RADIOACTIVE WASTE REPOSITORY
SITE SELECTION IN
THE REPUBLIC OF SLOVENIA

ABSTRACT

The report shows the procedure for the low and intermediate level radwaste (LLW and ILW) repository site selection and the work performed up to the present.

The procedure for the repository site selection is divided into four steps. In the first step the unsuitable areas are excluded by taking into consideration the rough exclusion criteria. In the second step, the remaining suitable areas are screened to identify the potential sites with respect to preference criteria. In the third step three to five candidate sites will be assessed and selected among the potential sites. In the final, the fourth step, detailed site investigation and confirmation of one or two most suitable sites will follow.

In Slovenia the 1st and the 2nd step of site selection have been completed, while step 3 is now in its final stage.

POVZETEK

Referat prikazuje postopek izbora lokacije odlagališča nizko- in srednje radioaktivnih odpadkov v Republiki Sloveniji.

Postopek izbora lokacije odlagališča poteka v štirih stopnjah. V prvi stopnji se izločijo neprikladne področja z upoštevanjem grobnih izočilnih kriterijev. V drugi stopnji se primerna področja zožijo na potencialne lokacije ob upoštevanju primerjalnih kriterijev. V tretji stopnji se med potencialnimi lokacijami položka 3 do 5 najprimernejših lokacij, vrednotenih na osnovi kvalitativne ocene potencialnih lokacij. V zadnji, četrti stopnji, se pristopi k detaljnem terenskim raziskavam, s katerimi se preveri ustrezno izbora. Rezultat četrti stopnje sta 1 do 2 strokovno potrjena najprimernejša lokacija.

V Sloveniji sta bili zaključeni 1. in 2. stopnje izbora lokacije, medtem ko je 3. stopnje v zaključni fazi.
1. INTRODUCTION

Waste is the problem of every civilized society. Unfortunately, no real attention has been paid to its safe disposal for decades. Nowadays, this problem has gained an emphasized negative connotation in our society, which makes its solutions even more difficult. It is indisputable, however, that waste is not hazardous, provided that it is professionally conditioned and safely disposed off.

As a result of development and use of radioactive and especially nuclear materials in nuclear power plants, research work, industry and medicine, a certain quantity of radioactive waste has been and still is generated. Radioactive materials that cannot be further used become waste that should be isolated from the human environment for the time necessary for the radioactive waste to reach the level which is not dangerous. The time depends on half-lives of individual radionuclides and is for LLW and ILW approximately 300 years. The purpose of the LLW and ILW repository is the final disposal of radwaste in the manner that will not affect human life and environment neither at present nor in the future.

2. QUANTITIES, TYPE, AND FORM OF RADIOACTIVE WASTE

LLW and ILW from the NPP Krško are packaged into 200 liter drums. The low-active compressible waste is packaged without additional protection, while the remaining more active waste is protected with an additional concrete shielding inside the drums.

During the operation of the NPP Krško (by the end of the year 1991) 1647 m$^3$ of LLW and ILW in 8241 drums were generated. The average specific activity in the drums, calculated as of the date of filling, is 21.5 GBq/m$^3$ which ranks them into the group of ILW with beta and gamma emitters (according to our Regulations).

The assessment of the anticipated amounts of LLW and ILW includes the needs of the NPP Krško as the main generator of LLW and ILW and user of the repository for an operational period of 40 years. Considered is also the decommissioning of the NPP Krško and of the Research Reactor TRIGA as well as the LLW and ILW from other users in Slovenia.

The assessment is made conservatively so that the anticipated amounts of LLW and ILW represent a maximum amount of LLW and ILW.

During the operational period of the repository of 40 years, the total net volume of ILW and LLW in Slovenia will amount to 17,623 m$^3$.

3. CONCEPT OF THE REPOSITORY

To solve the problem of LLW and ILW disposal, there are two basic concepts developed and adopted in the world:

a) tunnel-type disposal
b) shallow ground disposal.

The method of final disposal of this type of radioactive waste particularly depends on the natural geological features (landscape configuration, soil composition, groundwater, etc.) in individual countries.

Potential areas in Slovenia include various sites, of which some are more suitable for shallow ground disposal and others which enable tunnel type disposal.
The basic requirement in planning a repository is to ensure safe disposal of LLW and ILW for a longer period of time.

The technical solutions of both concepts are to be such that the impact of radioactive waste to the environment will be negligible.

The type and conditioning of radioactive waste are exactly determined by regulations in order to meet the requirements of safe disposal. Regulations allow final disposal of radwaste only in solid form. Radioactive materials which do not meet this requirement are to be solidified.

The safety concept of multi barriers for LLW and ILW disposal reduces the possibility of radionuclide migration into human environment. An adequate number of natural and engineered barriers will reduce the release of radioactive materials into the environment and retain the migration of radionuclides into the environment, so that their effect will be within the acceptable limits.

Natural barriers are achieved with proper repository site selection. The site shall have the natural features to reduce the migration of the radionuclides into the environment.

