

Remediating Oil-Contaminated Soil with Bioremediation

From the boring survey to the remediation plan and treatability test, then four remediation methods and monitoring

Overview

Bioremediation is a soil-remediation method in which microbes break down oil. Its advantages are a low environmental burden and the ability to clean up contamination without demolishing buildings. This article explains the sequence from investigating the contamination through carrying out the remediation, as well as the representative remediation methods, which differ according to how the microbes are delivered.

Target oil contamination of soil	Sequence boring survey → remediation plan → test → remediation → monitoring
Main methods landfarming / in-situ mixing / rod injection / well injection	Completion criterion oil (TPH) concentration reaches the target value

Boring survey and remediation plan

Once an oil leak is found, a boring survey is used to confirm whether the contamination is limited to the surface layer, whether it has reached the groundwater, and whether it has spread underground. A dedicated machine bores a hole from the ground surface to collect soil, and the oil content is analyzed to determine the extent of contamination. As a rule, the site is divided into unit blocks of 10 m square, and samples are taken at the center of each block. The boring depth is decided with reference to the volume of leaked oil and the soil type, geological strata, and presence of clay layers from past surveys.

Based on the survey report, the optimal remediation method is determined from the soil type, the spread of contamination, the presence of buildings, the budget, the handover date, and whether the groundwater is contaminated. When bioremediation is adopted, the dosage of the agent, the injection interval, and the injection method are set at this stage. Clients most often consult us once this survey report is available, and we prepare our estimate based on the report.

- **Treatability test**

Treatability test

Whether remediation is feasible depends on site-specific conditions such as the oil type, oil concentration, and soil type. We therefore ask the client to send us the oil-contaminated soil and run a test to confirm the remediation effect in advance. The test takes roughly one week to one month. Once we judge that remediation is feasible, we begin preparations for remediation at the site.

- **Surface methods**

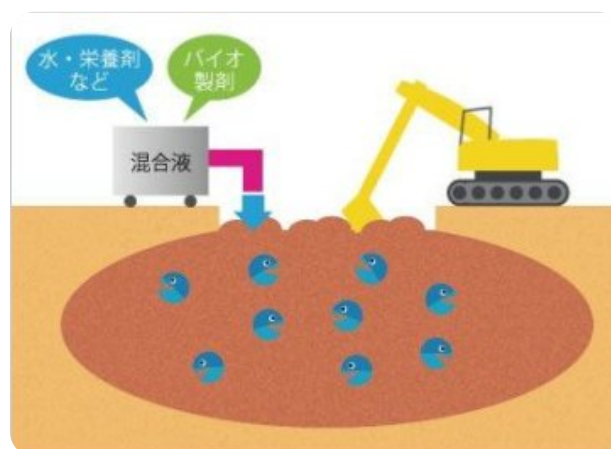
Methods for shallow contamination: landfarming / in-situ mixing

Landfarming is a method in which the contaminated soil is excavated, piled up in one place, and mixed by spraying it with the microbial mixture. Because the soil can be handled at any time, oil odour and oil sheen are easy to check and oil concentration is easy to analyze, making progress easy to track. It is important to water and stir the soil regularly so that it does not dry out, keeping the moisture in contact with the microbes and the oil — and this is the method we recommend most. However, because the soil must be excavated, it cannot be applied where buildings are present, and a temporary storage area is also required.

In-situ mixing is a method in which the contaminated soil is not excavated but is mixed with the microbial mixture in place using a backhoe or a soil-improvement column machine. It can be applied to the depth the bucket can reach, and because no excavation is needed there is no concern about secondary oil contamination. As with landfarming, it cannot address contamination beneath buildings.



Landfarming: excavated soil is piled up and stirred to mix it



In-situ mixing: mixed with the microbial mixture in place

Monitoring

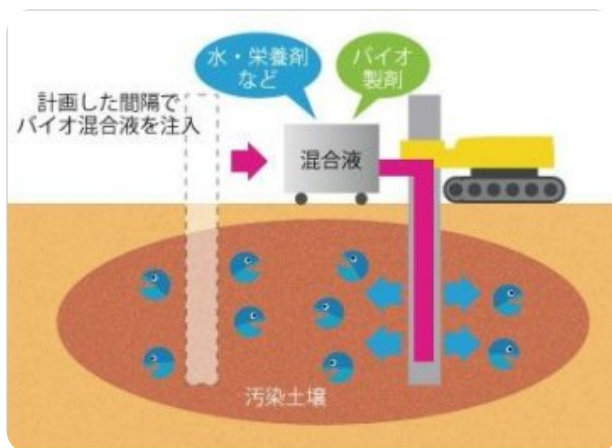
With landfarming and in-situ mixing, soil is sampled to monitor the progress of remediation. The items measured include oil (TPH) concentration, oil odour and oil sheen, moisture content, pH, nitrogen and phosphorus concentrations, and total microbial count. Nitrogen and phosphorus are nutrients the microbes need to break down the oil; when they run short relative to the remaining oil, a nutrient agent is added. The frequency is once every one to two weeks at first, and thereafter about one to two times per month. Remediation is complete once the oil concentration reaches the target value.

Methods for deep contamination: rod injection / well injection

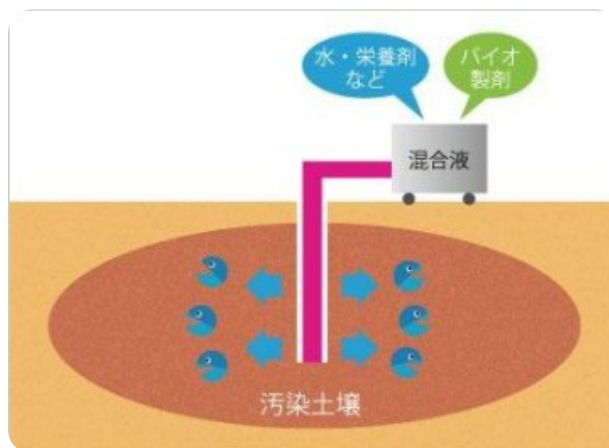
Rod injection (direct push) is used to remediate deep soil that landfarming and in-situ mixing struggle to reach, and it is the method we turn to next after landfarming. A boring machine inserts a rod into the ground, and the microbial mixture is injected at each depth as the rod is withdrawn. The injection interval varies with the soil type; in soil with poor permeability, more than 40 rods may be needed within a 10 m square.

After injection, bioventing is sometimes carried out to accelerate decomposition. Because the microbes used are aerobic and require oxygen, a solid (non-perforated) pipe is inserted into the injection hole and a blower exhausts the underground gas to introduce oxygen. Once the oil odour of the exhaust gas disappears and the measurements reach the expected values, soil is sampled again by boring; if the oil concentration is below the target value, remediation is complete.

Well injection is a method in which a well of about $\phi 50\text{mm}$ is installed and the microbial mixture is injected. There are two approaches: gravity infiltration, in which the mixture seeps in slowly from above under the natural pressure of the elevation difference, and pressure injection, in which the well is capped and pressure is applied.



Rod injection (direct push): injected at each depth



Well injection: the microbial mixture is injected from the well and made to infiltrate