Uranium mining & milling: Assessing issues of environmental restoration

The IAEA is providing assistance toward solving problems in Central and Eastern Europe and the Newly Independent States

by
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Following political changes in Central and Eastern Europe (CEE) and the emergence of Newly Independent States (NIS) from the former Soviet Union, a great deal has been learned about the environmental situation in these countries. Extensive industrialization and exhaustion of the region's natural resources had been pursued to accomplish quota-based productivity goals. In many areas, the preservation and protection of the environment were often neglected in the process.

The political changes brought forward a fragmentary disclosure of radioactively contaminated sites. They also created conditions in which these countries became receptive to co-operation from a range of countries from which they previously had been isolated.

Although the need for environmental restoration is not limited to the CEE and NIS regions, a few distinctive features may raise additional complications. For example, if the uranium production facilities are found to require some form of remedial action, the size and location of the CEE and NIS production centres pose potential complications in the restoration work. Unlike some countries in which mineral development occurred in remote areas (e.g., the United States) or resulted in relatively small volumes of waste, the CEE countries and NIS face greater logistical complications for two obvious reasons. Firstly, the volumes of the accumulated radioactive waste are far too high to be removed at a reasonable cost. Secondly, safer alternative disposal sites are either not available or else are impractical.

During the 1980s and early 1990s, many older uranium mines were closed because of a decrease in the demand for uranium and an increase in the overall supply. The resulting low prices and the cost of providing the extra measures needed to satisfy society's higher expectations in the area of environmental and radiological protection made production of uranium unprofitable for many low-grade mines. Moreover, this economic consideration has further complicated implementation of site restoration.

Although some of these mines/mills will probably reopen when demand and prices increase, many will be shut down permanently and need to be decommissioned/closed out. As this situation has evolved in a relatively short period of time, limited resources were put into remediating or even securing contaminated areas in CEE countries and the NIS.

The following factors contribute to an increased risk of radioactive contamination:

- long operational periods contribute to greater risk of contamination;
- higher ore grade increases radiation dose rates from the residues;
- natural climatic conditions (e.g., rain, wind) significantly enhance dispersal and contamination; and
- countries with limited resources can only allocate marginal resources to environmental restoration.

Unfortunately, most of the CEE countries and NIS "qualify" under these factors. This article briefly describes some of the typical problems in planning and implementing environmental restoration projects in these countries.

Basic conditions and problems

Although some political, economic, and infrastructural conditions are common to many countries in the CEE and NIS regions, large variations exist. In general, three categories of basic environmental restoration situations can be identified:

- countries with limited development of the uranium industry having small amounts of min-

