Problems of groundwater and environmental protection in connection with abandoning of mining activities in the Czech Republic

Arnost Grmela *, Jiri Tylcer **

* VSB - Technical University Ostrava, Institute of Geological Engineering, 17. listopadu St., 708 33 Ostrava -Poruba, Czech Republic. tel. +420 - 69 - 699 3500 ; E-mail address: arnost.grmela@vsb.cz

** AQ-test, Inc., Mlynska 5, 702 00 Ostrava, Czech Republic, tel. +420 - 69 - 611 52 24 ; E-mail address: aq@aq-test.cz

ABSTRACT

Environmental safety requirements for an underground waste disposal are discussed in the paper. A principle of „safe" disposal depth, at which only a limited groundwater exchange with shallow groundwater and surface waters exists, is explained.

There are attempts in the Czech Republic to exploit closing mines for an underground disposal of large-volume industrial wastes with low hazardous potential. Due to difficulties with interpretation of waste legislation requirements, wastes could be disposed only to one mine till now.

GENERAL ASPECTS OF AN UNDERGROUND WASTE DISPOSAL

Two principal cases of an underground waste disposal can be distinguished in practice:

- waste disposal in underground spaces that stay permanently accessible and maintained,
- waste disposal in mine workings into which no access is possible after the mine closure when no permanent maintenance of the disposal spaces continues.

The first approach represents no extraordinary problem in a view of environmental safety. In principle, **an underground waste disposal in workings with permanent access** can be regarded as any other waste storage. The specifics of its safety, maintenance and control can be technically solved in case some basic requirements for the particular properties of the host rock massif are fulfilled. In case of any problem, stored wastes could be evacuated any time without substantial difficulties. However, long-term maintenance and drainage of workings are usually not a cheap matter. Therefore, this way is considered especially for cases when economic aspects are predominated by environmental advantages issuing from the fact that the underground disposal offers certain shielding of some extraordinary wastes (e.g. radioactive wastes) from the sphere of an active environmental usage.

Of course, extraordinary character of disposed wastes calls for extraordinary careful choice of a host geological structure and verification of its properties. Its safety must be assessed also for worst case accident scenarios. For some potential accidents, an underground disposal can be a positive element.

These host rock massif properties are decisive in this context:

- homogeneity and characteristics of the particular host rock massif in a point of view of geotechnical stability of disposal and access mine workings,
- permeability of the host massif,
- seismic stability of the area,
- hydrogeological regime characteristics - a location of a disposal site above a groundwater drainage base of the area is preferred (less problems with groundwater inflows, reduction of risks from potential migration of pollutants).

The other approach to an underground waste disposal does not take a permanent access to a disposal site and any maintenance of mine workings into account. These so called **"buried" disposal sites** are out of any direct control from the moment the mine is closed, dewatering ceased and a shaft liquidated. Site remediation or its evacuation in case of any emergency is unrealistic or it would mean an extraordinarily complex and expensive problem.

This kind of an underground waste disposal is more frequent, being an attractive alternative for improving economy and extension of an active life of mines at the end of their working life.

It is almost a rule that the approaches of investors and designers to environmental safety for this underground disposal type are wrong in principle. An emphasis is laid to elements which are important from a point of view of short-term safety - great attention is used to be paid to technical aspects of the waste containment, to impermeable floor lining of disposal workings, to closure barriers between disposal sites and other mine workings etc. The consequences of a principal changes in the groundwater regime which occur after a mine closure are neglected, sealing properties of the rocks are over-estimated.

The safety of a "buried" underground waste disposal site must be assessed from a long-term point of view. It should not be based on elements, the reliability of which can not be guaranteed with absolute certainty for a time horizon of thousands of years.

Such a long-term safety assessment should take into account a final failure of sealing properties of both the disposal site walls as well as closing barriers and waste containers due to rock pressure and/or corrosion. If a site elevation is under a regional drainage base and mine dewatering is ceased, the site as the whole massif - which is never absolutely impermeable - will be watered after some time. Therefore, the safety assessment must be based on a premise that it is technically impossible to guarantee permanent isolation of stored wastes from groundwater in an unmaintened mine for unlimited time.

Under these circumstances, the feasibility study and the environmental impact assessment must be based on a quantitative balance evaluation of:

- a potential transfer of contaminants from disposed wastes to surrounding groundwater, following a failure of technical sealing barriers,
- environmental consequences of further transport of contaminants with groundwater flow.

This balance must be based on a detailed site - specific analysis of hydrogeological conditions of a respective site which should deal with the following problem subjects:

- evaluation of permeability of the host rock massif as a whole,
- assessment of the importance of inhomogeneities (significant tectonics, fissure zones, rock loosening resulting from mining activities, mine workings themselves) as potential preferential pathways for communication of groundwater from a waste disposal area with the surrounding environment,

- analysis of a host massif groundwater regime for these principal situations:

  a) a period before the mine dewatering is ceased (the lowest mine floor is a drainage level for infiltrated water descending through the massif),

  b) an interim period following the mine closure, before the massif is fully saturated by water,

  c) a final groundwater regime after the full saturation of the massif previously dewatered during mining - that regime is supposed to be close to the original situation before the mining started.

