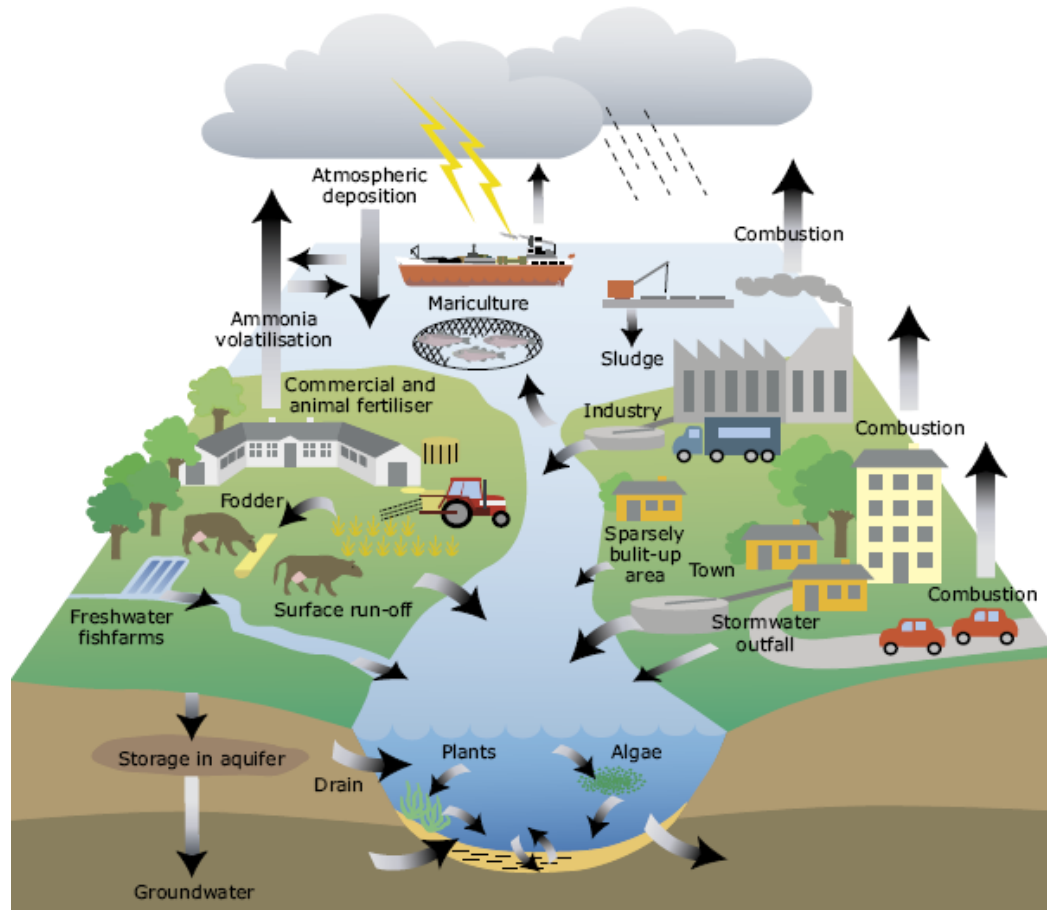
■ Project

- Objectives
- Technical Approach
- Results

Pollution

■ **Pollution Definition:**

Pollution is the introduction of substances into the environment resulting in undesirable changes in physical, chemical or biological characteristics of air, water and soil that harmfully affect the ecosystem (human, animal, plant health)



- **Interest in Soil Pollution:**

Soil is the great connector of life. Without taking proper care for it we can't have good community and life



- **Most Common chemicals involved in soil pollution:**

Petroleum Hydrocarbons (TPH)

Heavy Metals

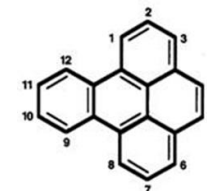
Pesticides

Solvents

Polycyclic Aromatic Hydrocarbons (PAHs)

■ PAHs Definition:

PAHs are group of organic contaminants that are composed of two or more benzene rings formed mainly from the incomplete combustion of hydrocarbons



■ PAHs Characteristics and Toxicity:

- Hydrophobic, ubiquitous, stay in the environment for a long period of time and hard to degrade
- **Effect on Health of Human Being and food safety:** They are classified by the Environmental Protection Agency, the World Health Organization, and the European Union as top priority pollutants. Many PAHs are known as carcinogenic

Carcinogenic potency of 16 EPA Priority PAHs

Pollutant

#	Chemical name	MF	MW	CP
1	Acenaphthene	C ₁₂ H ₁₀	154.2078	-
2	Acenaphthylene	C ₁₂ H ₈	152.1919	-
3	Fluorene	C ₁₃ H ₁₀	166.2185	-
4	Naphthalene	C ₁₀ H ₈	128.1705	-
5	anthracene	C ₁₄ H ₁₀	178.2292	3
6	Fluoranthene	C ₁₆ H ₁₀	202.2506	3
7	Phenanthrene	C ₁₄ H ₁₀	178.2292	3
8	Benzo[a]anthracene	C ₁₈ H ₁₂	228.2879	2B/B2
9	Benzo[b]fluoranthene	C ₂₀ H ₁₂	252.3093	2B/B2
10	Benzo[k]fluoranthene	C ₂₀ H ₁₂	252.3093	2B
11	Chrysene	C ₁₈ H ₁₂	228.2879	3/B2
12	Pyrene	C ₁₆ H ₁₀	202.2506	3
13	Benzo[g,h,i]perylene	C ₂₂ H ₁₂	276.3307	3
14	Benzo[a]pyrene	C ₂₀ H ₁₂	252.3093	2B/B2
15	Dibenzo[a,h]anthracene	C ₂₂ H ₁₄	278.34	2B/B2
16	Indeno[1,2,3-cd]pyrene	C ₂₂ H ₁₂	276.3307	2B/B2

CP: Carcinogenic Potency

B2: probably carcinogenic to humans

2B: possibly carcinogenic to humans

3: Not classified as to human carcinogenicity

Blank: not tested for human carcinogenicity

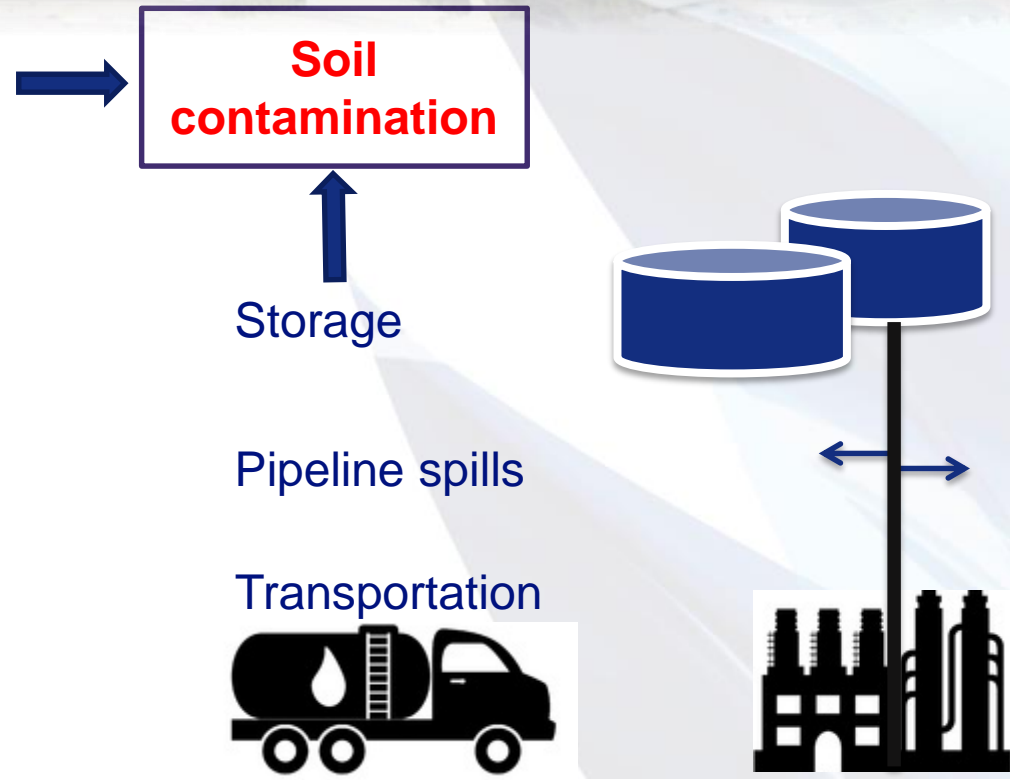
Adopted from, IARC: International Agency for Research on Cancer and US EPA: US Environmental Protection Agency

