THE USE OF UNDERGROUND MINING SPACES FOR THE STORAGE OF HAZARDOUS WASTE

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Abstract: *Pressure as a result of economic, political and environmental factors determines the limited possibility of using the free space on the surface, so that the underground space becomes one of the few areas which may be used without a further degradation of the environment on the surface. This paper focuses on the need, advantages and disadvantages of using the underground space, especially the one created by the mining sector. Among the multiple possible uses of this space, we should pay attention to the storage of hazardous waste, in general, and mainly to a pilot storehouse project proposed for Romania.*

Keywords: *hazardous waste, underground mine space*

1. The need to use the underground space

The use of underground space can help solve the dilemma *environment - resources*, in some ways expressed by direct physical benefits and indirect economic advantages, less relevant for individual consumers [3], [5]

Among the direct physical benefits, the most important ones are: location, insulation, conservation and exposure.

Some of the advantages of indirect physical benefits are: the efficiency of land use, energy conservation, transportation, national security. These advantages are rarely important for an individual user but have a great value at the level of the economy.

The economic advantages are determined by the value of the initial costs (reduced costs for the purchase of land necessary for the carrying out of the projects) and of the operating costs (maintenance and use of energy).

The use of the underground space, nonetheless displays a series of disadvantages: underground geological environment can sometimes be adverse, insulation of groundwater can create thermal disadvantages within the underground facilities, television, radio, and mobile communication systems are not operational without antennas and special facilities, safety and psychological (claustrophobic) issues, financial impact (initial costs and operation costs), etc.

2. Reuse of underground mining space

The mining industry displays during its evolution three successive stages of development of the underground space [3]:

- traditional underground mining, when useful minerals were produced as well as waste rock dumps at the surface of the soil;
- underground mining with reuse of underground mining space, first unplanned and then planned;
- creating the underground space for certain underground developments while using the stuff from the excavations carried out.

The underground mining sites may be reused for various applications, such as: storage of various petroleum products, natural gas products and weapons, food and agriculture, storage of radioactive and hazardous waste; other civilian use, such as: museums, documents, bank safes, research centers, offices. On the other hand, the re-use of the mining areas can increase the value of the deposit or of some marginal parts of it, and they can become exploitable if the economic value of the resulting underground space is also considered. The reuse of the mining areas results in a reduction of operating costs in the mining industry.

One disadvantage is that the mining process can lead to the stability of the rock mass, making it improper for storage. In the case of hazardous waste, storage solutions can be found by excavating special mining works, in which case mines are used only for access to and from the operational facilities.

When designing the reuse of abandoned mines or when designing a new mine with future uses of empty spaces, already thought out, many different variables should be considered.

Mining engineers play an important role in this process by providing relevant information in locating and presenting current and existing underground excavation conditions as well as a source for concepts to be employed in the post-mining use of the underground space, contributing to economic solutions.

Due to the growing environmental constraints imposed by various laws in most developed countries, a significant number of underground projects have been built in recent years, while many others are under construction or in the state of conception.

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There is now a general focus on these types of engineering solutions and many countries have begun to consider the underground as a resource that needs to be treated and managed with care. Some developed states have decided to evaluate this important resource in their territory, meaning measuring natural underground spaces, abandoned mines, or other underground excavations, in order to contribute to adequate planning for large-scale projects, to search for and implement new solutions.

The underground environment is not only an object of potential impact but also a tempering element, which becomes clearer when the housed arrangement has the purpose of protecting the environment such as water treatment plants or landfills.

Underground layout and storage projects are feasible, can be economically viable and certainly provide environmental benefits.

Therefore, a detailed analysis of the environmental benefits associated with the use of underground spaces in economic terms can often allow for a change in the perspective that eliminates the setting of very high underground costs compared to their involvement in the infrastructure on the surface.

The benefits resulting from the underground arrangement are not only environmental benefits, they are valid for:

- everyone who is directly involved in the work (customer, user, building firm);
- economic and social units and people directly or indirectly involved due to the effects of the work.