The analysis of a final groundwater flow pattern following the mine closure is decisive for the long-term environmental safety assessment. The most important factor here is the disposal site elevation in relation to a regional drainage base level of groundwater flowing through the site after a restoration of the original groundwater regime.

The bigger the depth under the regional drainage base, the lower the intensity of the groundwater exchange with shallow groundwater and surface water. In greater depths, groundwater circulation runs under very low gradients with adequately low speeds. It results in very low quantity of groundwater flowing through a cross section which can be directly influenced by leachates from a waste disposal site. Very low gradients also eliminate an influence of potential hydraulic shortcuts represented by remaining mine workings and other inhomogeneities of the rock massif.

In case of the sufficient disposal site depth with respect to the reach of an active water exchange zone and in the massif with generally low permeability, the contact of groundwater from the disposal site location area with an upper sphere of an active living environment can be practically negligible.

Site-specific quantification of indicated presumptions issuing to a „safe" disposal depth specification must be based on reliable input data. From this point of view, long-term mine dewatering records and other hydrogeological and hydrochemical data gathered during the mining within a respective mining region have an irreplaceable value here. Knowledge gathered from this experience can not be matched by any wide-scale and cost demanding special investigation works.

Finally, a potential impact of contamination caused by disposed wastes can be derived from the share of groundwater flowing through the site area on the total water balance of target water receptors (shallow groundwater, surface water bodies, other aquifers in contact). Groundwater contamination in the site area is governed by waste leachate characteristics and by a leachate transfer dynamics.

The waste containment, their encapsuling by low permeable materials with sorption properties, another artificial site sealing barriers, etc., can be considered to be additional measures to increase the disposal site environmental safety. In spite of the fact that we cannot guarantee their permanent functionality, they can reduce contact area of the wastes with groundwater, thus contributing to the elimination of leachate of contaminants and their entry into further transport. Sealing dam barriers on entries to disposal workings can suppress preferential groundwater flow through workings and thus total flow through the massif. An appropriate location of the waste disposal site out of the zones with higher permeability (tectonics, loosened zones) is also important from this point of view.

A recharge of liquid wastes into mined off petroleum or gas deposits or into other suitable structures is a specific variant. of a „buried" waste disposal. Existence and preservation of such deposits for geological epochs up to the current time can be considered as a sufficient proof of a host structure isolation. When exploiting these structures for waste disposal, original deposit pressures and fracturing pressures should not be exceeded.

EXPERIENCE WITH UNDERGROUND WASTE DISPOSAL IN THE CZECH REPUBLIC

There was a project for storing radioactive wastes from nuclear power stations in a controlled underground storage in the Czech Republic. The idea had to be abandoned due to the strong public opposition.

All other projects for underground waste disposal are aimed on exploiting closing mines. At present, mining activities are decreasing in most mining regions of the Czech Republic. Many mines are closing, huge capacities of mine workings in various depths and geological conditions are abandoned and liquidated. There are attempts to use these spaces for underground waste disposal. The attention is focused on disposal of industrial wastes with low hazardous potential, mainly from heat and energy production and from metallurgy (ash, flay ash, gypsum, slag, cinder, inorganic sludges and dusts). Annual production of these wastes reaches highly above 20 mil. tons in the Czech Republic and their surface disposal is considered to be a serious environmental problem because of land-use constraints in densely populated areas.

Czech waste management legislation has turned up to be a crucial obstacle to employing liquidated mines for that purpose. The legislation specifies general technical requirements for waste disposal. These requirements were written with regard to surface disposal and it is impossible to comply with them in case of mines. Basically, industrial wastes must not be in any contact with groundwater - it is accepted only for wastes with leachate concentrations on the level that is close to the drinking water standard.

To overcome that obstacle, wastes must be declared not as wastes but as a filling material for liquidated mine workings. Of course, a thorough assessment of environmental impacts is required in any case. Approval procedures are carried on a site-specific base. They are time consuming. In many cases, mines had not been able to continue with maintenance and dewatering until a final official approval for underground waste disposal was obtained.

The Sverma mine in the Upper Silesia coal basin is the only case is the only success story in the Czech Republic till now.

The Sverma mine is located in a closed hydrogeological structure that has no contact with any exploitable aquifer. General permeability of the rock massif is in an order of 10^{-8} m.s^{-1}, higher values can be observed only in loosened or tectonic zones. Analysis of hydrochemical and hydrodynamic data confirmed that under a natural conditions, after a mine dewatering is ceased and an original groundwater regime will be restored, an intensive groundwater exchange can reach maximally to depths of few tens of metres. Groundwater can be regarded as practically stagnant in depths below 400 m.

Nearly 250 thousands tons of ash, flay ash, flotation tailings were disposed in the mine. Altogether, 16,6 km of mine workings were fully filled with them. Wastes were transported to the mine hydraulically, separated water was recirculated. It is supposed that a self-solidifying waste mixture will have a positive effects on the geomechanical stabilisation of the rock massif and its impacts to the surface. Analyses of separated water and mine water quality monitoring confirm predicted minimum impacts of waste leachates to groundwater of the host structure.