Getting to the Core of
Environmental Remediation

Reducing radiation exposure from contaminated areas to protect people

IAEA
International Atomic Energy Agency

Getting to the Core of Environmental Remediation

Taking care of the environment today is a sustainable act for the generations of tomorrow. Avoiding the need for excessive remediation programmes after the end of operations is a fundamental aspect of life cycle thinking of any nuclear facility or industry handling radioactive material.

Before remediation...

This brochure provides general information about environmental remediation areas, from planning to the implementation of remediation projects, including stakeholder involvement, which is an important factor for the successful completion of remediation projects.

Content

...after remediation (photo courtesy of Wismut, Germany).

Getting to the Core of Environmental Remediation

Environmental remediation refers to reducing radiation exposure, for example, from contaminated soil, groundwater or surface water. The purpose is more than just eliminating radiation sources; it is about protecting people and the environment against potential harmful effects from exposure to ionizing radiation.

In the past, many nuclear activities were developed without appropriate consideration of their environmental aspects and impacts. Operations were run in situations in which laws and regulations did not exist or if they did, they were neither adequate nor comprehensive enough. As a result, radiologically contaminated sites were created. Such sites have also been created by nuclear and radiological accidents, as well as by non-nuclear industries in which human activities have increased the potential for exposure from naturally occurring radioactive materials compared to the unaltered state.

As contaminated sites can ultimately lead to undesired health effects for local people, appropriate actions must be taken. Remediation of contaminated land areas — or other contaminated media, such as surface or groundwater — is applied in two ways:

(1) By applying actions to the contamination itself. This can lead to isolation, immobilization or removal of the actual source of radiation, for example by means of decontaminating areas, surfaces and environmental media.

(2) Evaluating risks related to radiation exposure to people and thinking of ways of breaking the pathways between the radiation source and people. This approach might lead to evacuation, area isolation or changing land use and the local population's living habits.

The two ways are complementary. When deciding on the actual remediation work, several different factors need to be taken into account. As every site has its own characteristics, there is no simple quick fix.

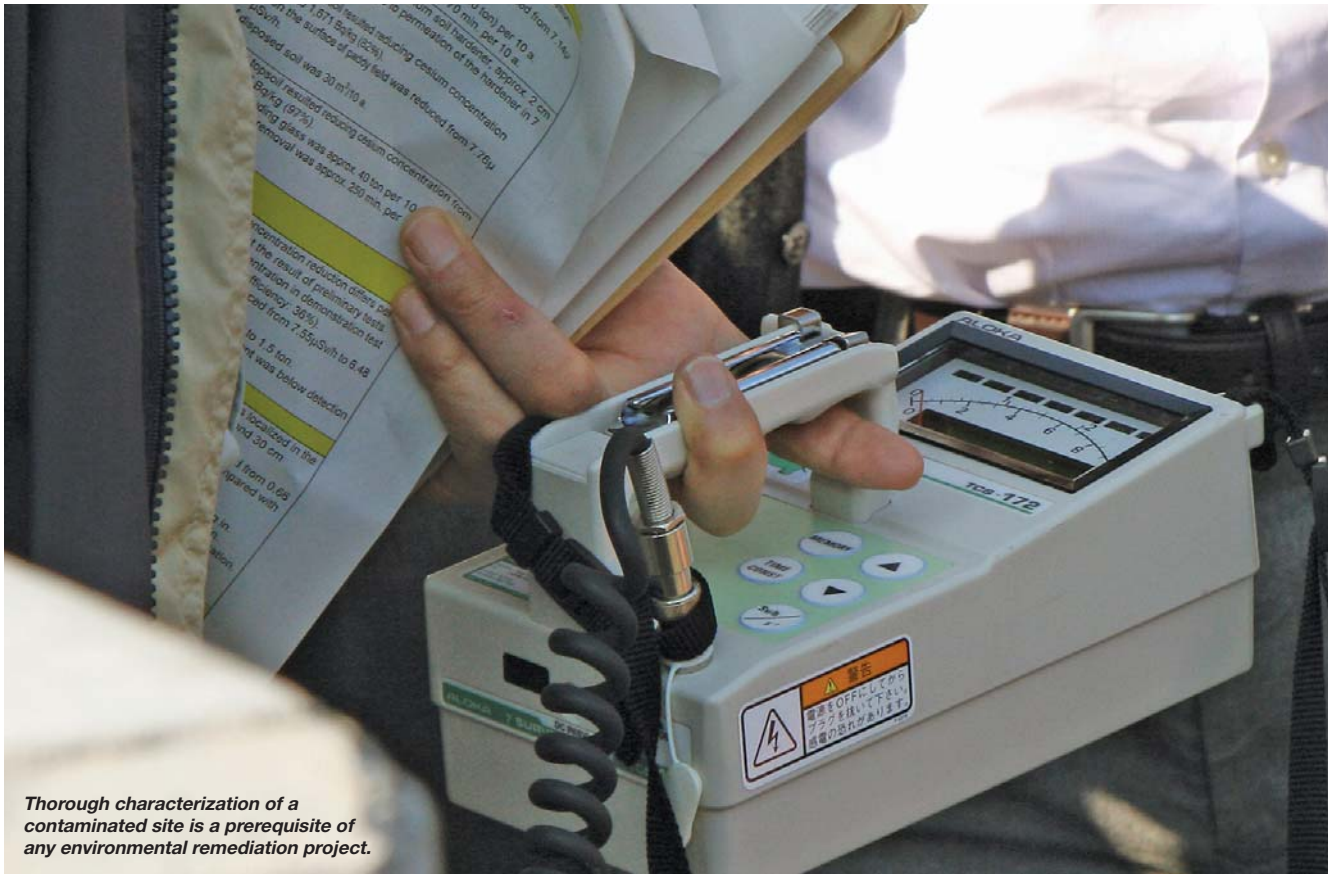
The most important thing is to understand that remediation actions need to be justified and optimized — the adopted actions must do more good than harm. For example, increased radiation levels do not necessarily mean that the increase is harmful; some living environments have inherently high radiation levels. Thus, evacuating or isolating areas without firm scientific grounds for it can needlessly cause distress to the people it concerns.