In Romania, the use of the underground space in general, of the mining, in particular, consciously or its insufficient use, may be caused by [1], [5]:

- incorrect perception that geology is inadequate;
- the absence of strategic underground land use planning;
- the level of insufficiently allocated funds to this area;
- the absence or insufficient knowledge of the benefits of using the underground space;
- the absence of the necessary technology;
- insufficient monitoring of the respect for the environment

Research in Romania in this direction should include the following objectives:

- presentation of the key points of technical, geological and economic considerations in accepting or rejecting the use of underground spaces;
- assessment of geological, market, legislative and administrative frameworks related to the use of groundwater throughout the country.

It is also important to analyze the following areas with direct implications in the economic, social and environmental activity [2], [3]:

- storage of natural gas and petroleum products;
- industrial warehouses and consumer goods;
- food storage facilities;
- landfills;
- systems and elements of storage and operation of plants providing treatment of industrial and domestic waste waters;
- storage of agricultural products;
- storage of various building materials and raw materials; safety deposits;
- museum, tourist, recreational and sanatorium objectives.

This paper displays a pilot project using the underground mining space for the storage of hazardous solid waste.

3. Overview of hazardous waste

Hazardous waste means any waste which has one or more of the hazardous properties listed in Annex II. 4 to Law 211/2011 (republished) on the waste regime [7].

Hazardous wastes are harmful to human health as well as to the biological environment. Industrial uses employ artificially processed chemicals as well as various heavy metals extracted from the underground, which do not exist or do not represent an appreciable amount in the natural biosphere where the living organisms were designed or evolved. Thus, waste containing chemicals and / or excessive heavy metals content may be dangerous to the animals, which may lead to illness or severe intoxication, and even to death.

From a technical point of view, hazardous waste can be defined and characterized from three points of view:

• category/type of waste
• components
• properties that can cause the waste to be hazardous

The heavy metal content of the waste generally determines the hazardous nature of a waste.

4. Legal bases for waste management

At the level of the European Union, in the waste management sector, the main regulatory acts are grouped into [6]:

• Waste Framework Legislation: Directive 2008/98 / EC, Regulation 1013/2006, Decision 2000/532 / EC;
• Legislation on waste treatment: Directive 1999/31 / EC and Directive 2010/75 / EU;

• Legislation on waste streams: multiple Directives

The Romanian national legislation transposes the provisions of the Community legislation in the waste management sector. The full list of waste legislation, including secondary legislation, is presented in the preamble to the National Waste Management Plan (PNGD) version 5 of 2 November 2017 [6], which includes:

- Law no. 211/2011 on the waste regime, republished in 2014, as subsequently amended and supplemented;
- GD no. 1061/2008 on the transport of hazardous and non-hazardous waste on the territory of Romania;
- GD no. 349/2005 on waste disposal, with subsequent amendments and completions.

5. Generating, managing, exploiting/storing hazardous waste in Romania

The total amount of waste generated in a country reflects the efficiency of using natural resources, i.e. the ratio between production and consumption of goods.

Compared to other Central and Eastern European countries, Romania occupies a middle position in terms of the production waste / consumer waste ratio.

Quantities of hazardous industrial waste are generated in a low amount of non-hazardous industrial waste.

Table no. 1 shows the total amount of hazardous industrial waste generated in Romania, related to the period 2010-2014, as shown by the data presented by the National Environmental Protection Agency (ANPM). In addition, another 100-120 thousand tons of hazardous waste generated by other activities need to be added.

Table 1 *Generation of hazardous industrial waste in Romania, including extractive industry [7]*

Amounts generated	*2010*	*2011*	*2012*	*2013*	*2014*
Industrial hazardous waste generated, thousand tons	343,20	204,53	326,48	320,04	281,67

Data [6] show a slight decrease in hazardous waste generated during 2010-2014, with the exception of 2011 when there is a drastic decrease of about 40%. For 2014, the amount of hazardous industrial waste fell by about 18% compared to 2010, i.e. by 12% compared to the previous year. It can be noticed that despite the economic growth of Romania during the period 2010-2014 the amount of hazardous industrial waste has been capped less than 330 thousand tons annually.

Excluding the quantities of hazardous waste from the extractive industry, i.e. 42% of the amount of hazardous industrial waste generated during 2014, the three main categories of hazardous waste are:

- wastes from refining petroleum, natural gas purification and pyrolytic treatment of coal;
- wastes from the shaping, mechanical and physical treatment of the surfaces of metals and plastics;
- waste from thermal processes.