Source of soil contamination by PAHs in Kuwait

Wars



Oil Refineries



Control of Soil Contamination by PAHs

■ **Methods for PAHs Remediation:**

Biological, physical, chemical or their combination are the proposed approaches to solve this problem without transferring to the future

■ **Bioremediation Versus Physical and Chemical Methods:**

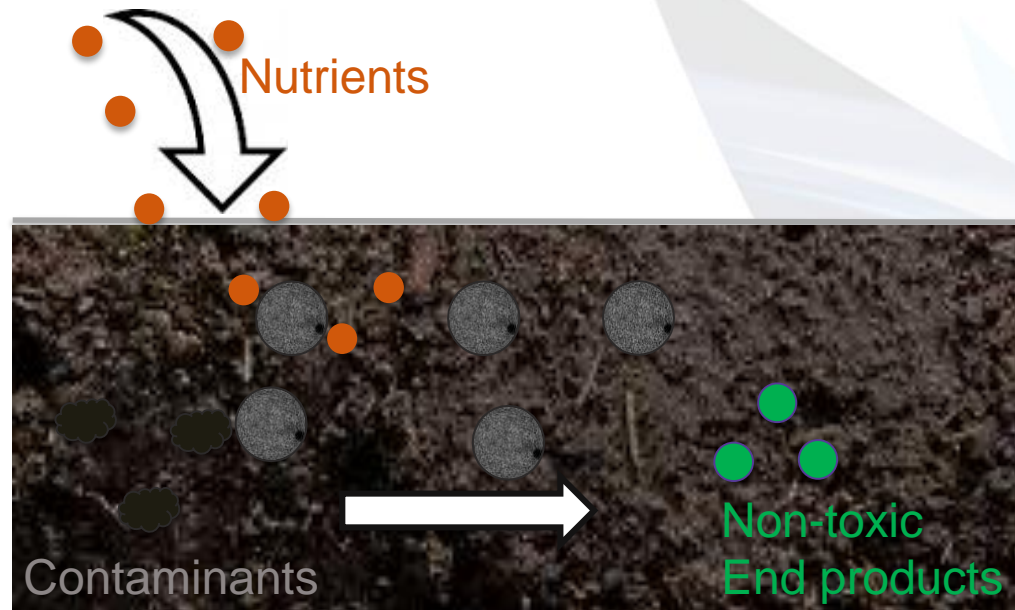
- Eco-friendly technology regarding to its sustainable character (i.e., when successful, is often leads to complete degradation of the pollutant)
- Efficiency and cost-effectiveness particularly for dealing with petroleum hydrocarbon contamination

Bioremediation To Clean-up PAHs in Soil

- **Bioremediation of HMW-PAHs in soil is governed by:**
 - Presence of microbial consortia capable of their degradation
 - Environmental conditions
 - Bioavailability of the contaminant

Bioremediation To Clean-up PAHs in Soil

■ Optimization of Bioremediation Process:



- 1) Improvement of our comprehension of the composition of the functional microorganisms present in the polluted site
- 2) Optimization of the environmental conditions permitting microbial growth and activity

