Current State and Future Prospects of Countermeasures to Soil Contamination

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1 Introduction

Soil contamination is one of the seven major forms of pollution. The seven major forms of pollution are listed in the Basic Environment Law and consist of air pollution, water pollution, soil contamination, noise, vibration, ground subsidence, and offensive odors. In the case of air pollution and water pollution, contaminants are diluted as they diffuse through the air or water, and as such, certain improvements can be achieved by regulating the emissions of contaminants. In contrast, contaminated soil is unlikely to be diluted. Even if contaminating substances are found and the emission of such substances is stopped, the soil condition will not improve on its own and the soil will remain contaminated.

The Soil Contamination Countermeasures Act (hereinafter referred to as “the Act”) was enacted in 2002 to reduce the risk of soil contamination. In addition, the Third Basic Environment Plan[1] established in 2006 set a policy of preventing soil contamination, cleaning up contaminated soil, and maintaining a healthy soil environment. The plan considers it essential to take into full consideration that pollution crosses boundaries between soil, air, and water, and that human activities are the cause of environmental pollution. This is because there are concerns that contamination in soil may lead to air and water pollution.

In 2002, this Quarterly Review[2] published a report that covered the state of soil contamination, remediation technology, and a comparison of systems to combat soil contamination between Japan, the United States, and Europe. After the report was published, the Soil Contamination Countermeasures Act (which was still undeveloped in 2002) was established. In addition, many old factory sites have recently been converted into sites for other uses, soil contamination problems have been attracting closer attention, and the significance of combating soil contamination has been discussed more regularly. This report covers trends in technology and current issues that have emerged since the above-mentioned report was published.

2 Development and Current State of Laws and Regulations Surrounding Soil Contamination

2-1 Development of Laws and Regulations Surrounding Soil Contamination

As Table 1 shows, several laws relating to soil contamination have been established. Among them, the Water Pollution Control Law was the first one to be enacted in order to regulate factories’ and other establishments’ discharge of substances that may harm human health into public water areas. The law is significant in terms of the quality management of groundwater, a valuable life resource. It was much later (during the 1990s) that soil contamination was defined for the first time as pollution in the Basic Environment Law. In 2002, the Soil Contamination Countermeasures Act was established, and it prescribes the prevention of further soil contamination. Most laws concerning action against pollution were enacted when health problems caused by pollution became visible and were recognized as social problems. In contrast, the Act was characteristically enacted in order to create social rules to respond to potential health risks associated with soil contamination.[3]

To prevent the general public from entering soil-contaminated sites and to prevent human health hazards, the Soil Contamination Countermeasures

Table 1 : Laws relating to soil contamination

Name	Issued on	Contents related to soil contamination
Water Pollution Control Law	Dec. 1970	The law prescribes the continuous monitoring of groundwater conditions, restrictions on permeation of harmful substances into groundwater, cleanup of contaminated groundwater, etc. The law restricts the discharge of effluent from factories, and thus, construction in soil-contaminated areas requires special attention. Prefectures may establish more stringent standards than the national effluent standards as well as revise the standards by adding items.
Agricultural Land Soil Pollution Prevention Law	Dec. 1970	If agricultural land is contaminated by specific harmful substances (cadmium, copper, and arsenic), the land may be designated as an agricultural land soil pollution policy area, and if so, a policy for agricultural land soil pollution shall be established and projects to tackle the pollution shall be conducted accordingly.
Basic Environment Law	Nov. 1993	The law prescribes that the Government of Japan shall establish environmental quality standards (relating to soil contamination and groundwater pollution), the maintenance of which is desirable to protect human health and conserve the living environment.
Law Concerning Special Measures against Dioxins	Jul. 1999	The law prescribes that the Government of Japan shall establish environmental quality standards concerning dioxins in air, water, bottom sediment, and soil. The environmental standard for soil is 1,000 pg-TEQ/g or less. The index value for investigation is 250 pg-TEQ/g (the concentration level requiring a soil investigation).
Soil Contamination Countermeasures Act	May 2002	The act prescribes designated hazardous substances, soil contamination investigation, the designation of designated areas, prevention of health damage due to soil contamination, designated investigation institutions, designated support corporations, etc.

Prepared by STFC based on Reference[4]

Table 2 : Designated hazardous substances prescribed in the Soil Contamination Countermeasures Act

First-class designated hazardous substances (volatile organic compounds, 11 substances)	Second-class designated hazardous substances (heavy metals, etc., 9 substances)	Third-class designated hazardous substances (agricultural chemicals, 5 substances)
Carbon tetrachloride	Cadmium and its compounds	Simazine
1,2-Dichloroethane	Hexavalent chromium compounds	Thiobencarb
1,1-Dichloroethylene	Cyanogen compounds	Thiuram
cis-1,2-Dichloroethylene	Mercury and its compounds	PCB
1,3-Dichloropropene	Selenium and its compounds	Organic phosphorus compound
Dichloromethane	Lead and its compounds	
Tetrachloroethylene	Arsenic and its compounds	
1,1,1-Trichloroethane	Fluorine and its compounds	
1,1,2-Trichloroethane	Boron and its compounds	
Trichloroethylene		
Benzene		

Source: Order for Enforcement of the Soil Contamination Countermeasures Act

Act prescribes that when the operation of a facility that handles hazardous substances (shown in Table 2) is shut down, an investigation shall be conducted and, if the investigation shows that there is soil contamination that may harm human health, necessary procedures shall be taken.