In the period 2010-2014, most of the hazardous industrial waste generated, in stock, was subject to recovery or disposal operations. Among the capitalized ones are quoted:

- refinery waste, natural gas purification and pyrolytic treatment of coal;
- wastes from inorganic chemical processes;
- wastes from the shaping, mechanical and physical treatment of the surfaces of metals and plastics, and
- waste from thermal processes.

The most used elimination methods reported for 2014 were:

- physicochemical treatment (evaporation, drying, calcination, etc.);
- incineration;
- storage in specially built warehouses (depositing in sealed separate compartments which are covered and isolated from one another and from the environment and the like);
- storage prior to any operation, excluding temporary storage, prior to collection, in the waste generation area.

Elimination installations are either waste generators or other authorized operators for waste disposal.

The most widely used methods for the recovery of hazardous industrial waste for the year 2014 were:

- use primarily as a fuel or other source of energy;
- recycling / recovery of metals and metal compounds (5%)

In the case of hazardous industrial waste, there are two types of recovery: material recovery (reintroduction into various technological processes) and energy recovery (in co-incineration plants).

At the national level, there are about 40 authorized economic operators for the material recovery of hazardous industrial waste and 12 incineration plants dealing with industrial waste taken from third parties and 7 plants dealing with industrial waste generated from their own activities.

As far as storage is concerned, there are currently 10 landfills for hazardous waste, of which only 2 take away waste from third parties, the remainder being warehouses belonging to generators.

6. Current state of use of underground space for the storage of hazardous waste

Compared with the storage of underground radioactive waste, which has been studied for several years, in the case of the storage of underground hazardous waste, there is not yet a fully comprehensible term or concept.

Specialized literature around the world today reports on possible solutions for mine reuse and the considerable funds allocated to research into this concept reflect the increasing interest in this topic.

The entry into operation of Harfa-Neurode underground storage facilities (Germany) in 1972, Heilbronn (Germany) in 1987, former salt mines and Zielitz (Germany) in 1994 (former potash mine) opened the door to new research for the purpose of re-using the underground mining areas [4].

Successes and security provided led to similar arrangements in Norway and France, and implicitly the concern and involvement of a large number of research institutes in the development of a concept of safe underground storage.

Today, most Western countries that have underground mining sites have speeded up research, assessing the behavior and safety over time of these facilities, checking the possibility of using them as possible landfills for hazardous waste. These assessments have led to the conclusion that almost all types of mines (salt, coal, gypsum, ore, etc.) can offer such perspectives, while the investigation of the nature and characteristics of the waste, and the nature of the host rock, could result in proper underground storing spaces.

Romania has relatively recent concerns in this area, yet, not directly through the storage of hazardous waste, but on the inventory, the assessment of the underground spaces that can be converted into underground deposits and the finding of technical solutions for safe storage due to the initiative of some researchers who have become aware of the potential offered by this bold concept.

7. The concept of hazardous waste storage in deep geological formations

The purpose of underground storage of hazardous waste is to isolate it from the biosphere, so that in the case of migration of hazardous substances in the storage area (heavy metals, etc.), it does not pose a threat to the safety of environmental components.

Of particular importance to ensuring and fulfilling this requirement is the action of multiple geological barriers, both natural and technical, which should ensure by their concurrent action the isolation of the body of waste and also avoid the possibility that an environment conveyor (water or brine) come into contact with the hazardous waste.

If this is impossible to do, it must be ensured that, through the action of multiple geological barriers, the amount of harmful substances mobilized within the landfill does not reach a hazardous concentration in the biosphere.

The wall of the host rock surrounding the deposit as well as the secondary rocks and the rock strata of the mountain massif act as a natural geological barrier.

Geological barriers have to fulfill the primary barrier function owing to their property of being impermeable or very little permeable to conveying media (water, brine, gas), but also by the sorption capacity of the substances that cross them.

Technical barriers (e.g. closure of galleries) supplement or replace natural barriers, having the role of delaying and reducing, in the event of a migration of dangerous substances, the pollution of the environmental factors.

Research to date has studied and analyzed the possibility of landfilling hazardous waste in various geological formations.