Objectives

- To degrade TPHs and PAHs in oil-contaminated soil in Kuwait through applying bioremediation approach
- To monitor TPHs and PAHs degradation during 9 months of bioremediation

Technical Approach

Soil Collection



KNPC Mina Abdullah refinery

Soil Characterization

Physico-chemical properties
Water content (%)
Water holding capacity (%)
Dry density (g/cm ³)
pH
Conductivity μS/m
Salinity (ppm)
Organic matter content (% db)
Total Carbon (% db)
Total organic Carbon (% db)
Total Nitrogen (% db)
Total Kjeldahl Nitrogen (% db)
Total Phosphorous
TPH Concentration (mg/kg)
16 priority PAHs concentration (mg/kg)



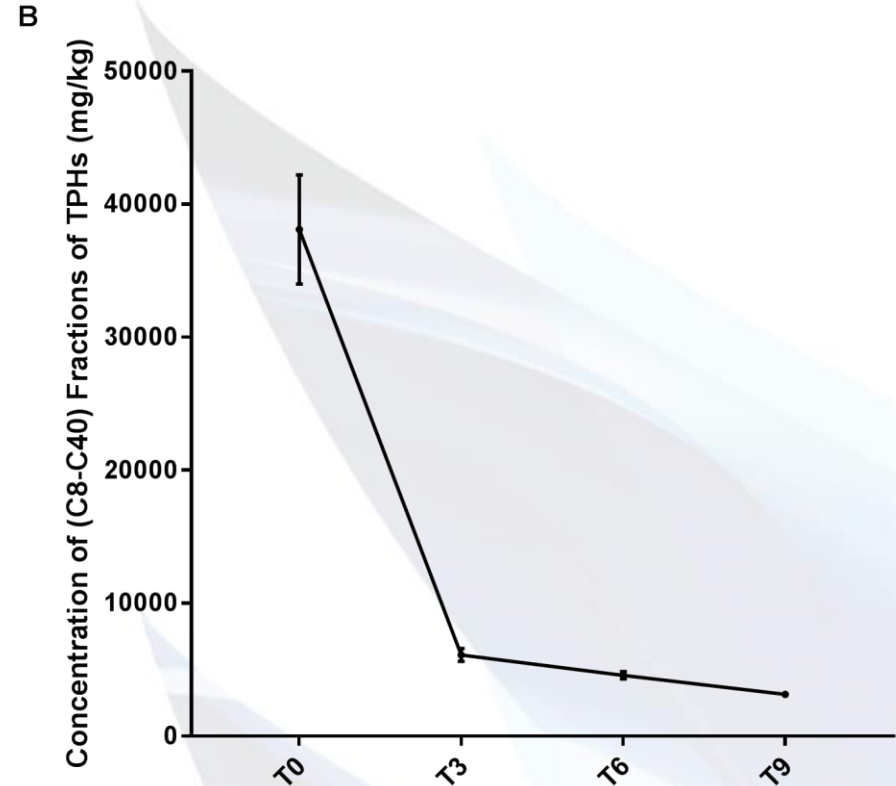
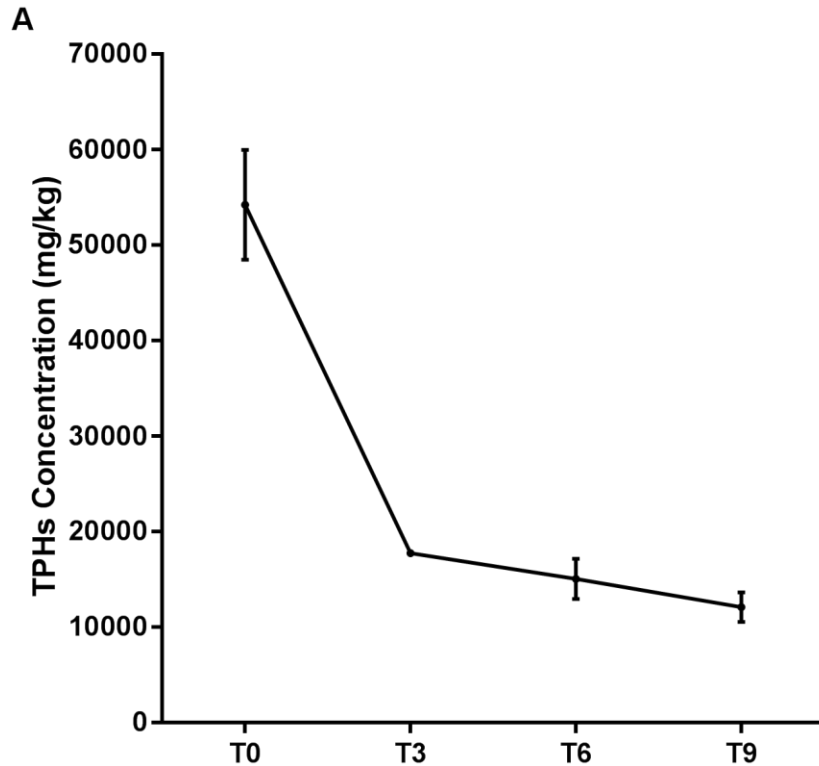
✓ FT-IR spectroscopy



