CRITERIA AND APPROACHES FOR THE REMEDIATION OF SITES CONTAMINATED WITH NATURAL RADIONUCLIDES IN GERMANY

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Abstract

In some parts of Germany substantial areas have been contaminated with naturally occurring radioactive material (NORM) from past activities. Particularly important are residues from past uranium mining operations (WISMUT), being subject to a massive 13 billion DM clean-up program, as well as other mining activities dealing with elevated levels of NORM.

Decisions concerning the necessity and the required extent of remediation measures are based on a combination of criteria addressing limitations of maximum individual doses for critical groups as well as the optimization of the net benefit from the remediation. From these basic requirements secondary criteria have been derived, defining, for example, soil contamination levels below which a remediation is not required. The optimization analyses, carried-out to identify optimal remediation options, address radiological risks as well as short and long term costs within a cost-benefit analysis framework. Other relevant factors of influence, e.g. chemical risks or ecological damage, are incorporated as well. Comprehensive methodologies utilizing probabilistic methods have been developed to assess site conditions and possible remediation options on this basis.

Introduction

The clean-up of contaminated sites requires appropriate and efficient methodologies for the decision-making about priorities and extent of remedial measures, aiming at the two, usually conflicting, goals to protect people and the environment by reducing detrimental impacts to the extent feasible, and to save money and other resources.

Finding the cost-effective balance between these two primary objectives often is complicated by several factors. Examples are incomplete data or a variety of different factors of influence to be considered. Sensible decision-making in this situation requires the use of appropriate methodologies and tools which assist in identifying and implementing the optimal solution. The paper discusses an approach developed in Germany to achieve environmentally sound and cost-effective solutions. This includes the discussion of approaches for mixed wastes, which are of particular relevance for the reclamation of mining sites, but also have to be dealt with in other areas.

Regulatory Approach

Within the German remediation program for mining sites, an Action Level of 1 mSv per annum is used as a primary criterion for the identification of remediation requirements [1].

This corresponds to a risk-based approach, within which decisions about reclamation measures are based on actual risks to the population.

This primary reference level for the individual dose only partially meets the demand for easy applicability, because the effective dose is a quantity which has to be calculated based on measurements using exposure models and parameters. Therefore secondary reference levels for measurable quantities such as activity concentrations have been derived from the Action Level. These depend on current or planned land-use and are practically applicable even in situations with a large number of small sites [2].

The planning and implementation of remedial action at sites exceeding the Action Level is based on the optimization principle. Its application is discussed in the following section.

Assessment Methodology for Complex Sites

The German mine reclamation program is faced with a large number of small residues, partially dating back to Middle Age mining activities. The uranium mining by WISMUT after World War II also resulted in several relatively small sites. In addition to these, however, a few very large uranium mining and processing sites have been established [3,4].

The environmental situation at these sites is very complex. There is a large variety of different types of wastes present, some of which represent huge volumes in the order of 100 million m^3. The clean-up of these contaminated sites must take into consideration a variety of different contaminants and risks to humans and the environment arising on various exposure pathways. A particularly important aspect for assessing the clean-up measures required is the combination of radiological and non-radiological risks involved. In general, the following factors must be included in the investigations:

- Radiological risks through external irradiation and incorporation of radioactive substances.
- Risks from carcinogenic substances such as arsenic and organic contaminants.
- Possible health damage through toxic substances such as heavy metals in the uranium ore or chemicals used in the uranium extraction process.
- Damage to ecosystems, especially lakes and rivers, by contaminants discharged into them.
- Damage to resources, such as the contamination of groundwater aquifers.
- Direct physical risks, e.g. the danger of dam failures.
- Risks entailed by the clean-up activities themselves, e.g. additional release of contaminants, or traffic accidents when transporting materials on public roads.

The relative significance of these different risk components cannot be determined in general, because substantial differences exist between the individual sites with regard to contaminant levels and land-use of the surroundings. Comprehensive planning of the clean-up operations must therefore be capable to take each of these risk components appropriately into consideration.