There have been identified four technical possibilities for the underground storage of hazardous waste [4]:

- in a salt mine;
- in a salt cavern;
- in rocks that do not allow the infiltration of water;
- in rocks allowing the infiltration of water

The criteria for the admission of waste for underground storage should be related in particular to the analysis and composition of the host rock, following the concept of neutral emission storage, especially in the case of storages in mines that allow the infiltration of water. This category includes deposits in gypsum, mineral deposits or coal mines.

The concept of neutral emission storage asserts that the contact of water wastes or other solutions (brine) does not lead to impurification of these, leading implicitly to changes in the groundwater or surface water quality in the immediate vicinity of the landfill waste.

Driving dangerous substances (heavy metals, etc.) and increasing their concentration in the conveying phase will only be achieved within the maximum allowable concentration limits, as if the water crossed the layers of soil and rock in the storage area of the deposit.

This means that the waste that would be deposited in such deposits must have or acquire the characteristics of an inert waste.

Therefore, when depositing into sewage that permits water infiltration, the quality of assessing the safety of a storage system depends on the knowledge of the chemical and physical effects occurring in situ and within the natural and technical barriers, this information helping to determine the transport and mobilization data of dangerous substances.

Due to the large diversity of the geo-mechanical structure of the various mining operations, research continues to identify optimal storage conditions and other formations and rocks, as well as to identify the characteristics and properties that hazardous waste would have to meet in order to be stored in them.

For a site (former mining) to be considered as a possible location, for the construction of an underground storage, it must meet the following minimum criteria:

a) ensure tightness against liquids and gases;
b) have sufficient expansion capacity;
c) be surrounded by a sufficient rock layer in the chosen storage area;
d) the geo-mechanical properties of the massif must ensure the provision of safe cavities;
e) the walls of the cavities should not be found in the vicinity of rock beds which allow the infiltration of water;
f) areas with a 99% probability of producing earthquakes shall not exceed 8, according to the MSK scale (Medwedjew-Sponheuer-Karnik).

The European legislation on underground storage requires the demonstration of the compatibility of the mass to build an underground deposit by assessing the safety of the area chosen. To estimate the safety of the underground space, the following aspects should be assessed: geological; geo-mechanic; hydrogeological; geochemical; the impact on the biosphere; the exploitation phase; the duration of the deposit; the impact of all installations located at the site's surface.

As a conclusion, the most important points to be achieved for the safety investigation of permanent storages are::

- developing and testing safety methods and analytical system methods, including mathematical modeling for the transport of dangerous substances in the geosphere;
- analyzing the geophysical and chemical processes near and away from the storage area;
- enriching the database for behavioral modeling over a long period of time (stability/porosity) of geological and geotechnical barriers.

8. General criteria for the acceptance of hazardous waste in underground stores

A complete list of wastes that are suitable for underground storage still does not exist, and many research studies currently focus on this issue, but European legislation specifies with precision that underground waste should not be physically, chemically or biologically transformed.

This category includes those wastes which have the following characteristics and properties:

(a) waste and containers thereof which could react in contact with water or the host rock under storage conditions, producing:

- a change in volume;
- the production of self-inflammable, toxic or explosive substances or gases;
- any other reaction that could jeopardize the operational safety and/or integrity of the barrier.

Waste that may react with each other must be defined and classified into compatibility groups; at the time of storage, the different compatibility groups must be physically separated;

(b) biodegradable waste;

(c) strong smell;

(d) wastes which can produce a toxic or explosive air-gas mixture. This concerns in particular waste that gives rise to:

- toxic gas concentrations due to the partial pressures of their constituents,
- concentrations of 10% greater than the concentration corresponding to the lower explosion limit when they are saturated within a container;

(e) wastes with insufficient stability, taking into account geo-mechanical conditions;

(f) self-igniting or self-ignition waste under storage conditions, gaseous products, volatile wastes, waste collected as unidentified mixtures;

(g) wastes containing or likely to cause pathogenic germs of communicable disease

(h) liquid waste

(i) explosive, corrosive, oxidizing, highly flammable or flammable wastes

The basis for assessing the long-term behavior of chemical-toxic waste in an underground deposit is the exact knowledge of its composition.

