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WATER TREATMENT STRATEGY FOR UNDERGROUND AND SURFACE WATERS IN ORDER TO REDUCE THE HYDRO-NETWORK CONTAMINATION DUE TO CLOSE OUT OF A URANIUM MINING AREA IN ROMANIA

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Abstract

Under the present circumstances, in correlation with the national nuclear program and strategy, it is foreseen to stop the exploitation activities in two important uranium mining areas from Romania. This close-out action is involving a number of technical decisions for environmental restoration. Reduction of waters radioactive contamination in these zones, both during the operating period and after the closeout period, is one of the main components of the environment rehabilitation strategy.

In this paper there are presented the today situation and the program foreseen for ground and surface water treatment at an uranium mining unit situated in the SW side of Romania, program based on the results of our own research carried out to decrease the content of pollutant radioactive elements.

General

Nowadays the uranium industry has to face the lowering of uranium price on market. The interested companies are adopting various strategies to survive. The actual restructuring strategy of Romanian uranium industry is to stop the activity in several mines.

In Romania there are three mining districts: Bihor in NW, Banat in SW and Suceava in the NE side of the country. The uranium ore mined in these zones is sent to the processing plant in the country center. In the future, as a result of the closeout politics, some mines from Banat and Bihor will undergo processes of closeout and ecological remediation.

In Banat district there are several mines still operating i.e. Ciudanovita, Dobrei North, Dobrei South and Natra. The geological exploration of uranium ore bodies in Banat started in 50's but the exploiting activity of these uranium deposits started at different times for each mine. The geological and mining conditions of uranium deposits, corroborated with the existence on the mines surface of water flows, sites communications, have led at the mining methods only with filling in the excavated space. The area where mines are located has mountainous relief, forested slopes and narrow valleys with the hydrographic network consisting mainly of tributaries from the left bank of the Caras river basin. The main watercourses are Jitin (crossing Ciudanovita) and Lisava (crossing Natra and Dobrei) brooks. These surface flows influence the underground waters. Their flow rate isn't constant, varies from 0.2 to 1.0 m^3/sec. The multi-annual average of rainfall is 860 mm.
Figure1 presents the diagram of opening works for this studied area, including the underground water evacuation system.

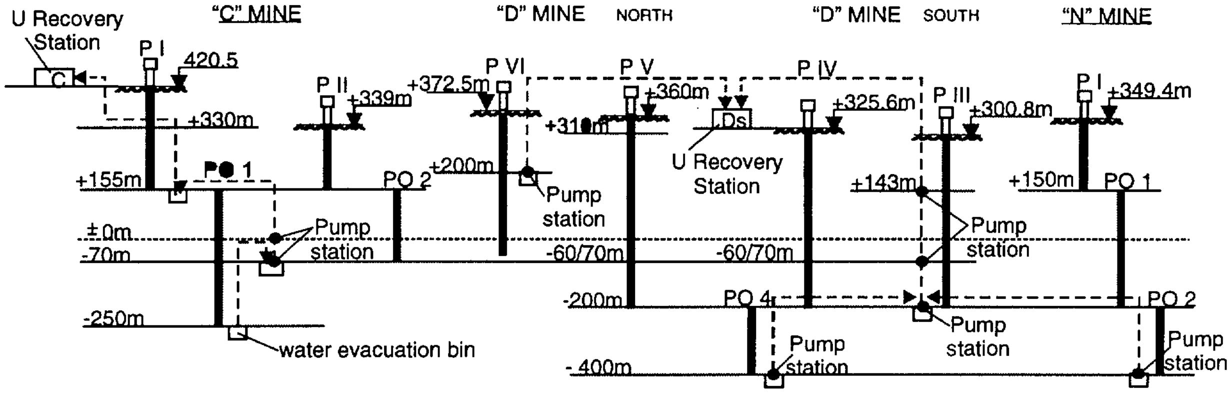

Figure 1. The diagram of opening works - underground waters evacuation system

Generally, the polluting sources from uranium mine are: (1) mine and surface waters (2) waste and poor ore heaps or dumps and (3) radon release. The main pathway of contamination is water: mine water and water washing ore piles. This water discharge to surface water has the greatest environmental impact. When closing a uranium mining area it is very important to settle a water treatment strategy in order to reduce the hydro-network contamination.