Soil usually refers to earth and sand covering a portion of the earth's surface. However, soil contamination does not only refer to contaminated earth or sand but it is also used to refer to contaminated land or sites. This is because the condition of contamination at a site is directly connected to the price of the land in a real estate transaction. Unlike water or air, land is characteristically owned, and as such, there used to be many cases where contamination was hidden. However, more information has been disclosed and the general public has been paying more attention to the matter as more factories relocate and factory sites are used more actively for new purposes due to changes in industrial structures.

2-2 Outline of Soil Contamination Countermeasures Act

The Act was established in 2002 to understand the state of soil contamination and prevent human health hazards associated with soil contamination. The Act clearly prescribed how to treat soil contamination for the first time. Excerpts related to this report can be seen below. Additionally, to solve problems found after the enforcement of the Act, a revision will be made in April 2010 to extend the scope of application of the Act. Matters related to the revision are also discussed below.

(1) Soil Contamination Investigation

The Act prescribes that the land falling under the following categories shall be investigated.

i) Land used as a site for a specified facility (which produces, uses, or treats hazardous substances), the operation of which was shut down.
ii) Land recognized by a prefectural governor as a site that may harm human health hazards due to soil contamination.
iii) Land determined by a prefectural governor as a site where soil contamination may exist at the time when the site (3,000m^2 or larger) is about to be transformed (by, for example, excavating soil and rocks or other objects, developing residential areas, and cultivating the land). This category will be added at the time of revision in 2010.

The owner of such land is required to submit to the prefectural governor the results of investigation conducted by a designated investigation institution. The designated investigation institution has the technological capacity to conduct such investigation and is designated by the Minister of the Ministry of Environment in order to ensure the reliability of investigation.

(2) Designation of Designated Area and Designated Area Register

If a site does not conform to the standards based on an investigation, the site shall be designated as a designated area and the designation shall be publicly announced. Additionally, a register of designated areas shall be made and shall be available for inspection. The revision to the Act in 2010 will make it possible for the results of voluntary investigations conducted by landowners to also be registered, in addition to the results of mandatory investigations described in 1) above, if the landowners desire and offer to do so. In addition, the revision will also prescribe that prefectural governors shall do their best to collect, organize, conserve, and provide information.

(3) Prevention of Health Hazards Associated with Soil Contamination

When a prefectural governor finds that soil contamination of a site may harm human health, the governor may order the landowner to take action to remove the contamination, etc. (making access to the site restricted, covering the soil or paving the surface, containing the contaminated soil, cleaning up the soil, etc.).

2-3 Investigation Results Based on the Act

The Ministry of Environment compiled the results of soil contamination investigations[5] based on the Soil Contamination Countermeasures Act. The results up to fiscal 2007 have been published so far, and a total of 270 sites exceeded the standards and were designated as designated areas. Among these sites, 73 sites exceeded only the standards set for volatile organic compounds (first-class designated hazardous substances), 179 sites exceeded only the standards set for heavy metals, etc. (second-class designated hazardous substances), and 18 sites exceeded both of the standards (first-class and second-class designated hazardous substances). No sites exceeded the standards set for agricultural chemicals (third-class designated hazardous substances). (This report hereinafter refers to the first-class designated hazardous substances as VOCs, the second-class designated hazardous substances as heavy metals, and the third-class designated hazardous substances as agricultural chemicals, etc.)

Figure 1 shows changes in the number of sites found to exceed the standards and be designated as designated areas after investigations were conducted based on the Act. The number has been increasing every year. Figure 2 shows the cumulative number of sites that exceeded the standards by hazardous substance, and the figure shows that the most common substances are hexavalent chromium, lead, and fluorine, in that order.

2-4 Law That Remains to Be Established

Action will continue to be taken against soil contamination as long as the Soil Contamination Countermeasures Act exists. However, the Act is a corrective act that requires that contaminated soil be investigated and that action be taken thereafter; it is not a preventive act. Soil contamination found