Traditionally, the assessment of the hazards and risks is made under various jurisdictions with different philosophies, methods and standards. This separate assessment, however, does not give due consideration to the overall risk originating from a site and can therefore lead to inappropriate decisions. Under unfavorable circumstances this can result in clean-up measures

which, for example, improve the radiological situation but produce undesirable consequences for other environmental aspects. Furthermore, the positive effect achieved by clean-up activities usually appears in several environmental contexts. For example, covering a heap or tailings impoundment can at the same time lead to a reduction of radon released into the air and a reduction of radioactive and non-radioactive contaminants discharged into rivers. The determination of cost-efficient clean-up measures requires in this situation cost/benefit considerations, which take into account all improvements achievable in the different sectors on a common basis and relate them to the required financial expenditure.

In such situations, quantitative risk assessments can only be performed if a common assessment basis for the different risk components is available. This can then serve to identify appropriate protection and clean-up measures for the respective objects and sites. This makes it necessary to develop an assessment approach with which all relevant risk and damage components can be quantified consistently in an integrated method. Decisions aiming at a cost-effective use of financial resources can then be based on a quantitative analysis, determining to what extent clean-up measures should be implemented for individual objects, exposure pathways and risk components, and as from which level of protection further efforts for reduction of risk would no longer be considered reasonable.

On this basis, an integrated assessment methodology has been developed. Its main goals consist of the following aspects:

- Making the different risk and damage components quantitatively accessible.
- Establishing a basis for comparing the various possible risks to human health and the environment.
- Allowing for quantitative optimization decisions by determining the willingness and ability of society to pay for the prevention of risks and damage.

Substantial work for developing the integrated assessment approaches described below has been carried out within the scope of research projects commissioned by the German Federal Ministry for the Environment, Nature Conservation and Reactor Safety. A provisional conclusion of this work, which has already been running since 1990, was recently reached with the submission of a summarizing report [5]. An overview is given in [6]. Although the development of these methods is an ongoing process, an approach now exists whose practical viability has been demonstrated by application within the scope of a number of important clean-up decisions.

An important element of the developed approach is the monetarization of risks and damages, making them comparable with each other and with the financial expenditures required for the reclamation work. The assigned monetary equivalent can be considered as a measure for the societal willingness to pay for preventing the respective damage (statistical risks for lethal and non-lethal diseases, damage to resources such as drinking water, damage to ecosystems). The data basis used to define the parameter of the monetarization (so-called "conversion factor α") reflects this definition and is based upon payments actually made or investigations of the willingness to make payments in order to prevent or mitigate damage in the specified categories.

Setting out from the monetarization of the damage, it is possible to make a comparison with the short-term and long-term financial expenditures, which can be brought to a common reference basis by appropriate discounting techniques.

The different aspects of risk reduction and the expenditure necessary for implementation of the remedial measures, are assessed within the scope of a costs/benefits analysis for the clean-up options to be considered. The final result consists of recommendations for clean-up measures which combine economic aspects with ecologically sound clean-up measures consistent with the overall goal of a sustainable development. Examples for the application of this approach are given in [7,8].

The described approaches have been developed and tested with regard to concrete situations, particularly in connection with the clean-up at uranium mining sites in Saxony and Thuringia. So far no legally binding stipulation for the concrete application of these or other methods from the German Federal Ministry for the Environment or from the responsible government authorities of the federal states exist. This will only be possible after a still outstanding comprehensive discussion of the presented and possible alternative approaches, which will probably take a considerable amount of time. In the opinion of the responsible government authorities, however, it is nevertheless possible and appropriate, to apply the presented methods to concrete cases already now. On the one hand, this assists further qualification of these methods, and on the other hand relevant results are obtained for the required clean-up decisions. The extent to which the actual decisions for clean-up operations are based on the results of these methods, is determined individually on the merits of each case.

Conclusion

An overview of approaches to address the environmental problems associated with the reclamation of residues from uranium mining in Germany has been given. These approaches are also applicable to other environmental restoration activities. Key elements are the limitation of individual risks applying an Action Level concept and the derivation of monetary equivalents to the various kinds of risks and damages incurred by theses sites. This serves as a basis for a cost-benefit analysis for the determination of the optimal clean-up option.

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