Major sources of the surface water contamination are:

- Surface discharges from controlled underground discharges from treatment plants;
- Leaching of radionuclides by surface streams flowing through or eroding spoil heaps;
- Contaminated groundwater from uncontrolled discharges from surface drifts; and
- Run-offs from surface spoils heaps.

The Present Mine Water System

Different laboratories sampled the waters courses from Banat area in the past twenty years viewing the assessment of environmental impact of uranium ore mining. The Romanian standards for discharge waters are the drinking water standards specifying the following accepted limits for radionuclides:

- Natural uranium	0.021 mg/l
- Radium	0.088 Bq/l

These limits are more restrictive than those of almost all-European states. The existing levels of U and Ra measured in surface waters exceed the limits. There were sampled also the sediments from rivers and brooks at different distances upstream and downstream from mines.

There were analyzed the mine waters to find which are the polluting elements and their contents. The analysis showed that the pollutants exceeding the Romanian standards are solid suspensions (which proved to contain radionuclides), uranium and radium in soluble forms and sometimes arsenic. The radionuclides content was varying in time, depending on the mined ore quality. The content of solids in suspension was 5-10 g/l, uranium concentration was sometimes (in the years with intense mining activity) greater than 4 mg/l (now is 1.5-2 mg/l) and radium content is 0.1-0.5 Bq/l.

At present there are treatment stations at Ciudanovita and Dobrei South that processed mine water to decrease its uranium content. Their capacity is 1000 (12 l/s) respectively 1500 (18 l/s)

m^3/day. The mines closeout program includes a flooding strategy along with water treatment strategy. The water treatment strategy depends on which type of flooding is chosen.

If only Ciudanovita mine is going to be closed by stopping the pumping of the deep mine water from below –70 m it means that:

- it'll be decommissioned the treatment station;
- the deep waters will flood the mine's depths and overflow down the –70 m roadway into the Dobrei mining complex;
- the inflow from Ciudanovita will require an increased capacity for water treatment in Dobrei with additional groundwater problems; and
- during periods of high rainfall it is to be expected high levels of groundwater contamination from surface waters that cross the spoil rock piles, thus it will be necessary to treat this contaminated water.

Other closeout strategies include the construction of high or low-pressure plugs with totally or partially controlled flooding.

Water Treatment Technology

The present operating water treatment stations, whose capacity is already too small, are treating the water only to diminish uranium content. Thus, the '98 average inflow U content was 2.71 mg/l and the discharged water had 0.176 mg/l. The future situation generated by mines closeout will imposed a new, enlarged strategy, developed to perform uranium removal from a much larger volume of water, to a greater extent and also to remove solid suspension and radium as to comply with the standards. The technological present flowsheet is presented in figure2.

The new mine water treatment technology has three main phases:

- removal of solids in suspension by natural or forced decantation in multi compartmented horizontal decanters;
- uranium removal by ion exchanging in batteries of 3-4 columns filled with ion exchange resin; the process occurs in fluidized bed system, each column being possibly to be disconnected; and
- Radium removal by adsorption on active coal columns linked serially to the ion exchange columns of each battery.

Water is pumped with flocculant addition into decanters. The clear overflow is passed into a reservoir and from there enters the ion exchange battery. The ion exchange columns are operating till the uranium content in discharge reaches the maximum accepted limit of 0.021mg U/l. At this moment the first operating column is disconnected from battery, washed with water and eluted with a mixture of sodium carbonate and chloride. The first two BEVs of eluate with a minimum content of 5 g U/l are to be stocked in a tank and sent to the uranium processing plant for uranium recovery as sodium diuranate. The eluted resin is washed, regenerated and connected back in exchanging circuit. The discharged water from ion exchanging battery is supplying the activated coal columns till the discharged water from the last column reaches the accepted limit. The coal columns may be washed with a hydrochloric acid solution and radium co-precipitated as $Ba(Ra)SO_4$.