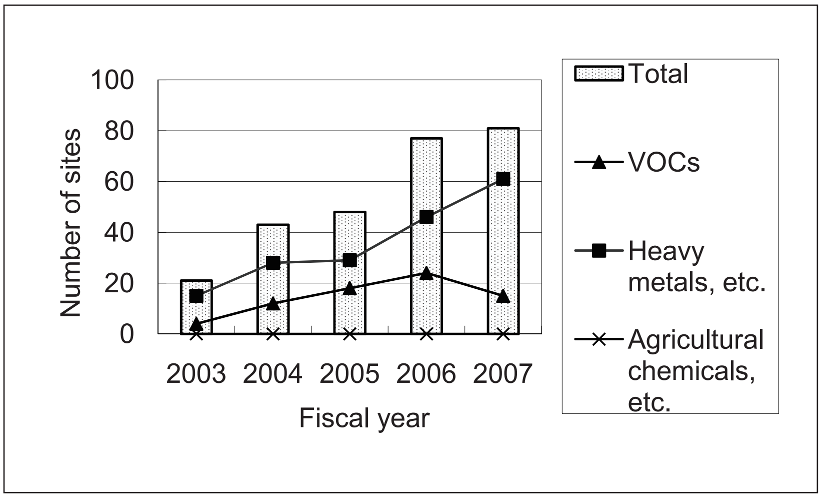
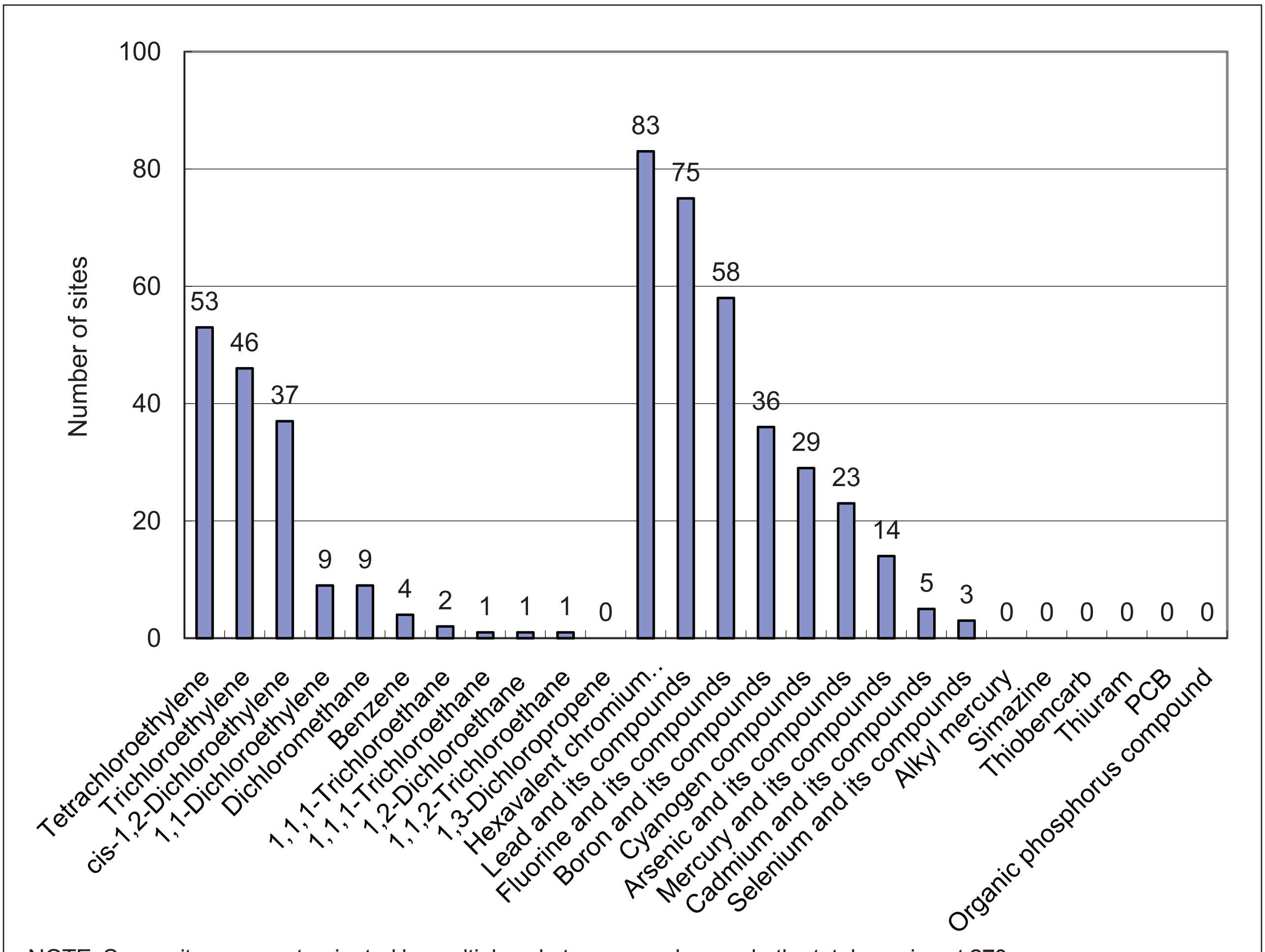


Figure 1 : Changes in the number of sites designated as designated areas by fiscal year

Prepared by the STFC based on Reference[5]



NOTE: Some sites are contaminated by multiple substances, and as such, the total sum is not 270.

Figure 2 : Number of sites designated as designated areas by hazardous substance (cumulative number between fiscal 2002 [when the Act was enforced] and 2007)

Source : Reference[5]

so far is probably the negative legacy of the period of high economic growth; however, new types of contamination might be progressing. The concept and practice of CSR (corporate social responsibility) has spread through companies in Japan, and as such, it is very unlikely that no action will be taken against soil contamination. However, to prevent soil contamination for sure, it is hoped that a preventive act will be established.

3 Progress in Technology to Clean up Soil Contamination

3-1 Current Issues

3-1-1 Brownfields

As discussed in Chapter 2, the Soil Contamination Countermeasures Act requires an investigation of a site if its soil may be contaminated. In recent years, the number of voluntary investigations has been increasing for the purpose of land transactions, property value assessments, etc. The fact that more investigations are being conducted is advantageous since previously overlooked soil contamination may be found.

Figure 3 shows data based on a survey conducted by the Geo-Environmental Protection Center, targeting its member companies. The center is a public service corporation, engaging in soil contamination investigations as well as taking action to solve soil contamination. Some 159 companies engaged in investigation, analysis, construction consulting, construction, etc. comprise the members of the center (as of December 2009). The center conducts various kinds of investigations relating to soil contamination. In particular, such data as shown in Figure 3, acquired through surveys that target the member companies, is valuable in that it shows the state of soil contamination. Investigation results based on the Act are discussed in Chapter 2-3, but Figure 3 shows that the number of voluntary investigations and actions taken to solve soil contamination (at the time of land transactions, etc.) is much larger than the number of investigations and projects conducted based on the Act.

For example, in addition to the hazardous substances specified by the Act and shown in Table 2, oil is included as a contaminating substance subject to voluntary investigation. The number of oil-contaminated sites has been increasing, so the Ministry of Environment created the Guidelines for Countermeasures against Oil Contamination[6] and releases investigation and solution methods.

