• ARTICLE — INTERNATIONAL TRENDS

International Trends

How does the world handle petroleum hydrocarbons? — The current state of regulation, with cases from China and Kuwait

BioRangers

Overview

Contamination of soil and water bodies by petroleum hydrocarbons (PHs) is a serious problem worldwide. Other countries regulate them as pollutants on account of their toxicity, mutagenicity, and carcinogenicity, yet under Japan's environmental laws the only petroleum hydrocarbon regulated is benzene. In Japan, research and specialist literature on "oil contamination" remain very scarce. Here we share insights drawn from overseas literature and actual projects.

Target substances **Petroleum hydrocarbons (PHs / TPH, BTEX, PAHs)**	Regulation in Japan **Benzene only (Soil Contamination Countermeasures Act)**
Other countries **Set standards down to TPH, BTEX, and PAHs**	Featured cases **Remediation projects in China and Kuwait**

Petroleum hydrocarbons	Aliphatic	Alkanes
		Cycloalkanes
		Alkenes
	Aromatic	Monocyclic aromatics (BTEX)
		Polycyclic aromatics (PAHs)

Fig. 1 Classification of petroleum hydrocarbons (aliphatic / aromatic)

Impacts of petroleum hydrocarbons

Petroleum hydrocarbons can accumulate in the human body through vegetation and the food chain, potentially causing health risks. Total petroleum hydrocarbons (TPHs), composed of hundreds of PHs such as diesel, gasoline, and lubricating oil, include substances of high toxicity, mutagenicity, and carcinogenicity, and their toxicity increases as molecular weight rises.

Effects on humans: abnormalities of the blood-forming organs, liver, kidneys, and lungs; changes in cognitive function; psychological problems; disorders of the reproductive and respiratory systems; and cancer

Benzene has been identified as a causative agent of human leukemia

The US EPA classifies seven PAHs (such as benzo(a)pyrene) as probable human carcinogens

Toxicity to ecosystems stems from a substance's water solubility and bioavailability. Hydrophilic PHs are readily adsorbed and absorbed by organisms, causing sublethal effects (lesions, developmental disorders, behavioral changes, etc.) or death. Even hydrophobic, non-bioavailable PHs become available to benthic organisms (invertebrates, fish, and fish eggs) once they adsorb onto fine particles and sediments.

• Regulations

Regulation abroad and in Japan

In the United States, Canada, New Zealand, the Netherlands, Australia, and elsewhere, the assessment and management of sites contaminated by petroleum hydrocarbons is treated as a key priority, and standards are set not only for TPH but for BTEX and PAHs as well. Japan, by contrast, has "Guidelines for Oil Contamination Countermeasures," but these mainly address effects on the living environment such as oil odour and oil sheen, and set no standards for TPH or PAHs (benzene is regulated under the Soil Contamination Countermeasures Act, while toluene, ethylbenzene, and xylene are not covered).

Substance	Canada	NZ	Netherlands	US	Australia	China	Taiwan	Japan
TPH	○	○	by carbon number	○	○	○	○	
Benzene	○	○		○	○	○	○	○
Toluene	○	○		○	○	○	○	
Ethylbenzene	○	○		○	○	○	○	
Xylene	○	○		○	○	○	○	
Acenaphthene	○			set per state				
Acenaphthylene	○							
Anthracene	○					○		
Benzo(a)anthracene	○					○		
Benzo(b)fluoranthene								
Benzo(b+j)fluoranthene	○					○		
Benzo(k)fluoranthene	○							
Benzo(g,h,i)perylene								
Benzo(a)pyrene	○	○			○	○		
Chrysene	○					○		
Dibenzo(a,h)anthracene	○					○		
Fluoranthene	○							
Fluorene	○							
Indeno(1,2,3-cd)pyrene	○					○		
Naphthalene	○				○	○	○	
Phenanthrene	○							
Pyrene	○							
Total PAHs					○			

Table 1 Regulatory status of petroleum hydrocarbons by country (○: regulated substance. The Netherlands regulates by carbon number; US PAHs are set per state.)

Springer's "Total Petroleum Hydrocarbons: Environmental Fate, Toxicity, and Remediation" notes that, building on the frameworks of Western nations, developing countries such as China, India, Japan, and South Korea can likewise create new regulatory frameworks. Indeed, in January 2019 China enacted its "Soil Pollution Prevention and Control Law," establishing a framework on par with those of Western nations.

- China & Kuwait

Cases in China and Kuwait

Together with local companies, we work overseas as well—including in China and Taiwan—to remediate soil, groundwater, and marine contamination caused by petroleum hydrocarbons.

China: This case dates from when we were exploring joint research with the Jilin Academy of Agricultural Sciences. The black-soil belt of the northeastern region is one of the world's three great black-soil belts and accounts for about a quarter of China's grain output. As the world's sixth-largest oil producer, China is home to the Daqing, Shengli, and Liaohe oil fields, and petroleum-contaminated soil—from landed crude oil, oil sludge, and oil-extraction waste—has become a problem in the farmland around these fields. The TPH remediation standards were 800 (826) mg/kg for construction land and 500 mg/kg for agricultural land. Against Japan's 26 designated soil-contamination substances, China has 85 items, and whereas Japan's analytical method is based on leachate concentration, China's is based on content concentration.

Kuwait: During the Gulf crisis of 1990–91, oil wells were destroyed, causing severe damage across 114 km² and forming enormous oil lakes. In 2005 the United Nations Compensation Commission (UNCC) funded a remediation program, and under the Kuwait Environmental Remediation Program (KERP) the remediation of an estimated 26 million m³ of oil-contaminated soil was approved. In 2021—thirty years after the war—remediation of five projects in northern and southern Kuwait (13 million m³) was awarded, with three further projects in southern Kuwait (8.35 million m³) due to be awarded.

Three points stand out in the Kuwait case: (1) The remediation technology was selected by TPH concentration measured via hexane-extractable matter (1–5% by bioremediation, 5–7% by bioremediation plus other technologies, 7–10% by other technologies, and over 10% left untreated). (2) It was bundled with revegetation and ecosystem restoration, with more than 8.6 million native trees planted over three years. (3) The remediation standard was revised from an initial TPH of 0.5% to TPH 1.0% in light of an ecological risk assessment. This reduced the volume of target soil by about 1.45 million m³, shortening the schedule and cutting costs.

• Conclusion

In closing

Soil is not the property of landowners alone; it is a shared resource of the entire planet. A single spoonful (about 1 g) of soil contains roughly 1–10 billion microorganisms, which drive the carbon, nitrogen, and phosphorus cycles and sustain life on Earth. Other countries are advancing legislation that protects human health and ecosystems in equal measure. Should Japan, too, not take seriously the effects of petroleum hydrocarbons on human health and ecosystems, and commit itself to conserving its ecosystems and soil?

Reference: Saranya Kuppusamy, Naga Raju Maddela, Mallavarapu Megharaj, Kadiyala Venkateswarlu (2020) Total Petroleum Hydrocarbons: Environmental Fate, Toxicity, and Remediation. Springer