Report on Soil and Groundwater Management in Taiwan

By
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Introduction

In the 1980s, various groundwater and soil contaminated sites were discovered in Taiwan. To manage and supervise growing numbers of site investigations and cleanup activities, the Environmental Protection Agency, Executive Yuan, R.O.C (the Taiwan EPA) embarked on establishing relevant regulations. After years of study and discussion, The “Soil and Groundwater Remediation Act” was enforced in 2000 and revised in February 2010. Pursuant to this Act, many tasks have been conducted to investigate and remediate contamination sites in the past 15 years.

In the past 15 years, 2,301 hectares contaminated sites were listed as control or remedial sites and were classified into 6 categories, including farmland, gas station, storage tank, industrial site, illegal dumping and other miscellaneous site. As November 30, 2015, 694 hectares contaminated sites were delisted.

The Taiwan EPA has been continuously improving the efficiency and effectiveness of soil and groundwater management. This report focuses on the major strategies implemented by The Taiwan EPA in the past two years including improvement on contaminated site management, development on pollution prevention and technology development.

Improvement on contaminated site management

Contaminated site management in Taiwan can be categorized into contaminated site life-cycle management, off-site soil remediation work and risk-based remediation, each of abovementioned contents are discussed as below.

1. Contaminated site life-cycle management

According to the Soil and Groundwater Pollution Remediation Act (hereafter in the Act), site management includes taking emergency actions to prevent contaminants from spreading, enlisting as pollution control site or pollution remediation site if site potential impact value estimated by preliminary assessment is higher than 1200. The flowchart of contaminated site management is shown in
For both pollution control and remediation sites, polluters are asked to submit a remediation plan. Pursuant to “Soil and Groundwater Pollution Remediation Review and Supervision Regulation” (hereafter in review regulation), reports related to pollution remediation should be reviewed by experts, scholars, and relevant agencies invited by the environmental authorities. The reports include the related investigation plan, control plan, remediation plan, health risk assessment, and verification tasks.

2. Off-site soil remediation work

Remediation technology selection in Taiwan is affected by many factors, such as the characteristics of the hydrogeological environment, physical and chemical properties of contaminants, time limits imposed by environmental authorities, and financial resources. Off-site soil remediation technology is often considered. Since most of the polluters tend to seek the fastest way to delist the site, contaminated soil are transported out of the site and the polluter is commissioning an off-site remediation institute for contaminants treatment.

However, whether the soil moved outside of the site is considered to be “soil” or “waste” was unclear in the past and thus posed difficulties on the management of offsite treatment. To ensure that businesses properly dispose of the waste they produce, The Taiwan EPA has decided that stricter management is needed for waste disposal and final destinations for waste, and has thus announced additions to the list of enterprises in Article 2 Paragraph 1 Subparagraph 2 of the Waste Disposal Act. The enterprises added to the list include any enterprise that removes soil from a soil or groundwater polluted site, operators of excavated soil storage sites, medical laboratories, medical care radiological clinics and public sewage treatment plants.

To strengthen the quality control management of the follow-up contaminated soil transportation and treatment, off-site soil removal, treatment and reuse institution should apply for certification from The Taiwan EPA started from July, 2015. Off-site remediation can only be done by organizations that are licensed to remove and treat the contaminated soil, or reuse it after remediation is completed.

Through the permit, review and follow-up operation, management and inspection, the off-site contaminated soil removal and treatment can be managed well. Furthermore, to introduce the lifecycle idea to contaminated sites management, The Taiwan EPA has revised "Soil and Groundwater Pollution Control Plan Report Guidance" and "Soil and Groundwater Pollution Remediation
Plan Report Guidance”. Therefore, the follow-up management is considered at the preliminary stage.

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**Figure Contaminated site management flowchart**
3. **Risk-based remediation**

The Review and Supervision Regulation was corrected in 2014. Not only incorporating the off-site contaminated soil removal and treatment consideration, but also comprising the risk management concept. If the concentration of the remediation goal is determined by risk assessment, the risk management and pollution control measures after site delisting are stipulated in the Review and Supervision Regulation.

4. **Subsidizing Local Governments to Inspect and Assess Soil and Groundwater Pollution**

On March 27, 2015, The Taiwan EPA formulated a set of guidelines that will facilitate the provision of subsidies to local government environmental protection authorities for the inspection, verification and assessment of soil and groundwater pollution.