Voluntary action to solve soil contamination is taken as a part of property risk management rather than environmental risk management, but this

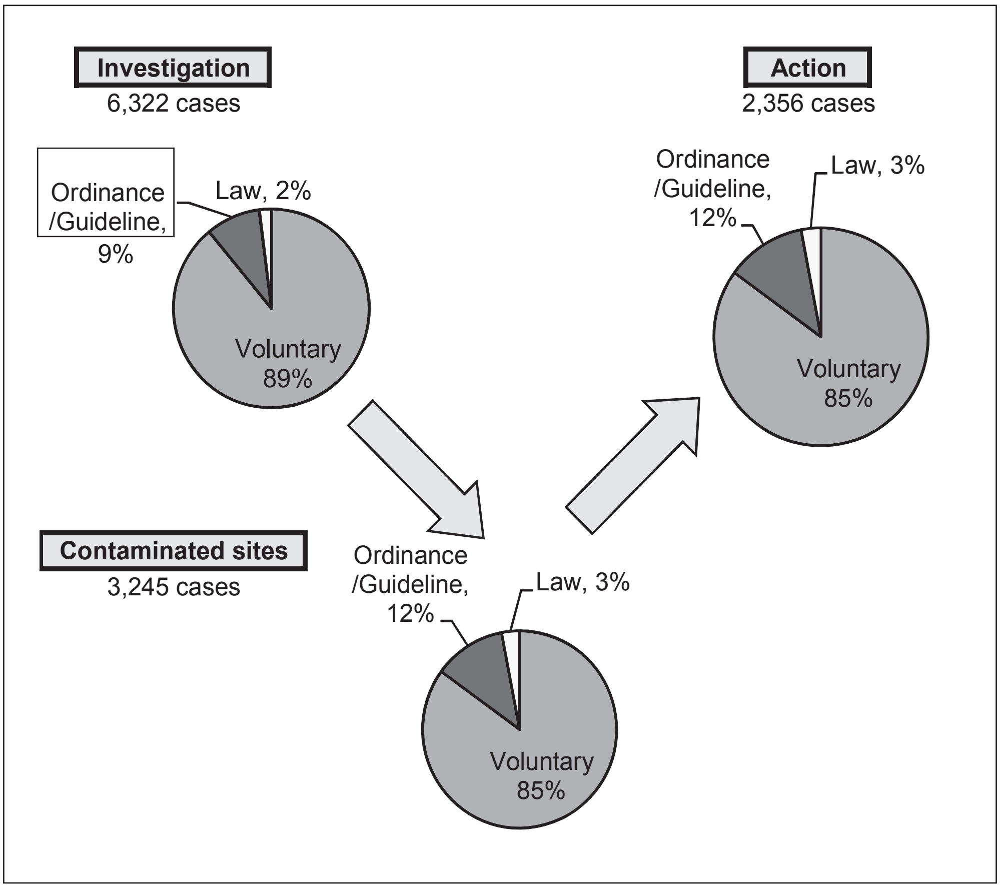


Figure 3 : Reasons for Conducting Soil Contamination Investigation and Taking Action to Solve Soil Contamination

Source : Reference[7]

situation is unavoidable considering the maintenance of Japan's economic activities. There have been cases where soil contamination has affected sales agreements during land transactions and where soil contamination has hindered the smooth use of sites. Such land that is not used at all or that is extremely underused compared to the extent to which it was originally used is called brownfield land.

Japan does not have a long history of taking action against soil contamination, and as such, the number of brownfield sites is currently limited. However, it is thought that there are many sites that may become brownfields. There are concerns that if the number of brownfields increases, it will affect not only the environment but also regional economies as well as people's everyday life.

3-1-2 Brownfields in Japan

Many brownfield sites[8] have been reported in Japan and typical cases has been shown in as follows.

(1) An old chemical factory site in a metropolitan area

There was a plan to sell an old chemical factory site (which had been closed before the Soil Contamination Countermeasures Act went into effect) to create a residential area, commercial facilities, and business offices. However, the plan was not realized because there are contaminating substances which are expensive to excavate and remove. There is a way to contain the contaminating substances at the site rather than removing them before trying to sell the land, but it is difficult to find a buyer this way.

(2) A machine factory site in an industrial city

There was a plan to sell an old factory site, which, as in case (1), had been closed before the Act went into effect. However, it is likely that the site will be found contaminated if the soil is investigated, and the landowner will not be able to cover the cost of cleaning up the site. The landowner does not want to find out that the site needs to be cleaned up, and as such, no investigations have been conducted and the land has not been used.

3-1-3 Land Likely to Become a Brownfield

Even if the soil is contaminated, if the economic value of the land is high, it is very likely that some action will be taken to solve contamination problems. In fact, many land transactions have been concluded when the cost to solve contamination problems is 30 percent or less of the transaction value. In case of a large site, it is rare that the entire site is severely contaminated, making the cost of solving contamination problems smaller compared to the sales value, and therefore, action will be taken for most sites. Thus, land that is small and has low value is inclined to become a brownfield.[8]

3-2 Existing Cleanup Technology

3-2-1 Outline of Existing Cleanup Technology

Table 3 shows the outline of existing technology to clean up contaminated soil. The methods can be roughly divided into two: 1) the cleanup process occurs after contaminated soil is removed from the original site and 2) the cleanup process occurs at the site of contamination.

In some cases, soil removed from the original site may be treated at an appropriate treatment facility (decomposition, solidification, etc.), and in other cases, contaminated soil may be buried at a final disposal site. Among contaminants, heavy metals cannot be decomposed chemically, but VOCs can be decomposed chemically, and therefore, VOC-contaminated soil will be cleaned up.