✓ Agilent 6890 (+) gas chromatography (GC-MS)

Results

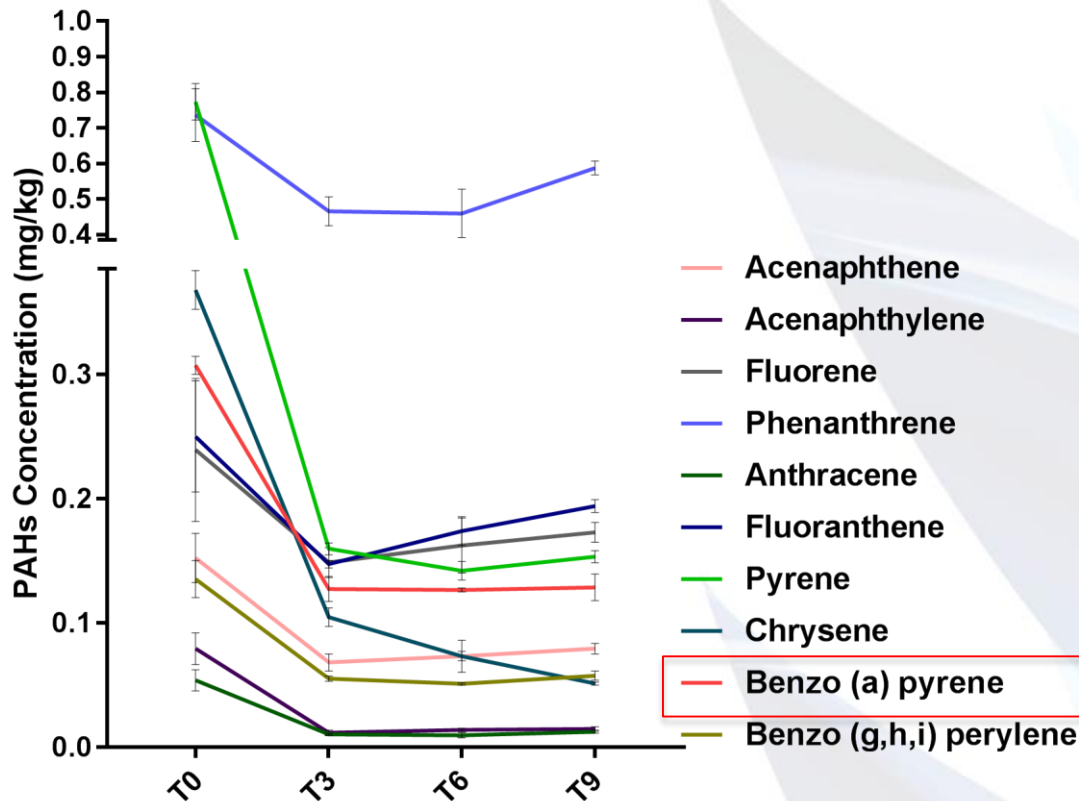
- **Degradation of TPHs and C8-C40 during the bioremediation process of oil-contaminated soil**