The analyses usually provide only partial information about their quantitative composition.

The main tasks of current research studies are the presentation of unresolved issues and appropriate solutions for quantitative and chemical-mineralogical analyses as well as the characterization of waste on the basis of their chemical, physical and mineralogical properties.

It is also important to analyze possible interactions between waste or rock coats or potential mine waters or bases, which may provide information on the stability and reactivity of the waste under groundwater storage.

The next task for researchers is to determine the phase of the physicochemical properties, the composition and the results obtained in the laboratory and in situ tests, which of these groups of wastes considered dangerous is suitable for underground storage, under what conditions, under what form and host rock that provides the best long-term safety.

From the experience of other countries that have such underground deposits, one can list some of these groups of wastes that have been and are successfully stored underground under safe conditions: residues from special waste incineration plants, galvanic waste, waste containing arsenic or mercury, residues from chemical distillates, capacitors and trays containing PCBs, etc.

9. Underground storage of hazardous waste in Romania

Romania's situation, from the point of view of hazardous waste management, is more or less similar to that of every European country and to the world, which requires the development of new ideas and concepts for the storage of waste.

Current landfill, surface or incineration solutions, used so far in Romania for the management of industrial and especially hazardous waste, are viable for short terms but not for long terms.

The novelties consist in the obligation to inert hazardous waste prior to underground storage as a further measure to protect the environment by eliminating or reducing the risk of contamination of environmental factors.

Considering climate change and seismic hazard, combined with the high cost of landfill management and the contribution of waste incinerators to the greenhouse effect, a viable solution for improving the management of hazardous industrial waste is its inactivation and specially arranged underground storage.

Until now, for the underground storage of hazardous waste, there are not many concepts that can be tracked.

The concept of maximum containment, through the underground storage of hazardous waste, regardless of the nature of the rock, is the unanimous opinion of the specialists.

9.1. Pilot underground storage in a mine that exploited copper

The Activity Termination Plan (PIA) of a copper mine in Romania and the Technical Project (PT) for the closure and greening of such mines, includes the topic of a solid waste storage.

On the basis of the existing information, two alternatives for the underground storage of the storage rooms in the host rock massif of this copper mine [3] were analyzed.

Thus, the reuse of the whole 3.5 km long coastal gallery, which crosses the entire copper mine, with the location of an inertia platform in the mine and the partial use of the same coastal gallery but isolated from the exploited area, having an inertia platform located in an area isolated from existing localities.

The accepted and improved version is with a coastal gallery parallel to the old one, where the pilot rooms will be located (figure 1).

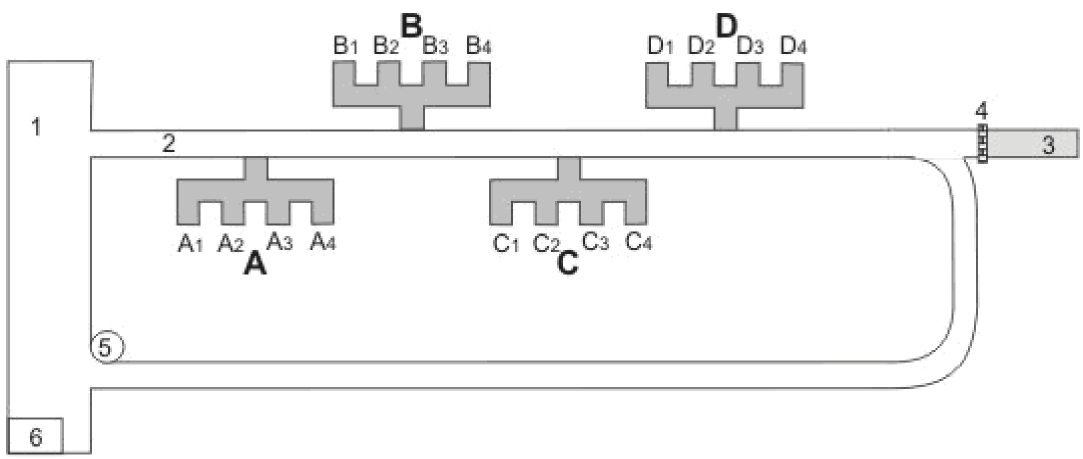

Fig. 1. *Pilot deposit*

1-platform for waste neutralization; 2-main transport gallery (GSB 1A-5.2); 3-link galleries with old mine; 4-dam; 5-compartment aeration; 6-water decontamination; A, B, C, D- storage rooms (RB 1A-3.1); Ai, Bi, Ci, D_i - storage niches (RB 1A-3.1)

Pilot cameras (A, B, C, D and 16-24 experimental niches) were located in or out of the I degree.