As laid out in the Guidelines Governing Subsidies for Local Government Environmental Protection Authorities to Inspect, Verify and Assess Soil and Groundwater Pollution, the subsidies are for the following items:

1. The tasks of inspecting, verifying, controlling, assessing and monitoring at sites that are suspected of having soil and groundwater contamination.
2. The tasks of inspecting, assessing, verifying, supervising, monitoring and auditing for sites announced as contaminated.
3. Any other items assessed by The Taiwan EPA as necessary in accordance with Article 28 of the Soil and Groundwater Remediation Act.

As stated in the said guidelines, the procedure for local government environmental protection authorities to apply for the subsidies is as follows:

1. Prior to applying for subsidies, the local authority must demand polluters, persons potentially responsible for pollution and interested parties of the polluted site to fulfill all of their legal obligations to remediate the sites in question. If the identity of the said persons cannot be verified or they do not fulfill their legal obligations, then the local authority can apply for subsidies to remediate the site.
2. Applications for subsidies should be submitted before the end of April every year by filling out the relevant forms on the Taiwan EPA’s online soil and groundwater management information system. Urgent cases, however, are not bound to this deadline.
5. Management of polluted farmlands

To safeguard the quality of farmland, the EPA has been screening areas considered to have high pollution potential and conducting ongoing soil pollution surveys. From July to August 2015, the EPA carried out farmland soil quality surveys along five irrigation systems around Changhua City and Hemei Township in Changhua County. A total of 210.6 hectares of farmland was investigated, and 54.9 hectares was found to contain levels of pollutants above the stated maximums for land that produces food. Since September, the Environmental Protection Bureau of Changhua County has been uprooting and incinerating all the crops produced on contaminated farmland to prevent them from entering the market. Regarding the affected farmers’ loss of income, The Taiwan EPA closely supervises the Government of Changhua County to estimate the farmers’ losses and submit the information for compensation as soon as possible.

6. Requirement of Environmental Liability Insurance Considered

The occurrence and presence of contaminated sites often result from industrial operations over the long haul. Soil and groundwater often are the ultimate media of industrial pollution, in which the cumulative or progressive risks of contamination is quite high. A large sum of remediation costs is usually required to restore contaminated sites to conditions with acceptably low risk levels to the environment and human health. Therefore, in addition to the management of multiple environmental media at the front end and the implementation of remediation at the rear end, a protection mechanism for the environment and public health is often considered to be a major point in devising the management policies for contaminated sites

After taking stock of the environmental protection mechanisms in advanced countries, The Taiwan EPA found out that environmental liability insurance is the most commonly used mechanism in the world. Such insurance not only protects the land, it also provides a protection mechanism for potential damage to the public. Therefore, using the structure of the Soil and Groundwater Remediation Act as the base, The Taiwan EPA has involved itself in the planning of an environmental liability insurance scheme relevant to contaminated sites and its supporting measures. In so doing, The Taiwan EPA held two meetings in July and August, 2014 to gather opinions from professionals in various fields, which can be used by the EPA as important references when establishing an environmental liability insurance system.
Pollution prevention

Regular monitoring is essential for groundwater quality management. In Taiwan, domestic background groundwater quality is monitored through the Regional Groundwater Monitoring Network, which includes 453 monitoring wells managed by The Taiwan EPA. Groundwater quality in industrial parks is currently under surveillance through 850 monitoring wells along with a Light Classification System, which is based on various pollution attributes, to comprehensively monitor the conditions. Meanwhile, investigations of sites suspected of having soil and groundwater pollution, such as gas stations, operating factories and military camps, are performed as part of the operations at over 1,000 site-specific monitoring wells installed nationwide. Moreover, the Water Resources Agency (WRA) of the Ministry of Economic Affairs has also installed 747 monitoring wells for obtaining hydrogeology data at different depths, to provide references for water usage policy-making. Statistics on and distributions of various types of monitoring wells in Taiwan are summarized in the Table.

In addition, since salinization of coastal groundwater is a common problem in Taiwan, with the southwest coast being the most affected. To gain a clearer understanding of the scope of the problem and to develop an early warning system, The Taiwan EPA has drawn up a plan to drill a groundwater salinization early warning network along the coast from Yunlin County down to Pingtung County, including salinization warning wells in the Pingtung coastal area. The wells will assist the government in controlling groundwater quality and allocating water resources.