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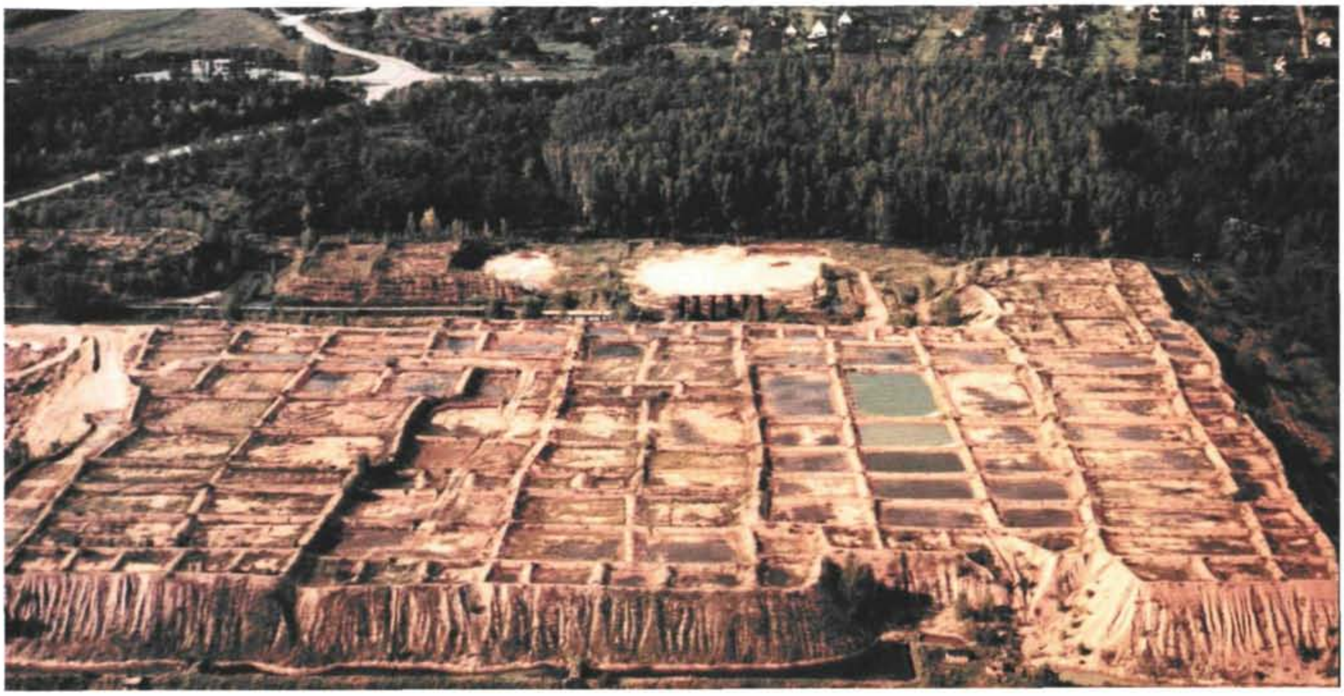


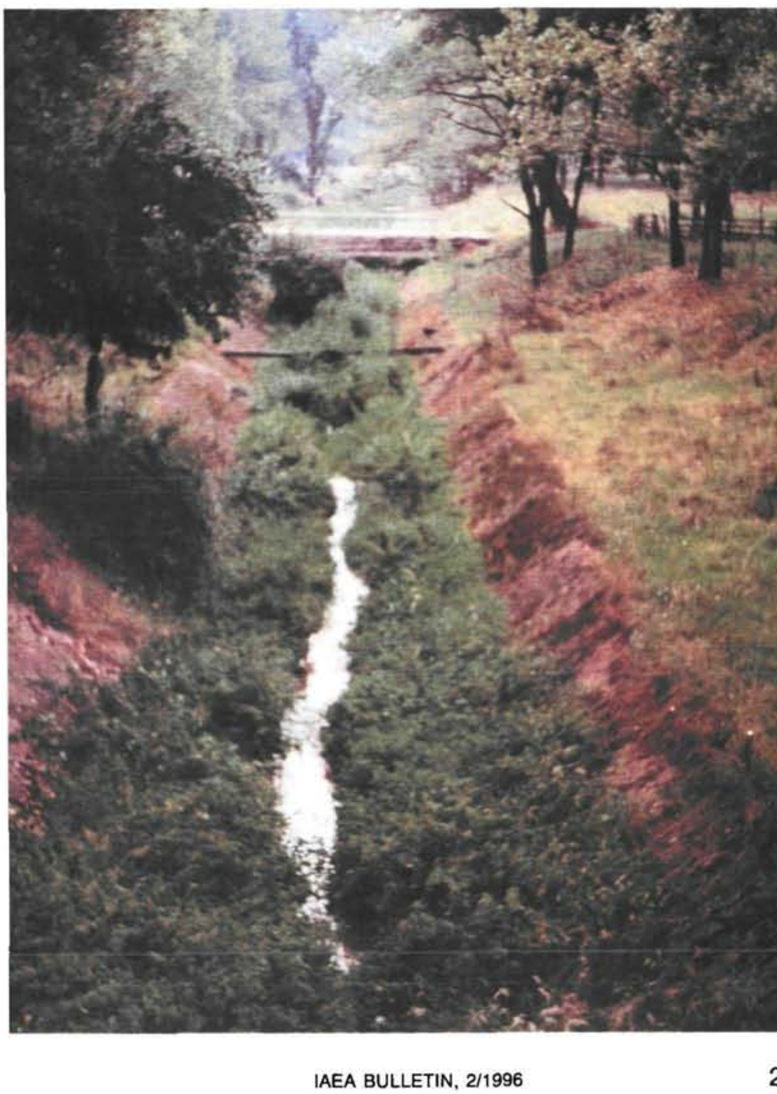
ing/milling waste and few contaminated sites (e.g., Poland);