Returning a contaminated site to its original state is often neither necessary nor possible. While environmental remediation aims to reduce radiation exposure to protect people, remediated sites can still be used for various purposes, for example, industrial operations and even housing.

Environmental remediation is usually not an urgent task, thus enabling proper planning which is an essential aspect of any remediation work.

What to Consider When Defining Remediation Approaches

Remediation should not be confused with an emergency response after an accident, and thus it usually does not require urgent actions. For this reason, thorough evaluation of the situation and formulation of the desired goal is not only possible but a prerequisite. Proper planning is an



Thorough characterization of a contaminated site is a prerequisite of any environmental remediation project.

Getting to the Core of Environmental Remediation

Remediation actions need to be justified and optimized. The end result is always a balance between risks, costs, benefits and remediation viability.

essential aspect of any remediation work in order to reach the justified and optimized end state of the site.

The issues to be taken into account in the decision making process vary from technical to economic and social considerations, such as:

- Radiation risk to the population due to the land use — this is derived from the exposure assessment of people to radioactive materials in the site;
- Occupational exposure due to remediation works — workers will also be exposed during the remediation works;
- Net benefits of the remediation works to the affected community — remediation should do more good than harm;
- Waste generation from remediation — remediation is generally a waste generating activity, and the amounts and properties of generated wastes need to be considered in the decision making process;
- Ethical issues — remediation may affect people's lives and their living environment, including how they live;

Environmental remediation may generate radioactive waste that needs to be managed.

- Financial costs of remediation — remediation work costs are generally high and, therefore, financing mechanisms need to be sought;
- Other non-radiological risks incurred — sites to be remediated may not be contaminated only by radionuclides but also by other non-radioactive substances such as heavy metals and hazardous organic compounds.

As every country is different and every site has its own characteristics, choosing the best possible environmental remediation solution means balancing between risks, costs, benefits and available technologies as well as public acceptance.

How Clean Is 'Clean'?

The people, whose lives a contaminated site might affect, often have three fundamental questions in their mind: Is it safe for me and my family to live here? Who is responsible for this? Who is going to cover the expenses of the remediation works?