The main transport gallery (2) is intended for the access of personnel and transport of solid waste to storage niches and will include the main works:

- re-profiling existing gallery from GSM-1A profile -5.8 on profile GSB -1A- 5.2 on a length of 320m, 13.75 kg/m railroad layout.

- live digging of the gallery parallel to (2) on a length of 300m on profile GSB-1A- 5.2

The length of the works, their dimensions, the category of rock, the excavation profile, the type of support and the arrangement are detailed in the above-mentioned measurements, figures and plans.

The access galleries of the storage rooms (7) will be GSB-1A-4,8, the free section of the access galleries will be 4.8 m^2, the excavation section being 7.37 m^2, the concrete surface 2.07 m^2. The length of the access galleries to the storage rooms is 120m.

The rooms (A, B, C, D) and storage niches (Ai, Bi, Ci, Di) have the purpose of storing solid waste under the conditions of labor safety.

The storage rooms will be assimilated to a mining work type RB 1A-3.1 with a 14.54m^2 digging section and a free section of 9.65m^2. 4 storage rooms will be dug out of which 4 niches will be executed. The total amount of waste that can be stored in these rooms and niches is approx. 2500 m^3.

Concrete sealing and dredging dams (4). The variant designed by digging the second exit path into a gallery parallel to (2) for a proper ventilation during the operation of the underground deposit requires the construction of a ram stop on the gallery (2) to isolate the underground deposit from the rest of the inactive mine, which will consist of the execution of two concrete dams. Between the two dams, at 15 m, the gallery will roll back to ensure proper security. Drops and materials for dredging are included in antitrust and quantity lists.

The warehouse has the entrance at the old coastal gallery and the new one, where the fan station, which is needed for the air, is located. Along the access paths there is a collecting ditch for potential infiltration waters with an inclination towards the exit, where a mine water treatment plant is also provided. Isolation of the deposit against the exploitation of the copper is made by a recessed dyke.

The monitoring of the whole underground storage will be done in real time by means of displacement / deformation transducers that will monitor the safety of storage rooms and access ways, gas and microclimate sensors and a surface meteorological station, all of which are connected to a computer which, through surveillance programs, will provide three levels of alarm.

Each experimental niche will be equipped with microclimate sensors and pressure / strain / voltage sensors.

The location of such landfill complies with all the conditions imposed by the legislation in force for the storage of hazardous solid wastes in the underground:

- the characteristics of the rock in which the landfill will be carried out meet the requirements imposed by the construction of such a site;
- hydrogeological conditions do not constitute an impediment to the storage of long-term inert hazardous wastes;
- the activities within the warehouse will be carried out with complete security of work and will not affect the environment, having no negative impact on the life of the local community

9.2. Dangerous waste stored, after inertization, in the pilot deposit

The basic waste selection criterion for underground storage is the non-acceptance for storage of wastes that may undergo alteration of biological, chemical or physical properties during storage.

Since the pH of the infiltration water in this mine is slightly acidic, a waste acceptance/ exclusion criterion specific to the pilot deposit is the stability of inert waste in this pH range. This condition was imposed in order to avoid the risk of environmental pollution in the case of accidental infiltration of water into the landfill.

Waste to be stored in the pilot depot:

- email waste: household appliances industry
- sludge containing heavy metals (iron oxides, nickel and cadmium): metallurgical industry
- glass waste: the glass industry

Two [2], [3] pilot tests were recommended for 99 types of hazardous waste, requiring that they be inert prior to underground storage. The inertization procedures to be applied are shown in Figure 2.

After applying the inertization procedures, waste will become solid material (Figure 3).

Samples of inerted waste will also be subjected to analyze in order to determine long-term stability under storage conditions and to determine the ability to remobilize hazardous substances.