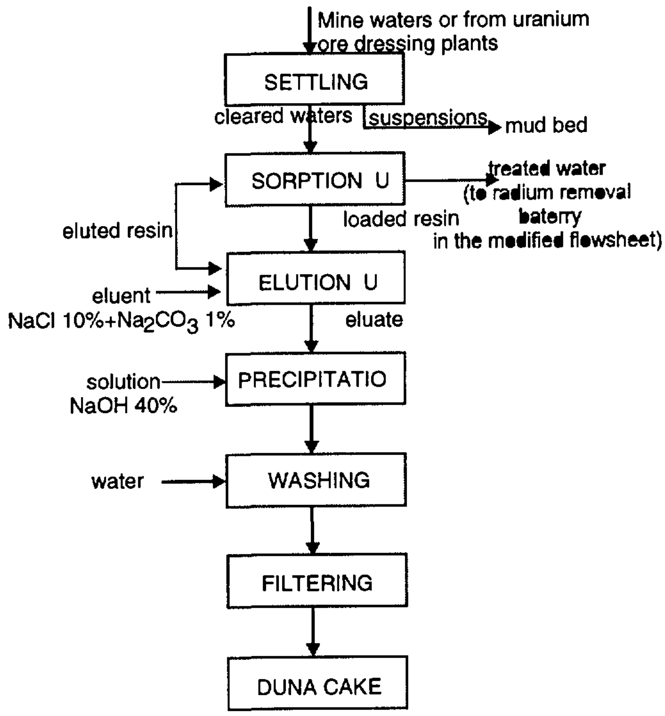

Figure 2. Scheme of main operations
Uranium recovery stetion

Estimated Capacities and Costs

The composition of artesian mine water likely to appear at surface when the Ciudanovita mine flooding is completed is actually estimated. However the mine water has a relatively high pH, the sulfide concentration in ore is relatively small so it'll be possible to suppose that the carbonate content will buffer the water and the increase of radionuclides concentration during flooding will be insignificant. The results of geochemical modeling of the flooding process suggest an estimate of 1.6 mg U/l and for Ra 0.2 Bq/l.

The costs depend on the estimated capacity correlated with the chosen flooding variant. Estimation of the investment costs for water decontamination has been made without taking into account the existing treatment stations nor salvage or reuse of some equipment. It was thought that a single treatment plant to control all mines discharges is more advantageous.

The following data were taken as future parameters for the treatment plant:

- Solid in suspension in feed water	max. 5g/l
- Uranium concentration in feed water	2-2.5 g/l
- Radium concentration in feed water	0.2-0.3 Bq/l
- Uranium concentration in discharged water	max. 0.021 mg/l
- Radium concentration in discharged water	max. 0.088 Bq/l
- Fixing cycle	max. 60 days
- Resin or coal columns charge	3.6 m^3

In these conditions result the following necessary equipment and investment costs:

- for 10 l/s mine water flow-rate: a battery of three ion exchange columns and two activated coal columns; the cost could be 65,000 US$;
- for 20 l/s mine water flow-rate: two batteries of three ion exchange columns and two activated coal columns each; the cost could be 75,000 US$; and
- for 30 l/s mine water flow-rate: three lines of three ion exchange columns and two activated coal columns each; the cost could be 85,000 US$.

The cost of processing water could be about 0.1 US$/$m^3$ of decontaminated water. It wasn't taken into account the uranium recovered from mine water that can be used to offset the cost of water treatment. The estimated costs for water treatment are to be compared with other costs concerning the environmental remediation.