4. PROCEDURE AND STEPS FOR SITE SELECTION

Siting of radioactive waste disposal facilities is an important step in developing a waste disposal system that would best suit the needs for accommodation of wastes from a national nuclear program and, simultaneously, satisfy all safety, technical and economic requirements set out in various national and international guidelines.

In the Republic of Slovenia the Guidelines for the low- and intermediate-level radwaste repository site selection were issued by the Republic Administration for Nuclear Safety. The Guidelines for site selection are the rules according to which, under given urban and social conditions, the most suitable sites for disposal of low- and intermediate-level radwastes in Slovenia would be selected.

The procedure for the repository site selection is divided into four steps. In the first step the unsuitable areas are excluded by taking into consideration the rough exclusion criteria. In the second step, the remaining suitable areas are screened to identify the potential sites with respect to preference criteria. In the third step three to five candidate sites will be assessed and selected among the potential sites. In the final, the fourth step, detailed site investigation and confirmation of one or two most suitable sites will follow.

Step 1 - exclusion of unacceptable areas

In the first step of site selection, the areas in Slovenia which are unacceptable for LLW and ILW disposal, are identified and excluded according to the following exclusion criteria:

- National parks
- Population distribution
- Drinking water resources - aquifers
- Known active faults
- Geothermal areas
- Seismicity of the site
- Flood areas
- Presence of ores, minerals, oil, gas
- Lithology
By screening method and considering all the criteria, the acceptable and unacceptable areas for LLW and ILW disposal are identified.

The result of step 1 is the identification of acceptable areas which are not ranked.

National parks

National parks are parts of natural and cultural heritage, defined by law, being of great and exceptional importance for the Republic of Slovenia. They are primarily intended for the preservation of ecosystems which are under severe state protection restricting interventions in this area.

Settlements with more than 5000 inhabitants

In Slovenia, the total number of excluded areas with more than 5000 inhabitants is 38. At this step of the study, the limits of urban zones for 7 settlements with more than 20,000 inhabitants are presented. In the next steps, the settlements with a smaller number of inhabitants will be excluded.

Drinking water resources

Excluded are all areas defined as drinking water resources.

Known active faults

Excluded are all areas located on a known active fault at a distance of up to 3 km.

Presence of active faults and fissures means a potential seismotectonic unstability of the site; it could cause fissures on the repository facility and subsequently also the migration of radionuclides into the groundwater and human environment. The way to the underground water is possible through open fissures. Such fissures are found in all seismic areas of Slovenia. These are areas with surface fissures caused by previous earthquakes.

Slovenia lies on a seismic territory. Tectonic causes of seismic activity are surface active faults, fissures and faulting zones. However, they are not evenly distributed all over Slovenia. Most frequently they occur in the West Slovenia, among the Karavanke, the Savinja Alps and the Julian Alps in the north-west as well on the Croatian border in the south-east.

Geothermal areas

The territory of Slovenia is relatively rich with hot-water springs. There are over 30 hot-water springs in addition to some others where hot-water comes up from the wells.

Seismicity

The maximum horizontal ground acceleration on the territory of Slovenia was evaluated with probabilistic seismic hazard analysis.

In this way three separate areas were excluded. In the West Slovenia this region is in the vicinity of
Breginj and Kobarid, situated in the Furlanija seismic zone. The central part of Slovenia includes the area of the Ljubljana basin, extending up to Idrija. Here are the main seismic zones of Idrija and Ljubljana. In the east there is another area in the vicinity of Brežice and Krško, situated in the Brežice and Zagreb seismic zone.

Flood areas

Excluded are areas along the majority of Slovene rivers and Karst region. The basis for defining flood areas are the observed limits of catastrophic floods. In the next steps a detailed investigation of floods of smaller rivers and torrents will be considered.

Presence of ores, minerals, oil and gas

Excluded are the areas with proven resources of ores, minerals, oil and gas.

The most important energy source in Slovenia is coal. It is mined in Velenje, Zagorje, Trbovlje, Laško, Senovo, and Kanižarica.

Another energy source in Slovenia is uranium which was mined in the mines at Žirovski vrh.

Oil and gas fields are located in the surroundings of Lendava.

Metallic minerals, like lead and zinc are mined in Mežica and mercury in Idrija. Potential copper ore deposits are in the Cerklje area and Sovodenj.

Lithology

Lithological layers, having the hydraulic conductivity greater than $1.10^{-8} \text{ ms}^{-1}$ and the thickness of layers smaller than 20 m, are excluded as unsuitable.

The thickness of the horizontally low permeable layers must be at least 20 m; in this way they represent a natural barrier between the repository and groundwater. The excavation is necessary to avoid the surface fractured zone. With sloping layers the thickness must be at least 50 m, in order to find a 300 x 300 m area for the construction of the repository. With the tunnel-type repository an adequate thickness of low permeable layers under and above the tunnels is necessary to form a natural barrier against water seepage.