Figure 4 shows experiments in Romania for inerted waste containing iron oxides, manganese, copper, lead, zinc, chromium, nickel and cadmium.

From the leach tests carried out, it results that inertization is effective only at a metal oxide content in the vitrified material of maximum 16-20% with the exception of lead, which also admits concentrations 66% higher.

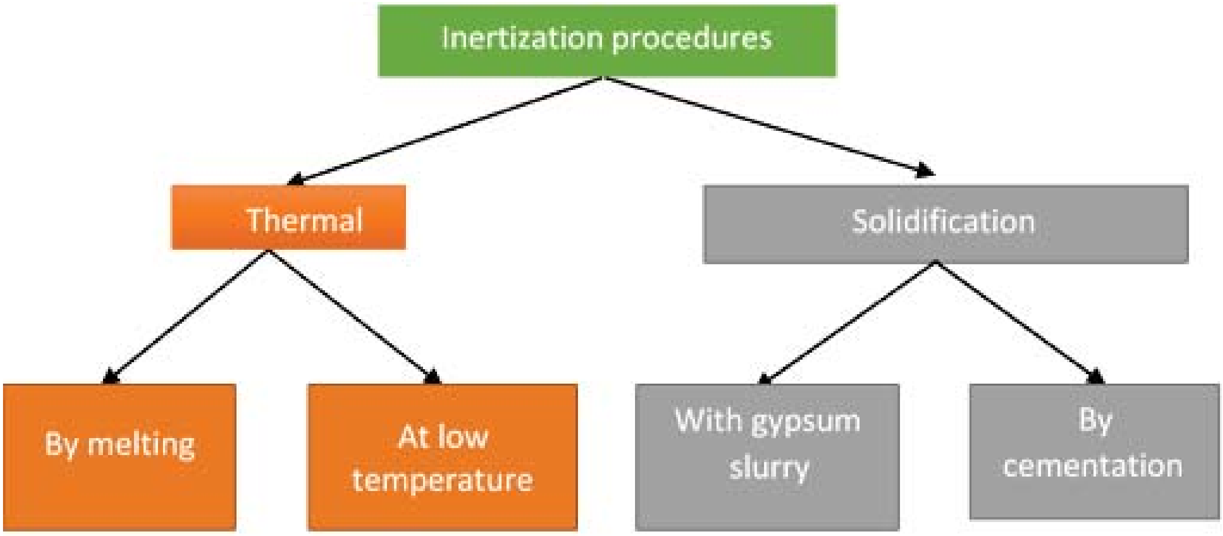

Fig. 2. *Hazardous waste inertization procedures*

Fig. 3. *Dangerously inert waste, to be deposited in the pilot deposit*

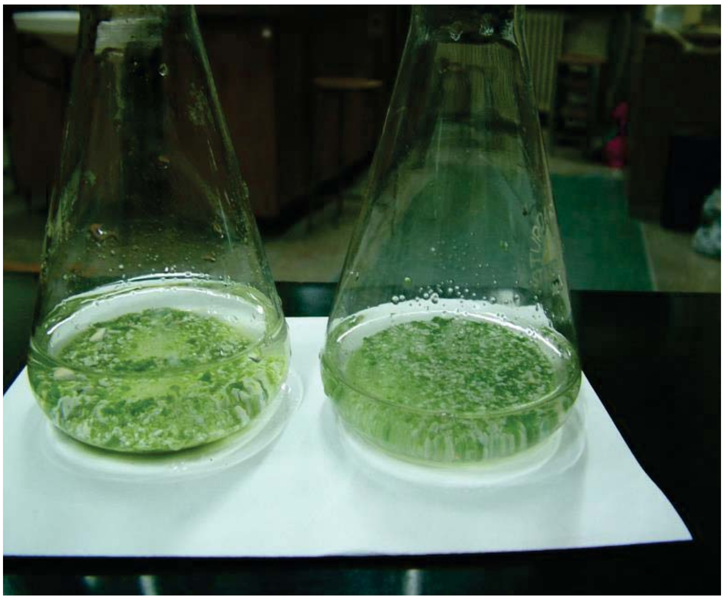

Fig. 4. *Leaching tests for underground storage in the pilot deposit*

10. Conclusions

As a result of the changes that have occurred in the development of the modern society, a series of major problems arose: increased energy consumption, increasing pollution, interest for environmental protection, acute crisis of the places for safe waste disposal, more and more toxic stuff.