• countries with a more developed uranium industry having several mines/mills and moderately impacted resources (e.g., Romania); and

• countries with a fully developed uranium industry having many mines/mills and severely impacted resources (e.g., the Czech Republic).

Typical problems associated with past practices in CEE and NIS include radon release; groundwater contamination; proximity of contamination to populations; lack of resources to conduct restoration; availability of disposal locations/alternatives; absence of regulations or a regulatory infrastructure for restoration; misuse or removal of tailings for use in construction; absence of responsible operators; and large inventories and areal dispersion.

In some cases, groundwater contamination is such a severe issue that major sources of drinking water are threatened by radiological and chemical contamination. Another typical situation in CEE countries is the proximity of uranium production sites to population centres. This proximity has, on occasion, led to the use of some of the waste rock and tailings materials for building purposes. Such structures are constant sources of indoor radon, one of the most significant radioactive hazards.



Above: **The Pécs uranium mining and milling site in Hungary shows "heap leaching" piles and waste rock.** *(Credit: Mecsekore Mining, Hungary)* ***Right:*** **A contaminated channel crossing the village of Yana, near the Buhovo mining and milling site in Bulgaria.**

Special problems of environmental restoration in the region

Site specifications. The siting and characterization of radioactively contaminated sites in CEE countries is probably the most difficult problem in relation to environmental restoration projects. The available data is not only incomplete but also somewhat questionable. A precondition for environmental restoration projects must be the availability of sources of data pertinent to the specific radioactively contaminated sites; otherwise the efforts and resources put into the process are useless.

Organizational problems associated with the political changes. In many CEE countries and the NIS, the old regulatory framework is being changed to reflect newly independent or radically altered political structures. Such frameworks, including the development of new laws and regulations, are planned or are just coming into existence. In some countries, existing laws will necessarily be adapted to changed political situations. There will be a period of transition, as such changes occur and ambiguities in new responsibilities are resolved. This situation is likely to complicate decision-making in environmental restoration.

The funding of environmental restoration work. A number of outside agencies, such as the World Bank and European Bank for Reconstruction and Development, as well as individual countries and groups of countries such as the European Union, are offering support for environmental restoration. However, there can be a lack of co-ordination and, therefore, duplication among these projects that could result in the inefficient use of available funds. Moreover, effective allocation and distribution of financial resources within countries may also prove to be difficult.

Available infrastructures for managing the wastes and residues from remediation programmes. To effectively manage the residues and wastes from the cleanup programmes, countries need waste management infrastructures/facilities to process, store, and safely dispose of any resulting radioactive wastes from restoration. In many CEE countries and the NIS, the stages of the nuclear fuel cycle were regionally co-ordinated. In most countries only parts of this infrastructure remain. Without having practical access to radioactive waste disposal facilities, cleanup efforts may be limited.

Increasing differences among the CEE countries and NIS. Large co-ordinated projects are likely to be more cost efficient and beneficial for these regions than having separate national programmes. Nevertheless, there are tendencies that these countries will go different ways, because of the dissimilarities in the nature of their present economic and political objectives. This is not beneficial in light of the overall goal of efficient use of resources in environmental restoration. Geographical proximity, similar political structure, and the same types of waste dictate co-operation and the use of similar technology and experience.

