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Soil and groundwater environmental standards across Asian countries and a PAHs degradation test example

The expanding Asian soil and groundwater contamination market, and responding to polycyclic aromatic hydrocarbons (PAHs) as regulation advances

BioRangers

• Overview

Overview

As Asia's economies develop, soil and groundwater contamination has come to the surface, and countries are advancing their legal frameworks. Japan's environmentally regulated substances are extremely few compared with other Asian countries, and the regulation of petroleum-derived substances in particular is thin. This article introduces a test example in which PAHs (polycyclic aromatic hydrocarbons), now increasingly regulated, were degraded with our multi-microbial agent Oppenheimer Formula™.

Theme **Asian soil and groundwater environmental standards and PAHs**	Substance of interest **PAHs (polycyclic aromatic hydrocarbons)**
Agent used **Oppenheimer Formula™**	Test examples **PAHs in diesel oil / comparison of 3 agents**

• Asian markets

Legal frameworks and market growth in Asian countries

In South Korea the Soil Environment Conservation Act took effect in 1995, in Taiwan the Soil and Groundwater Pollution Remediation Act in 2000, and in Japan the Soil Contamination Countermeasures Act in 2003. In 2016 a Ministry of Industry regulation was enacted in Thailand, and in China — which faces serious contamination — the "Soil Ten Plan" was promulgated. China's market is said to far exceed Japan's, and the Asian remediation market is expected to expand rapidly going forward.

The number of regulated substances in Japan is extremely small compared with other Asian countries (excluding South Korea), and it also differs greatly in that soil environmental standards are defined by "leaching amount" rather than "content amount." Whether Japanese companies, facing many unknown substances, can fully respond in terms of investigation, analysis and remediation is a challenge.

- **About PAHs**

What are PAHs

Overseas, standards are set not only for TPH (total petroleum hydrocarbons) but also for BTEX (benzene, toluene, ethylbenzene, xylene) and even PAHs. In Japan, by contrast, the oil contamination countermeasure guidelines focus mainly on oil odour and oil sheen, and there are no standards for TPH or PAHs (only benzene is regulated under the Soil Contamination Countermeasures Act).

PAHs (polycyclic aromatic hydrocarbons) are a general term for hydrocarbons in which aromatic rings are fused, comprising more than 100 chemical substances. They are lipophilic, poorly soluble in water and readily adsorb onto soil, with non-volatile properties; several have been confirmed to be carcinogenic, mutagenic and teratogenic. They are contained in oil, coal and tar sediments, and also arise as by-products of the combustion of fossil fuels and biomass fuels.

• Test 1

Degradation test example 1: Degradation of PAHs in diesel oil

Targeting the PAHs contained in diesel oil, an aqueous degradation test was carried out using the multi-microbial consortium agent Oppenheimer Formula™ (test period 24 hours). The combined concentration of the 16 compounds was reduced from 1,307,265 mg/L to 284,965 mg/L, showing an overall reduction rate of 78.20%.

Compound	Initial concentration (mg/L)	Post-treatment concentration (mg/L)	Reduction rate (%)
Acenaphthene	69,891	4,736	93.22
Acenaphthylene	11,327	67	99.41
Anthracene	4,687	1,159	75.27
Benzo(a)anthracene	28,189	6,204	77.99
Benzo(b)fluoranthene	5,105	8	99.84
Benzo(k)fluoranthene	10,282	303	97.05
Benzo(g,h,i)perylene	5,332	121	97.73
Benzo(a)pyrene	8,722	346	96.03
Chrysene	74,245	4,619	93.78
Dibenzo(a,h)anthracene	8,279	2,166	73.84
Fluoranthene	674,730	132,581	80.35
Fluorene	96,801	6,160	93.64
Indeno(1,2,3-c,d)pyrene	22,433	6,306	71.89
Naphthalene	54,088	2,991	94.47
Phenanthrene	197,875	110,153	44.33
Pyrene	35,279	7,045	80.00
Total	1,307,265	284,965	78.20

Table 1 PAHs analysis results (source: Oppenheimer Biotechnology, Inc.)

• Test 2

Degradation test example 2: PAHs degradation by each microbial agent

Three microbial agents (FR, FC, TE) and a control (CK) were compared in water, and the reduction rate of each PAH compound over 15 days was measured. Compared with the control, the microbial agents showed a high reduction rate for every compound, acting effectively even on the high-molecular-weight PAHs with a greater number of rings (the number at the end of each compound name indicates the number of rings).

PAH compound	FR	FC	TE	CK
Acenaphthylene(3)	45.4	50.2	49.9	19.1
Fluorene(3)	23.1	43.5	22.5	2.6
Phenanthrene(3)	29.6	19.6	21.7	3.9
Anthracene(3)	48.1	56.5	44.2	30.0
Pyrene(3)	65.3	50.2	28.8	6.7
Benzo(a)anthracene(4)	81.4	63.2	49.4	18.1
Chrysene(4)	78.9	69.7	50.6	11.7
Benzo(b)fluoranthene(4)	88.5	82.8	66.8	18.1
Benzo(k)fluoranthene(5)	86.7	79.8	58.6	2.2
Benzo(a)pyrene(5)	87.9	81.5	67.8	24.4
Dibenzo(ah)anthracene(5)	83.6	76.8	54.7	-0.8
Benzo(ghi)perylene(6)	85.2	79.0	57.5	6.4
Indeno(1,2,3-cd)pyrene(6)	89.6	85.4	80.1	-0.8

Table 2 Reduction rate of each PAH compound by three microbial agents (unit: %; the figure in parentheses is the number of rings)

Reference: Wang Xiaoju, Sugizaki Mitsuo, Hosono Shigeo (2010), "Research on the remediation of soil contaminated with persistent hazardous chemical substances through the application of bioremediation technology," Bulletin of the Center for Environmental Science in Saitama, No. 5, 135–140.