TPH concentrations were reduced significantly after 3 months of bioremediation treatment

Results

- Degradation of PAHs during the bioremediation process of oil-contaminated soil



PAH concentrations were reduced significantly after 3 months of bioremediation treatment

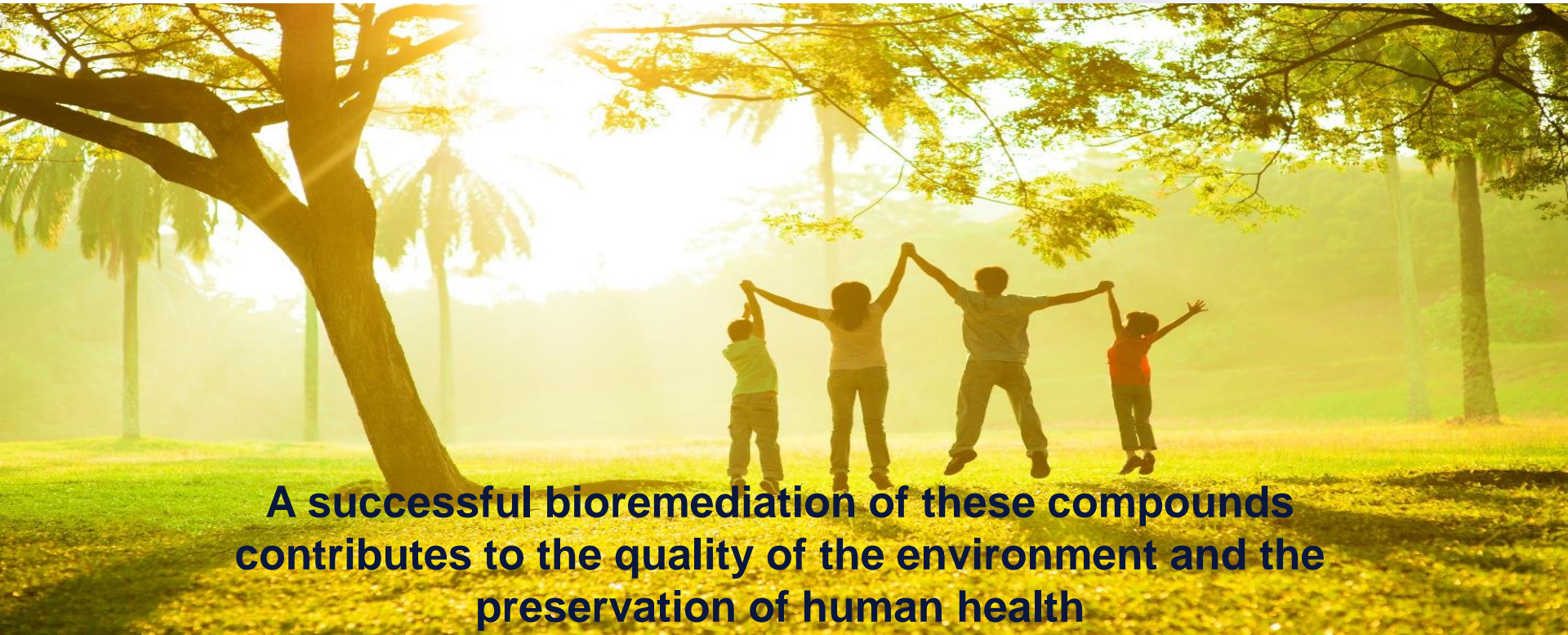
Conclusion

- Bioremediation is an adequate treatment to clean-up the soil contaminated by TPHs and HMW-PAHs
- The concentrations of TPHs decrease significantly after 3 months of bioremediation
- The concentrations of PAHs decrease significantly after 3 months of bioremediation

Benefits to Kuwait

- This study shows that bioremediation is an effective strategy that could be used for bioremediation of oil contaminated soil in Kuwait

Soil contaminations are major environmental issues that require urgent attention in Kuwait. HMW-PAHs in Kuwait environment poses serious risks to human health and affect environmental quality and ecological functions.