Depending on the condition of the site of contamination, soil can be cleaned up at the site. This is called in situ remediation. In situ remediation is inexpensive and many remediation companies have been engaging in the development of new in situ technology. Table 4 shows major in situ remediation technology, but there is no perfect in situ remediation technology. Depending on different types of contaminants, the condition of groundwater, and the condition of the site, an appropriate technology will be chosen. However, there are some cases where in situ technology cannot be applied at all. In all cases, understanding the condition of the site is a major factor for successful remediation.

3-2-2 Actual Case of In Situ Remediation

This section introduces a case where VOC-contaminated soil was cleaned up by the bioremediation[5] method. The word "bioremediation" is a combination of "bio," meaning "life," and the Latin word remediation, meaning "correction," and refers to a process of using microorganisms for contaminated soil in order to decompose hazardous

Table 3 : Outline of technology to clean up soil

Treatment site	Technology		Outline	Applicable hazardous substance		
				VOCs	Heavy metals, etc.	Agricultural chemicals, etc.
Off-site	Clean up of excavated soil	Cleaned up at a remediation facility	Chemical decomposition, biotreatment, thermal decomposition (cyanogens, agricultural chemicals), washing, thermal desorption, volatilization	○	×	○
	Containment of excavated soil	Treated at a treatment facility	Covering contaminated soil with a concrete barrier, seepage control, insolubilizing/solidifying treatment, reduction treatment	–	○	–
On-site (in situ)	In situ remediation	In situ decomposition	Chemical decomposition, biological decomposition	○	×	○
		In situ extraction	Extraction, washing	○	○	○
	In situ containment	Underground impermeable wall	Containment using impermeable zones, steel sheet piles, etc.	–	○	–
		Solidifying/ insolubilizing treatment	In situ solidifying/ insolubilizing treatment through injection and circulation of an agent	–	○	–

NOTE: "○" means applicable, "×" means inapplicable, and "–" means possible but not used often.

Prepared by STFC based on Reference[9]

Table 4 : Major in situ remediation technology

Technology		Outline
In situ extraction	Soil vapor vacuum extraction	Vacuum pumps, blowers, etc. are used to remove vaporized contaminants from the zone of low permeability.
	Air sparging	Air at high pressure is injected into the zone of low permeability or groundwater in order to facilitate the vaporization of VOCs.
	Extraction of groundwater	Groundwater at a contaminated site is extracted and contaminants are removed and collected from the groundwater.
	Soil vapor/groundwater vacuum extraction	Groundwater and soil vapor are extracted at the same time.
In situ chemical decomposition	Oxidative decomposition	A strong oxidizing agent such as potassium permanganate and Fenton (hydrogen peroxide and iron solution) are injected into the ground to decompose VOCs and cyanogens.
	Reductive decomposition	Strong reducing agents such as iron powders are injected into the ground to reductively decompose VOCs.
In situ biological decomposition	Bioremediation	Oxygen and nutrient salts are injected into the ground to increase the number of native degrading bacteria to facilitate the decomposition of chlorinated organic compounds and oil.
	Phytoremediation	Plants are used to collect, decompose, and insolubilize hazardous substances in soil. There have been reports that some plants are highly effective for collecting cadmium, lead, and arsenic, and some plants are highly effective for absorbing and decomposing VOCs and oil.
In situ soil washing		Water, surfactants, etc. are injected into the ground to extract and remove hazardous substances. Water for washing that contains hazardous substances is extracted and treated together with groundwater to separate and collect hazardous substances.

Prepared by STFC based on Reference[10]

Table 5 : VOC contamination case at an electronics-related company

Business	Electronics-related	Reason for investigation	Voluntary investigation based on corporate policy
Specified facility handling hazardous substances (the operation was closed)	Cleaning facility handling trichloroethylene (The operation was closed before the enforcement of the Soil Contamination Countermeasures Act.)	Groundwater contamination at the site	Yes
Area of the site	18,000m²	Groundwater contamination around the site	Yes
Area of contamination	4,000m²	Entry to the site	Restricted
Depth of contamination	Approx. 15m	Use of groundwater as drinking water around the site	No

Hazardous substance exceeding the standards	Standards	Concentration
Trichloroethylene	Elution	Approx. 100 times higher than the standard
cis-1,2-Dichloroethylene	Content	Approx. 10 times higher than the standard

Source : Reference[5]

substances.

VOC contamination problems can often be solved by in situ remediation depending on the degree of contamination. The following is a typical case of bioremediation.

An electronics-related company voluntarily investigated the soil and groundwater at its factory as part of its environmental management policy and found that the soil and groundwater were contaminated by tetrachloroethylene and its decomposition products. Table 5 shows the state of contamination. Trichloroethylene was used at the factory to clean electronic parts, and it was estimated that, for some reason, trichloroethylene seeped into and accumulated in the ground.

In situ remediation was considered the most economical and efficient way to solve this case based on the following reasons and was conducted accordingly.

-The factory was in operation and the soil under the factory was also contaminated, and therefore, large-scale engineering work was difficult.

-The depth of contamination was deep—about 15m—and the cost of excavation would have been substantial.

-There were anaerobic bacteria in the ground, which can decompose trichloroethylene and its decomposition products.

As Figure 4 shows, bioremediation is a process where nutrients are injected into the ground, through such means as a well, to stimulate bacterial growth and activity in order to decompose VOCs. In this particular case, nine injection wells were dug for the targeted site, and it took about 18 months to finish cleaning up the site once the nutrient injection began. After the remediation was complete, the site was sold to a related company, which built a new factory there.