The beginning of the 21st century is marked, almost worldwide, by raising interest in a clean environment and by reducing raw material consumption, paying more attention to recovering from waste, from production processes, in order to reduce the consumption of raw materials, and indirect environmental protection.

In the context of these new requirements, the issue of approaching the disposal of hazardous waste underground is today a topical issue in most European countries, but at the same time it is a rather complex issue, due to the many variables and unknown issues that need to be taken into account when we intend to study, understand, research, evaluate and implement the concept of underground storage, regardless of the chosen host rock.

However, as surface storage becomes more and more expensive due to the increasingly stringent safety requirements imposed by the legislation in force, with already existing legislative proposals, which, if applied, will make it even more expensive, studying and researching the concept of underground storage has and will be of paramount importance in the future.

One may conclude that the underground landfills for hazardous waste will gain in the future for the following reasons:

- They will have to compensate for the growing need for storage facilities due to economic growth, production and technical progress, which will implicitly generate additional volumes and new types of waste, despite high performance technologies or revaluation measures to the maximum, which would aim to reduce the volume of waste generated;
- • Despite the avoidance and revaluation, which is becoming increasingly important, the secondary raw material circuit will lead to large masses of substances, even by increasing the duration of this circuit over time, storage remaining the only solution for substances that can no longer be recovered and which should be removed from the circuit;
- The specific inventory of the hazardous substances in waste, which are considered suitable for underground storage, will be increased through the effort of reducing the mass of waste. The surface disposal of these wastes, which requires permanent surveillance and decontamination measures over a certain period of time, will be increasingly limited due to the experience so far accumulated with so called contaminated tomatoes.

There are nowadays in Europe and worldwide enough abandoned underground mining sites that have a downward trend in development, many of which are already being inventoried, and after researching and developing a safe storage concept underground, specific to each rock, they could be used in the future for the underground storage of hazardous waste or other types of waste. This trend will increase as the costs of storing hazardous waste on the surface are increasing, influenced both by the tough EU legislation and by the extremely high costs of decontamination of these areas, these issues leading in the future to an acute shortage of new surfaces available for use for this purpose.

The Dangerous Solid Hazardous Waste Depot pilot project may be of interest for the mining industry, affected by a sharp decline in activity, providing an alternative for development and a future solution to the social issues arising from restructuring/closure actions.

For the local community, the existence of a landfill will have the following economic and social advantages::

a. In the stage of execution of the deposit:
- employing miners and other professions (among the unemployed) for digging and arranging mining works in PT to build this warehouse.
- hiring personnel for the Waste Incineration Platform in the Warehouse.

b. In the stage of hazardous waste inertization/neutralization tests:
- staffing for services related to specific activities.

c. In the post-test phase, when the warehouse goes into the administration of the Town Hall (it is estimated that the Deposit will have a storage capacity of about 2000 m3), all the benefits will come into its budget.

Throughout the existence of the deposit, whose capacity can be expanded, other opportunities may be highlighted in favor of the local community.

References

1. Georgescu, M., Deak, Gy., Deak St.
Abandoned mining cavities reusage in respect of the European Union environment acquis. Buletin Resurse Minerale nr.1, 2006

2. Georgescu, M., Deak, Gy., Deak St.
Underground spaces: ressources for development and environmental protection. 2nd International conference AMIREG, Hania, Greece, 2006

3. Georgescu, M., Ciolea D.I.
Utilizarea spațiilor subterane, Ed. Universitas, Petroșani, 2017

4. Georgescu, M., Deak, Gy., Iordăchiţă, V., Buia Gr.
Solutions for storing dangerous waste in the romanian underground mining spaces. 17th International symposium MPES, Beijing, China, 2008

5. Ştefan, O.
Spaţiul subteran, factor de salvgardare a mediului înconjurător, Editura RISOPRINT, Cluj-Napoca, 2006

6. x x x
Planul Național de Gestionare a Deșeurilor versiunea 5, 2 noiembrie 2017

7. x x x
Legea 211/2011

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