IMPLEMENTATION OF SUSTAINABLE PRACTICES IN THE LIGNITE OPEN PIT ROȘIA DE JIU

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Abstract: *Exploitation of lignite in Rosia de Jiu open pit can be included in the broad concept of sustainable development through the development and integration of practices that lead to minimizing the environmental impact of mining operations. In this paper are analyzed solutions such as: rational exploitation of the deposit, reducing water and energy consumption, reducing the amount of affected land, preventing environmental pollution and ensuring the rehabilitation and reuse of degraded land. Thus, the land affected by mining can be reused for the development of sustainable activities in order to obtain the best results in terms of environment, community and economy.*

Key words: *environment; land rehabilitation; land reuse; open pit; sustainability*

1. Introduction

Rosia Jiu open pit, through its location in the region, the morphology of the terrain, the size of the mining area, the development of mining works, large volumes of industrial reserves, difficult geomining and hydrogeological conditions, relatively high reports between overburden and lignite, represents a base study for analyzing operating practices and reusability of the land after the closure of mining activities in the context of sustainability.

In Rosia Jiu open pit, the first mining works were started in 1973. After more than four decades of exploitation there were extracted over 100 millions t and in 2015 the available reserves were estimated at 21.5 million t.

Mining can become sustainable through the development and integration of practices that lead to minimizing the environmental impact of mining operations. These practices include measures to reduce consumption of water and energy, the amount of land affected, prevention of environmental pollution and measures for closure and rehabilitation of the area. [2]

2. Implementation of sustainable practices throughout the lifecycle of the open pit

Since mining activity in Roșia de Jiu open pit is viable for another decade, it requires the implementation of sustainable practices in relation to the exploitation of the resource available, to be effective, primarily in terms of environmental protection, health and safety of population, but also economically.

2.1 Rational and total exploitation of the lignite deposit

Complete extraction of lignite reserves and the quality of the extracted coal, are priority issues concerning the rational exploitation of deposits. In these circumstances, recovery of coal from the final slopes of the pit and from thin layers is in question.

In the first case, the method of extraction with Auger-Mining type drills can be applied. It consists in drilling of large diameter executed in the definitive slopes of the open pit, allowing recovery of coal at the rate of up to 60%, reserves which, under current operating conditions, remains untapped, representing also a financial loss. [1]

Coal mining from the final slopes of the open pit is conducted after sizing the drilling holes and security pillars, very important for the stability of the slope. After extracting the coal, the remaining holes in the slopes will be filled with sterile material from waste dumps.

In the second case, it is recommended the use of surface combines, which, due to the configuration of the extraction system have a higher degree of selectivity than conventional extraction machinery (bucketwheel, mechanic shovel, backhoe excavators etc.). By using surface combines, layers with small and very small thickness can be extracted selectively without lowering productivity. The extracted material is loaded and transported by trucks. [3]

The use of surface combines, in particular for the extraction of thin layers, has two important advantages: due to substantially reducing operating losses, the recovery of reserves is increased by 25%; separate extraction of sterile insertions with small thickness considerably improves the quality of extracted coal, leading, among other things, to a reduction in processing costs.

The technique of extracting coal by milling gives the material a particle size less than 150 mm, which corresponds to the requirements imposed by transport on conveyor belts and requirements imposed by power plants.

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Other advantages of surface combines, in terms of beneficiaries include: creating a clean working surface; the possibility of depositing directly the sterile derived from insertions; ability to use the equipment not only for extraction but also as auxiliary equipment.

2.2 Implementation of water spraying devices mounted on bucketwheel excavators

Following the operations needed to extract the resource, results large amounts of dust that lead to degradation of air quality. This in turn leads to increased risk of illness to employees and local communities situated at relatively small distances from Rosia open pit (Farcasesti Moşneni village at about 250 m, Rosia village and residential area of Rovinari town at about 700 m).