A successful bioremediation of these compounds contributes to the quality of the environment and the preservation of human health

Thank you

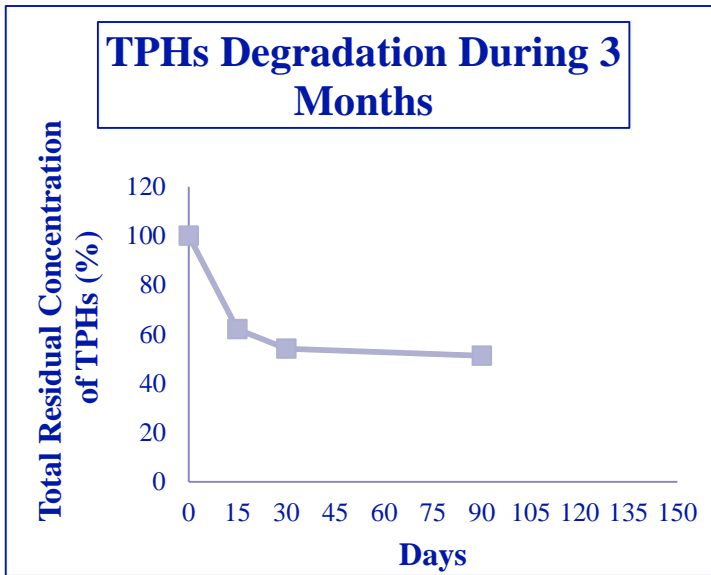


Table 1.2: Standard limiting PAH content ($\mu\text{g kg}^{-1}$) in the soil surface layer (Malawska and Wilkoirski, 2001)

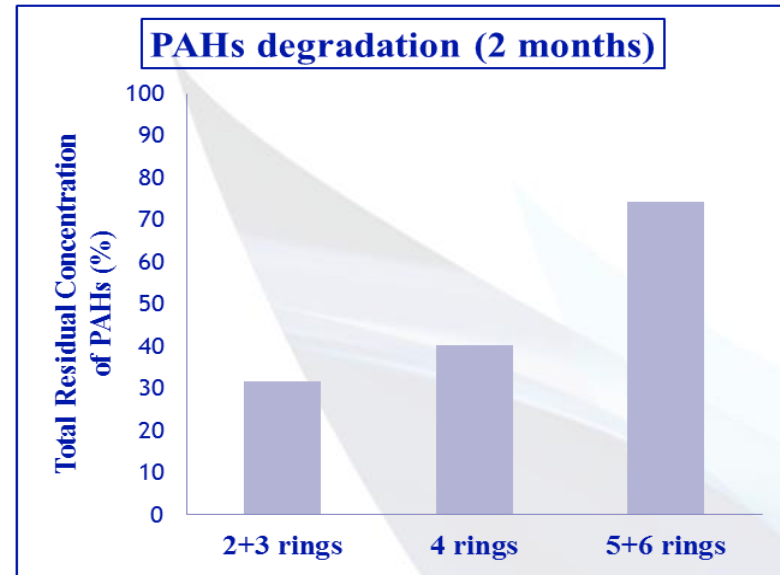
<i>Total PAHs content</i>	<i>Pollution class</i>	<i>Soil assessment</i>
<200	0	Unpolluted (natural content)
200-600	I	Unpolluted (increased content)
600-1000	II	Slightly polluted
1000-5000	III	Polluted
5000-10000	IV	Heavily polluted
>10000	V	Very heavily polluted

Preliminary Data

TPH Degradation During Lab-Scale Bioremediation



HMW-PAHs Degradation During Lab-Scale Bioremediation



Effect of UV-irradiation on TPH Degradation