3-3 Development of New Technology to Solve Soil Contamination Problems

3-3-1 Predicting Spread of Contamination

Many research institutes, including the Publics Works Research Institute, have been developing a system to predict how substances will be diffused due to the effect of groundwater flow, etc. (hereinafter referred to as advection-diffusion analysis). Some research institutes have released their advection-diffusion analysis software free of charge, and it is hoped that such software will be efficiently used for remediation and monitoring.

To appropriately take action against soil contamination, it is essential to understand the progress and the effects of contamination. As discussed earlier (during the discussion of in situ remediation), a major factor for successful remediation is how to accurately understand the state of contamination and choose an appropriate remediation method. Even in cases where remediation work is not conducted for various reasons, it is essential to monitor the state of contamination because some substances can move or diffuse due to the effect of groundwater flow, etc. The following are important perspectives for understanding the state and effects of contamination.

1)Possibility of spread of contamination (It spread easily or not)

2)Diffusion speed (It is in the order of several months or several hundred years)

3)Possible area and direction of diffusion

4)In cases where there are objects that should be protected in the surrounding area, the effect of contamination on the objects

Figure 5 shows an example of advection-diffusion analysis. If, under this condition, lead seeps into the ground at the contamination source, the contaminant diffuses due to the effect of groundwater flow, and in about 20 years, the well for drinking water (100m away from the source) may be contaminated. If such a prediction is made, it will become necessary to take action against contamination sooner or later.

3-3-2 Phytoremediation

As Figure 6 shows, domestic needs for cleaning up soil contamination can roughly be divided into high-cost short-term remediation and low-cost, long-term remediation. The former is for cases where the deadline of a land transaction has been determined and definite action needs to be taken. In contrast, the latter is for cases where the deadline of a land transaction has not been determined or the price of the land is not high and where cost is prioritized over speed. If there are no economical methods to clean up a site, it will become a brownfield. Therefore, it is essential to consider longer remediation periods and develop a cleanup method that is very inexpensive.

Phytoremediation is a method that can satisfy the cost requirement. The word "phytoremediation" combines the Greek phyto, meaning "plant," and the Latin word remediation, meaning "correction,"[12] and refers to a process that reduces or controls the outflow of contaminated substances in soil, bottom sediment, groundwater, etc. through the use of grasses, trees, and rhizosphere microorganisms. Plant roots act as a plower when they grow, and they provide oxygen and nutrients to soil, stimulating bacterial activity around the roots to decompose oil and other contaminants. When phytoremediation is used for soil contaminated by heavy metals, plants absorb contaminants in the soil and the contaminants are transferred to the aerial part of the plants, which can be removed to reduce the risk of soil contamination. Advantages of phytoremediation include that it is inexpensive, that it is ecologically friendly since no chemicals are used, and that it is good for the scenery. In contrast, its disadvantages include that it takes a long time to complete, that it can only clean up the area where roots can reach, that plants that have absorbed contaminants must be disposed of properly, and that the soil must be enriched enough for plants to grow.

The United States and Europe have a long history of actively studying phytoremediation. In Japan, phytoremediation-related patents began to be filed about ten years ago,[13] and many studies have

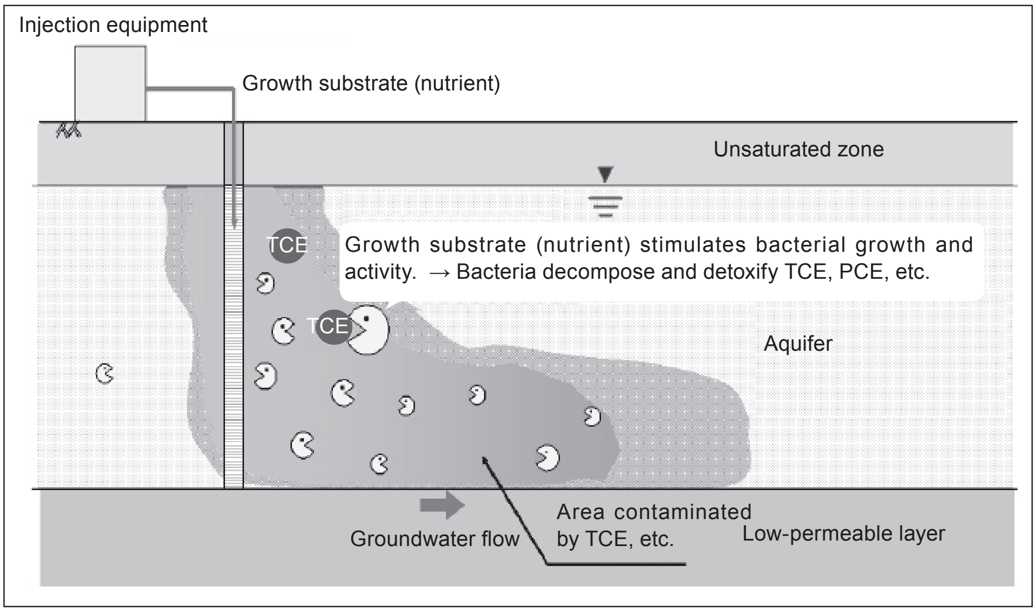


Figure 4 : Bioremediation

Source: Reference[5]