Due to the geological and lithological composition, as the well as hydraulic conductivity, the large limestone and dolomite areas in the west Slovenia, in the Julian Alps and the Savinja Alps and in the Karavanke are unsuitable.

Due to fissures, large slate areas on the Pohorje, Strojna and Kobansko as well as between Škofja Loka mountains and Kozjansko are unsuitable. For the same reason the tonalit of Pohorje is unsuitable.

Unsuitable are the areas with sand and sandstone layers in the east Slovenia, as well as gravelly dikes in the valleys and river plains due to their high hydraulic conductivity; besides this they contain large amounts of groundwater.
Potentially suitable areas after first step of selection

Considering all the exclusion criteria of the first step, suitable areas for the LLW and ILW repository site in the Republic of Slovenia have been identified. Potentially suitable areas are those that have not been excluded according to any criterion of the first step selection. All areas are considered to be equivalent, as suitable areas have not been assessed and evaluated.

As a result of the first step of selection, only ten suitable areas measuring from 1.5 to 84 km$^2$ have been identified. The sites are located in the eastern part of Slovenia and are shown on the map of suitable sites. (Fig. 1)

![Map of suitable sites](image)

**Fig. 1** Potentially suitable areas after step 1 of site selection

**Step 2 - Identification of potential sites**

In step 2 the acceptable areas are screened to potential sites.

Further assessment and comparison of acceptable areas is performed on the areas - units which are not greater than the required area for the repository site, i.e. 300x300 m.

For better and easier elaboration and division of work among various institutions, the criteria of step 2 have been divided into four groups.

**Land use**
- Natural heritage
- Populated areas - individual houses
- Populated areas - settlements, villages and hamlets of up to 1000 inhabitants
- Populated areas - settlements above 1000 inhabitants
- Industrial zones
- Health resorts, hospitals, educational institutions
- Roads
Transmission lines
- Other infrastructural routes and reservations
- Agriculture
- Forestry
- Cultural heritage
- Recreation and tourism

Water management
- Groundwater usage
- Surface waters destructiveness
- Energy (hydro power plants)

Seismicity
- Site seismicity

Geology
- Ground water
- Presence and vicinity of active geological faults
- Presence and proximity of geothermal areas
- Exploitation of ores/minerals, oil, gas
- Areal extent of soil
- Thickness of lithologically appropriate layers
- Soil unstability
- Erodibility

The result of step two is the selection of 36 potential sites having a total area of approx. 9 km². After the investigation had been completed, a site visit took place in order to check the procedure carried out so far and to establish any possible deviations from the results obtained.

Step 3 - selection of candidate sites:
In the third step three to five candidate sites will be assessed and selected among the potential sites.

The assessment is based upon the comparison and estimate of the criteria of step 2 and the additional preference criteria.

- Economic and technical feasibility
- Transport
- Social acceptability

Step 4 - confirmation of candidate sites by experts:
The three to five candidate sites selected in step 3 are further investigated in detail. Subsurface investigations to confirm the proper site selection, are required at the site.

The results of step 4 are one or two most suitable sites confirmed by experts.

Due to the complexity of the criteria, a large number of institutions participated in the elaboration of the study. Among them the Geological Survey of Ljubljana should be mentioned. The first and the second step for the repository site selection were completed by Elektroprojekt as the coordinator of the study. Now the third step for the repository site selection is underway.

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5. CONCLUSIONS

The radwaste repository site selection is being realized in accordance with the Guidelines approved by the Parliament of the Republic of Slovenia. The Guidelines summarize the international practice and the comments given by the international institutions who reviewed them. The repository site selection is not a technical problem, the problem is how to convince the people. The opposition of the people towards erecting a radwaste repository is vigorous for the reason that nobody wishes to have it in the immediate vicinity. Therefore, the repository site selection is more a social and political problem than a technical one, as there is a large number of repositories already built and operating worldwide. The public is to be confronted with the fact that radwaste are here and that safe disposal is the only alternative.

REFERENCES

/1/ Guidelines for the low- and intermediate-level radwaste repository site selection in the Republic of Slovenia Ljubljana, September 1991
Republic Administration for Nuclear Safety.

/2/ Low- and intermediate-level radwaste repository site selection in the Republic of Slovenia.

Step 1 - Exclusion of unacceptable areas
Step 2 - Identification of potential sites
Elektroprojekt Ljubljana, 1991

ANSWERS TO QUESTIONS FROM THE AUDIENCE

1. Who is going to solve the social problems concerning final repository?

A Radioactive Waste Management Agency has recently been established in Slovenia. Apart from the preparatory work, construction and operation of the repository, the tasks of the Agency also include public relations of solving the subject problems.

2. Is there an optimal site?

The final results of step 3 are not available yet. At this stage comparison of suitable sites will be made. The final decision on an optimal repository site and site characterization will undoubtedly be made during step 4. Up till step 3 the work included cabinet work only.