Public attitudes. Another problem with environmental restoration projects is the governmental, scientific and public view of the problem of radioactive waste. Since radioactively contaminated substances have been commonly used in these regions for nearly 50 years, in conjunction with outdated practices in the handling of the material, the public has had little recourse but to accept the presence of radioactive waste around them. In many instances, the public did not even know that these substances were in such close proximity to their homes. This situation appears to be changing, as people in these countries come to understand the hazards associated with such waste.

Solutions for contaminated sites

In many ways, the strategy used to deal with contamination and releases from operational mining and milling facilities is similar to that used in past practices. For example, erosion-driven, off-site contamination is characterized and, where practical, excavated and returned to the original site. Certain practices and strategies, if put into place during the operational period, can result in significantly reduced restoration efforts at the time of closeout.

Current strategies for mining and milling. Current operations employ certain practices, in conjunction with an overall isolation and burial strategy, which provide a safer and more effective approach to disposal. These waste management practices include spraying ore piles and tailings beaches with water and/or chemical stabilizers; use of baghouses at the crushing and blending areas; combined use of wet scrubbers with baghouses at U_3O_8 drying and packaging areas; grouting mine cavern walls; adding neutralizing agents to tailings liquids, and ventilation of underground mines.

Tailings impoundment and waste rock piles. Current waste management strategies at conventional mines and mills consist of burial, backfilling mines, and deep/shallow lake disposal. These types of disposal strategies can be greatly enhanced by additional features for environmental protection:

- backfilling mines with soil/rock aggregates;
- use of mine bulkheads;

- chemical neutralization;
- liquid waste impoundment liners;
- progressive trench disposal systems;
- pumping of ground water; and
- drainage/seepage collection and treatment systems.

Unconventional mining operations. In many cases, the mineral resource is of a nature which does not easily or economically lend itself to conventional mining and/or milling. Industrial processes are available which permit the resource to be extracted, but without the costs and other burdens associated with conventional ore processing. These processes are generally referred to as unconventional mining or milling. In contrast to conventional mining and milling, these types of operations tend to be smaller scale operations where it is uneconomical or impractical to excavate the ore loads. The main types are *in situ* leaching (solution mining), heap leaching, and byproduct recovery. If these types of smaller scale, relatively economical facilities are properly maintained and operated, CEE countries and the NIS could maintain a production level of U_3O_8 without having the burdens and hazards of large surface waste impoundments.

In some CEE countries, both *in situ* mining and conventional milling have been used (e.g., Czech Republic and Bulgaria). Heap leaching has been used in Hungary. The principle for byproduct recovery is to take advantage of an existing industrial process by diverting the operational — or even waste — stream for an additional extraction process. For example, former uranium mining and milling facilities in Kyrghyzstan (Karabalta) will be converted to processing for gold. Although heap leaching and byproduct recovery are fairly discrete and controllable operational strategies, *in situ* leaching requires a more carefully controlled operational sequence to be successful without contaminating useable aquifers.

Current strategies for restoration

The approach to restoration for contamination resulting from past practices in uranium and thorium mining and milling is very similar to the reclamation efforts usually exerted at the time of operational closeout of current mines and mills. Selecting the scope and extent of restoration is complex, because the impacts from these facilities usually become evident only after a number of years. In effect, the hazard is more of a latent or chronic one. The restoration effort involves one or more of the following:

General earthen construction. Backhoes, bulldozers, and scrapers are the typical kinds of earth-moving equipment involved. However, the radioactive nature of the contaminated soils and rock also requires monitoring of personnel and equipment and decontamination of equipment and work areas.

Cleanup of contaminated materials. In some cases, the residues of past operations have been used for construction purposes off-site. The legacy of this practice is a proliferation of such radioactive wastes in structures and land which would not ordinarily be so contaminated. Unlike the nuclear facilities themselves, there is a limit to the degree of restoration that can be performed at these off-site properties. More regulatory flexibility may be needed in such cases. For example, waste rock utilized in building a rail line may need to be treated *in situ*, because excavation and reconstruction might entail other more disruptive consequences.