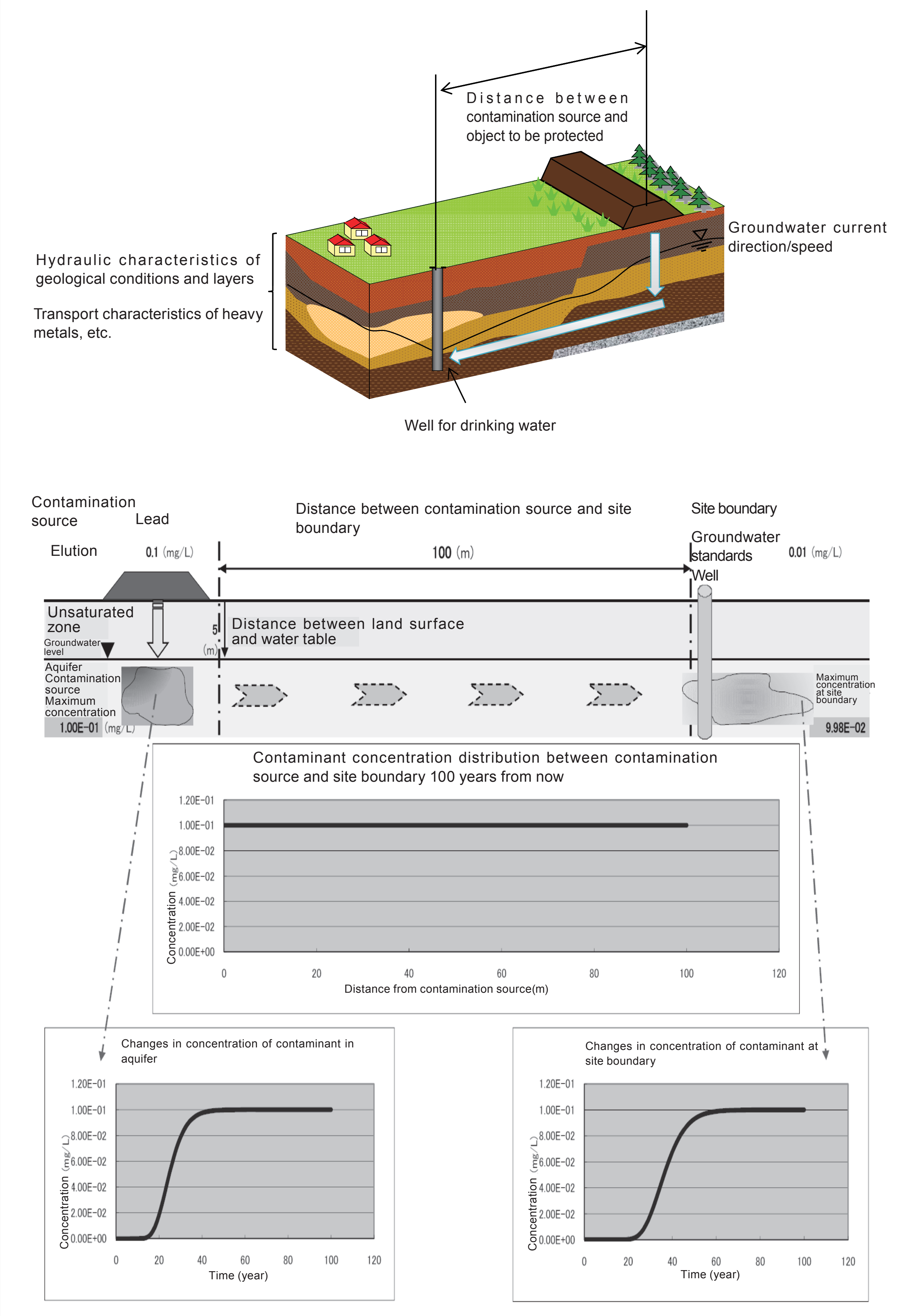


Figure 5 : Example of advection-diffusion analysis

Data from Public Works Research Institute recently been presented at academic conferences. Studies have been conducted on genetically engineering plants in order to increase their capacity to absorb heavy metals.[14] However, most of the reported studies are still in the experimental phase, and there are not many cases of cleaning up a large amount of contaminated soil at an actual site.

Phytoremediation is often called the ultimate low-cost remediation method, and as such, it is mistakenly believed that not much effort is necessary. However, soil at contaminated sites is very different from soil for growing vegetables, and plants do not grow well at these sites just by using regular agricultural or landscaping know-how.

For example, Italian rye grass is known to remedy oil contamination. The plant is commonly grown as a pasture grass, but it is difficult for its roots to grow in oil-contaminated soil because oil seeps through openings in the soil and also makes it difficult for bacteria to grow.

Figure 7 illustrates a case where Italian rye grass was successfully grown in oil-contaminated soil. In this case, perforated pipes were buried at intervals to create a good living environment for bacteria by improving air permeability, and the oil-contaminated soil was remedied.

Many plants have been found appropriate for certain contaminants, but we have not yet reached the stage where these plants can be cultivated to clean up actual contaminated areas. The above-mentioned phytoremediation method using Italian rye grass is the only case that has been reported