Without national policies, liability issues for the remediation are not addressed and it is unclear which parties are responsible for implementing the remediation works. In addition, the important question of who will pay for the remediation is not unequivocally answered.

National policy and strategies set up societal values regarding the environment and the population. Policy and strategies for implementing remediation need to be complemented by a consistent and well dimensioned regulatory framework. Regulations define in detail 'how clean clean is', i.e. the requirements that will need to be met in each given situation; the level of site characterization to be accepted before and after the remediation works; and the acceptable end state of the site. The overall process should be transparent, be communicated to the relevant stakeholders and allow for their participation in the decision making process.

Stakeholders' Input Matters

An important factor for a successful remediation project is for those people whose lives are affected by the contaminated site to be involved in and to contribute to the remediation process as they have a stake in the end result. It is not only an ethical matter but a moral obligation to involve various stakeholders in the remediation process. Listening to stakeholders' opinions, capturing their perspectives and taking them into account from the very beginning of the remediation process assists the decision making process for taking the most appropriate approach.

Typically, a remediation project has a series of stakeholders, including, for example, the immediate affected population and communities, operators,

regulators, non-governmental organizations as well as other segments of the society as a whole that may wish to have a say in the project decision making process.

Nuclear activities and operations must be planned in a way that minimizes excessive need for remediation activities at the end of operations.

Key Aspects to Take into Account

To encapsulate the main principles of environmental remediation, four major aspects should be taken into account:

(1) A contaminated site may not necessarily impose significant health risks to people living on it.

(2) The focus should be on radiation doses and risks that the exposure might pose. Reduction of doses — and not necessarily reduction of concentrations — is the ultimate objective of a remediation project.

(3) Returning a site to the conditions before the event that caused the contamination is not necessary and many times not even reasonably achievable.

After remediation, formerly contaminated sites can be utilized for various purposes (photo courtesy of Wismut, Germany).

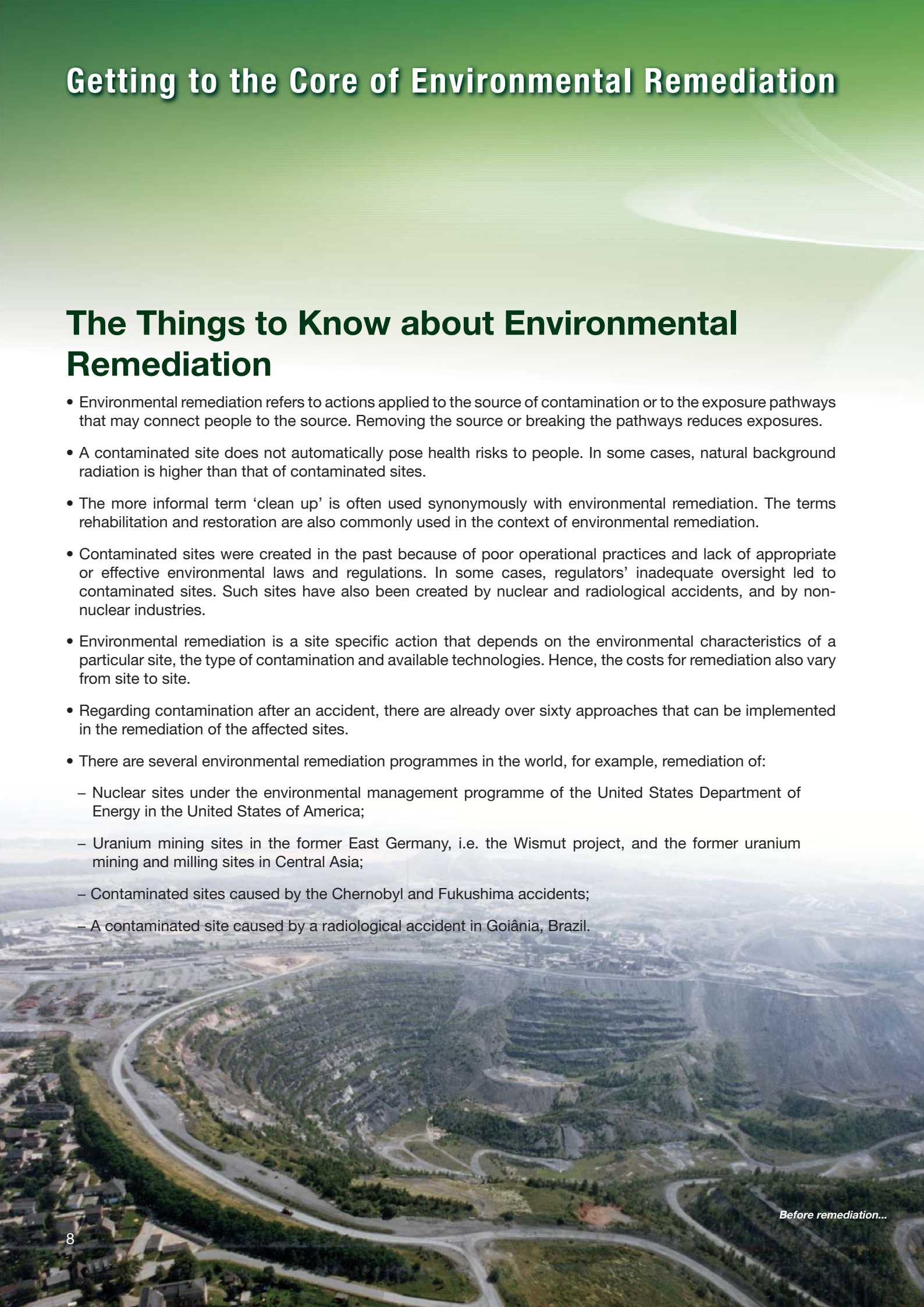
(4) The major driver for a remediation project will be less the scientific evidence of eventual health risks but rather public perception. Good communication and effective stakeholder involvement are, therefore, essential components for a successful remediation project.