Water contamination. Ground and surface water resources present a greater technological problem for restoration. The costs for restoring a deep aquifer forces a higher reliance on natural restoration as part of the overall strategy for cleanup. A number of countries in the CEE and NIS regions are faced with the problem of contaminated water bodies. Others are in the investigation phase to determine the extent of such contamination.

Although exclusive reliance on some of the more expensive technologies may be outside of an individual country's resources, a combined strategy involving natural restoration and active water treatment (e.g. ion exchange) may be worth considering. In many cases, an immediate benefit accrues when the source term is terminated. Uncovered waste rock piles and other radioactive materials should be isolated and stabilized, as soon as possible. Rain can interact with such waste to create additional contamination problems (e.g., acid wash from the waste rock).

An important facet to any restoration strategy is the benefit of partial restoration; natural restoration, or a more simple approach, can be greatly enhanced when the aquifer or water body is restored to an improved condition, which can enable nature to recover (e.g., modifying the pH by addition of neutralization agents as simple as limestone).

Role of monitoring in environmental restoration. In order to adequately characterize the extent of the problem and to measure the progress of any restoration strategy, it is necessary to employ an efficient, reliable, and well-placed monitoring system. Ultimately, such a monitoring system is necessary to demonstrate whether restoration has been successfully achieved.

IAEA programmes in uranium mining and milling

The IAEA has basically three mechanisms in its waste management programme:

• development of documentation to assist countries in implementing their own national programmes.

• providing a forum and clearinghouse for technical exchange of information.

• promoting technical co-operation and assistance to developing countries for peaceful use of nuclear materials.

Two examples of recent IAEA initiatives in this programme are provided below.

An IAEA programme focusing on radioactive waste standards (RADWASS) includes publications of guidance in the area of uranium mining and milling, including a proposed Safety Standard on restoration of facilities and the environment.

The IAEA has also supported a regional technical co-operation project on environmental restoration in CEE. Most of the efforts focus on characterizing the type and extent of waste and in the planning of the implementation strategies for the cleanup. A series of workshops has been held (1993-94) in some of the CEE countries to provide first-hand perspectives of the contamination problem. These workshops addressed characterization of the waste sites, planning restoration, and implementation of and techniques for restoration. The types of sites being considered included uranium mines and mills, but the project was not limited to only mining and milling contamination (e.g., Chernobyl was included). Countries with expertise in rehabilitation and remediation of radioactive waste sites have also taken part in the project. To the extent possible, those entities responsible for the monitoring and cleanup of each site were identified. Without having a responsible or accountable entity, there would remain doubts regarding initiation, execution, and completion of any rehabilitation effort.

This technical co-operation project, now into its 1995-96 phase, consists of establishing work plans for the restoration of mining and milling contaminated sites. Beyond 1996, efforts will shift to the national level, in order to focus on the site-specific aspects of these types of facilities. The results of these workshops have recently been published by the IAEA (as TECDOC-865).

Ongoing challenges

As the CEE countries and NIS move into the global economy, they are faced with significant challenges to compete in the private industrial sector, including uranium processing. Although some of these countries still possess viable quantities of the natural uranium ore, they still need to address the legacy of outdated waste management practices, which have burdened them with large inventories of tailings and waste rock, as well as other industrial waste.

The international community acknowledges this situation and has provided assistance to these countries through a number of means. The IAEA has participated in assistance efforts within the framework of its technical co-operation programme. In doing so, the IAEA is linking this assistance to internationally accepted criteria and standards. This is being done to assure that the future development of resources in the uranium mining and milling industry, as well as the associated environmental restoration of the residues of the past, are performed in a manner which does not repeat the mistakes of the past. ❐

Uranium open pit mining in Uchkouduk, Uzbekistan.
(Credit C Bergman, IAEA)