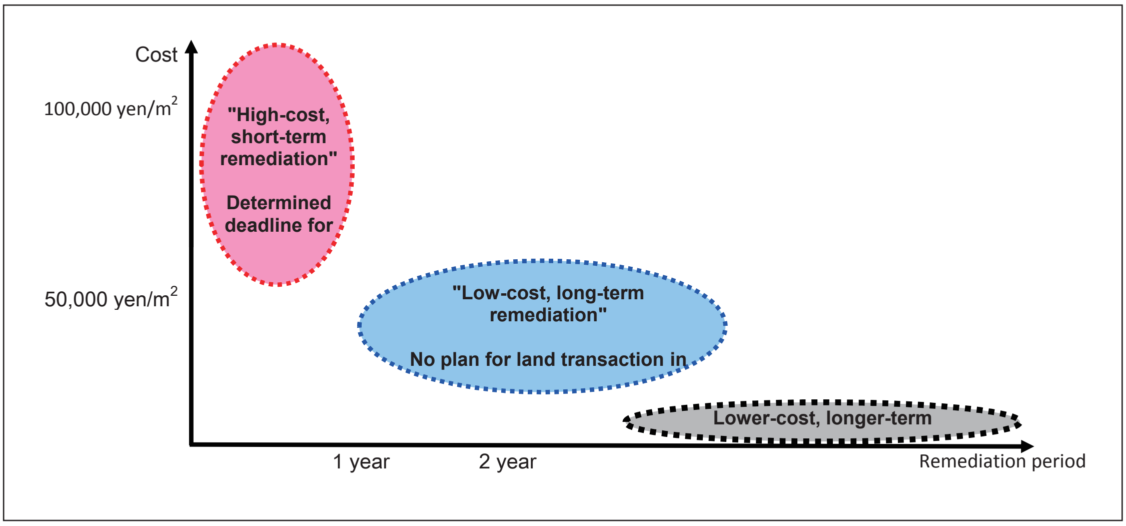


Figure 6 : Needs for soil contamination remediation

Prepared by STFC based on Reference[11]

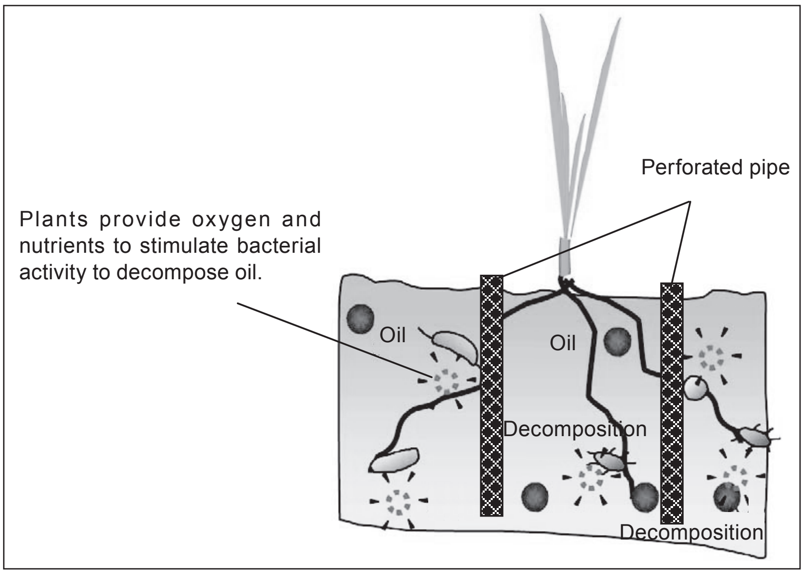


Figure 7 : Cleaning up oil-contaminated soil using phytoremediation

Prepared by STFC based on Reference[15]

for cleaning up oil-contaminated soil. Additionally, we have not yet established a method to treat plants that have absorbed heavy metals. We need to address these issues in the future. The number of brownfields in Japan is expected to increase in the near future, and thus, it is essential to begin accumulating know-how on phytoremediation.

3-3-3 Concept of Contamination Risk

The fundamental problem of soil contamination is not the existence of soil contamination itself but is the fact that hazardous substances in soil may affect human health through various routes. It is not covered by this report, but there are many cases where soil contamination occurs naturally, not anthropogenically. Therefore, our goal is not to eliminate soil contamination from the earth but to reduce the possibility of negative impacts of contaminants to a level that is not harmful to human health, that is to say, to control environmental risks to keep them within an allowable range. The United States and Europe adopted the concept of environmental risks earlier than Japan did, and their research and systems surrounding environmental risks are more advanced than Japan's.[16]

In Japan, the Geo-Environmental Protection Center, universities, and other research institutes have begun to consider environmental risks. The goal of environmental risk assessment is not to make assessments in a uniform manner based on the amount of contaminants at a contamination source but rather to consider exposure routes and assess the risks. The Geo-Environmental Protection Center was among the first to point out the significance of environmental risk assessments, and it drew up a proposal that addressed how Japan's risk assessments for soil environments should be,[17] and stated that information concerning risk assessments should be publicized to the public.

4 Conclusion

Since the enactment of the Soil Contamination Countermeasures Act in 2002, some progress has obviously been made in investigating and cleaning up soil contamination. The revision to the Act in 2010 will extend the scope of investigations, and therefore, it is expected that new contaminated areas will be identified. It is also estimated that the number of voluntary investigations will increase in order to reduce property risks.

It is a very significant matter for residents and other related parties that the state of soil contamination will be revealed. However, it will be a huge loss for Japan (with its small land area) if contaminated sites remain as-is and unused based on their economic assessment. To reduce the number of brownfields, it will be helpful to establish low-cost remediation methods (including phytoremediation) and technology to enable more reliable remediation as well as to take more reasonable action to solve soil contamination problems. In particular, it is essential to take action in a planned manner when developing technology that requires a long period to accumulate know-how, and to do so, it is also critical to receive cooperation from companies and other organizations that actually own a large amount of contaminated soil.

Overseas, there is a substantial amount of soil that has been contaminated due to natural disasters or wars. The climate and other various conditions may be different from those of Japan, but if we can test remediation methods in such land and accumulate know-how, it will help us establish global remediation technology. Some countries (which have large areas of land) may not yet be seeing brownfields as much of a problem, but if there are inexpensive remediation methods, these countries may also take action. This author hopes that Japan's technology will be used not only domestically but also globally.

Acknowledgement

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Profile

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