As sites contaminated by artificial and natural radionuclides or even exposures of natural origin may give rise to the need for environmental remediation, remediation can only start after a consensus on the necessity to reduce existing or future exposures to ionizing radiation. In all cases, the actual work, i.e. adopting certain environmental remediation actions, is always a case specific decision.

A range of different remediation technologies exists but regulators often tend to value proven technologies; in some cases, the available technologies are not adequate to achieve the desired goals and further development is needed. For the sustainability of nuclear energy, modern nuclear facilities and operations are designed in a way that also takes into account the end of the operation life cycle. In this way, the need for extensive environmental remediation activities is minimized.

The Things to Know about Environmental Remediation

- Environmental remediation refers to actions applied to the source of contamination or to the exposure pathways that may connect people to the source. Removing the source or breaking the pathways reduces exposures.
- A contaminated site does not automatically pose health risks to people. In some cases, natural background radiation is higher than that of contaminated sites.
- The more informal term ‘clean up’ is often used synonymously with environmental remediation. The terms rehabilitation and restoration are also commonly used in the context of environmental remediation.
- Contaminated sites were created in the past because of poor operational practices and lack of appropriate or effective environmental laws and regulations. In some cases, regulators’ inadequate oversight led to contaminated sites. Such sites have also been created by nuclear and radiological accidents, and by non-nuclear industries.
- Environmental remediation is a site specific action that depends on the environmental characteristics of a particular site, the type of contamination and available technologies. Hence, the costs for remediation also vary from site to site.
- Regarding contamination after an accident, there are already over sixty approaches that can be implemented in the remediation of the affected sites.
- There are several environmental remediation programmes in the world, for example, remediation of:
  - Nuclear sites under the environmental management programme of the United States Department of Energy in the United States of America;
  - Uranium mining sites in the former East Germany, i.e. the Wismut project, and the former uranium mining and milling sites in Central Asia;
  - Contaminated sites caused by the Chernobyl and Fukushima accidents;
  - A contaminated site caused by a radiological accident in Goiânia, Brazil.



Before remediation...

Experience has shown that interaction between less and more experienced countries can contribute to better conditions for implementing environmental remediation projects. To resolve environmental liabilities and to avoid the generation of new contaminated sites, the IAEA is helping many countries to adopt appropriate practices. By being the hub of international cooperation, the IAEA provides information and guidance on available remediation strategies and technologies.

...after remediation (photo courtesy of Wismut, Germany).

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12-16881