The Taiwan EPA also implements various measures to ensure the soil quality. Since gas stations and underground storage tanks are common sources of petroleum contamination, The Taiwan EPA promotes the program of Proactive Declaration Management to Prevent Contamination. Gas stations must carry out regular monitoring and reporting of underground storage tank systems through a network. In addition, the Taiwan EPA has set up an underground storage tank system reporting center as a fundamental management tool to promote industry self-management and EPA supervision. For industrial sites, according to Article 8 and 9 of the “Soil and Groundwater Pollution Remediation Act”, designated industrial enterprises should conduct self-monitoring when shutting-down plants, establishing plants, or transferring land.
Table  Groundwater Monitoring Network and distribution in Taiwan

<table>
<thead>
<tr>
<th>Monitorin g network</th>
<th>Regional monitoring network</th>
<th>Site-specific monitoring wells</th>
<th>Early-warning monitoring network for industrial parks</th>
<th>Monitoring wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
<td>Groundwater quality background monitoring and pollution prevention</td>
<td>Pollution investigatio n and verification</td>
<td>Groundwater quality monitoring and pollution early-warning</td>
<td>Water source investigatio n and management</td>
</tr>
<tr>
<td>Competent authorities</td>
<td>EPA</td>
<td>EPA</td>
<td>Industrial park, EPA</td>
<td>WRA</td>
</tr>
<tr>
<td>Number of wells</td>
<td>450</td>
<td>More than 1,000</td>
<td>More than 850</td>
<td>747</td>
</tr>
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</table>

Technology development

1. Research and technology development

Significant amount of technical and administrative experience has been gained since the enforcement of the “Soil and Groundwater Pollut ion Remediation Act”. The Taiwan EPA recognizes the importance of adopting up to date technologies in soil and groundwater investigation and remediation. In order to promote and enhance the research and development for soil, groundwater and sediment contamination investigation, evaluation and remediation among private sectors and research institutes, the Taiwan EPA has executed the program of “Soil and Groundwater Pollution Remediation Fund Subsidiary for Research and Pilot Study” since 2010 with the investment of 30 million NTD annually. Over the past four years 90 projects have been subsidized, including 70 research projects and 20 pilot studies. These projects are divided into four major categories: 21 investigation projects, 43 remediation projects, 7 evaluation projects and 19 projects on sediment. The total amount of the subsidies reached NT$110 million. The technology developed included the screening for oil leaks by laser-induced fluorescence, environmental forensics technology, bioremediation technology and electrokinetic remediation technology. The funded projects also studied
environmental liability insurance mechanisms, emerging pollutants, and bioavailabilities of sediment-associated pollutants.

The subsidized research projects have yielded fruitful results, with 29 articles published in international journals and 18 patents being applied for or granted. One of the technologies developed has already been successfully transferred to industry, with another three cases being discussed with commercial enterprises.

The Taiwan EPA is hopeful that 2015 will see a continuation of the excellent achievements of the previous years, and is keen to encourage other academic research bodies to participate. After a careful evaluation of the 53 proposals received this year, the EPA granted funding to 31 of them, the most ever approved in a single year. The EPA hopes that the open call for proposals will lead to more experts and academics joining in the research to further advance Taiwan’s soil and groundwater remediation technology.

2. Professional training

On 21 May 2014, the EPA’s Soil and Groundwater Remediation Fund held the Taiwan-US Workshop on Soil, Groundwater and Sediment. The workshop was divided into two sections – one for the application of sediment technology and the other for application of geophysical exploration technology. A number of American experts attended the workshop to give presentations and exchange experiences with their Taiwan counterparts.

The section on the application of geophysical exploration technology focused on case analyses and research on new methodologies being applied to pollution inspections and remediation assessments, with the intention of advancing mutual transfers of knowledge and technology. The workshop was also an opportunity for the participants from government, industry, and academia to broaden their horizons and raise their competitiveness in their fields.

The section on the application of sediment technology focused on using model evaluation tools to establish sediment remediation technologies that meet the particular characteristics of different types of Taiwan’s unique aqueous environments.
Conclusions
In the last two years, the Taiwan EPA has made several progresses in the following four areas.

1. **Improvement on contaminated site management**
   Considering of the increasing off-site treatment, risk-based remediation requirement, and of incorporating the site remediation life-cycle management, the Taiwan EPA has announced related management regulations and framework. The Taiwan EPA will continuously make sure that site management will be reviewed and supervised by experts regularly to confirm its effectiveness.

2. **Pollution prevention**
   Many soil and groundwater pollution prevention measures had been applied in Taiwan, such as monitoring wells and USTs’ pollution prevention facilities. Since site remediation works usually take time and cost a fortune, the Taiwan EPA promotes more attention on pollution prevention work shall be paid.

3. **Technology development**
   The Taiwan EPA continues to subsidize academic research bodies that are conducting soil and groundwater remediation research and a pilot study to encourage related research and development.