Splashing water on sterile materials and lignite, manipulated in the open pit, from excavation to deposition, aims to reduce the amount of dust and particulate matter from air, by maintaining a sufficient humidity of materials that do not allow to be driven by wind. [6]

The method consists in implementing sprayers mounted on bucket wheel excavators, dumping machines (spreaders), loaders and on conveyors.

The advantage of this system is represented by the reduction of the amount of dust and particulate maters in the atmosphere, with the possibility of using poor quality water. The costs to implement this system in Rosia de Jiu open pit are relatively low and the benefits are considerable.

2.3 Restoration of land while exploiting

In order to recover and reuse lands affected by mining from the operating stage, restoration of land is recommended to be carried out while exploiting (fig. 1), by the immediate start of reconstruction and rehabilitation processes of the areas freed from their technological tasks. [5]

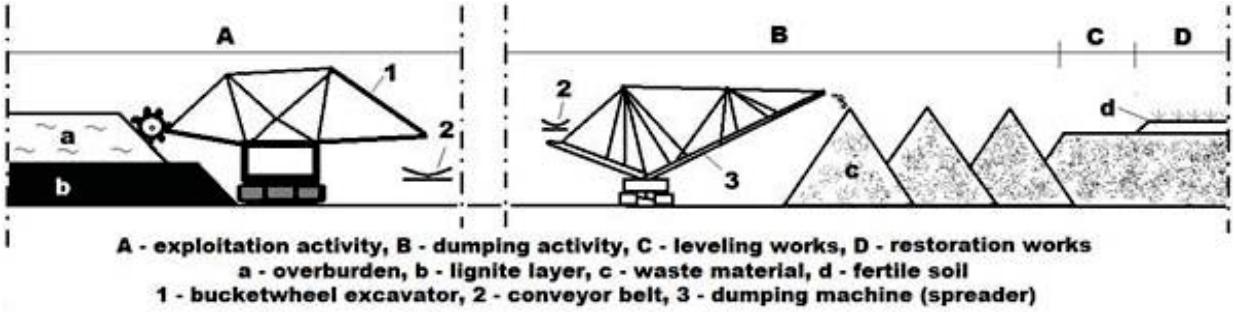

Fig. 1 *Restoration of land while exploiting*

This practice presents important advantages, such as reducing the period of rehabilitation of the area of land affected after closure of the open pit, reducing the degree of pollution of the environment, gradual reintegration of land in the adjacent landscape and the possibility to reuse of the rehabilitated land for other purposes.

2.4 Reuse of waste material

Waste rock resulting from the extraction of lignite in Rosia de Jiu open pit, are made of clay, sand and gravel and they contain no hazardous substances.

The waste material can be used as filler in the construction of highways and the rough fraction can be used as embankment to protect riverbanks, to ensure the stability of natural and artificial slopes and reinforce dams.

The advantages are represented by the reduction the amount of waste material deposited and thus the surfaces of natural lands occupied, and by the reduction of the amount of construction materials exploited.

3. Implementing sustainable practices after cessation of mining activities

Lignite resources from Rosia de Jiu open pit are sufficient only for the next 10 years. Given the fact that the local economy will be affected by its closure, is essential to recover the affected land and return it to the natural or economic circuit.

In this regard, the paper analyzed three land reuse solutions that can contribute to sustainable development of the region (that can be adapted for other similar regions):

- reconstruction and ecological rehabilitation of degraded land;
- construction of a photovoltaic park;
- implementing a system for collecting and recycling municipal waste.

By 2015, the open pit occupies 392.3 ha, the interior dump 573 ha, and the exterior dump 493 ha. It was chosen for the photovoltaic park to be constructed on the interior dump and in the open pit, while the remaining premises in the mining perimeter to serve for collection and recycling of municipal waste. Since the exterior waste dump is already restored (forestry plantation), it is recommended the maintenance and monitoring of the works.

3.1 Reconstruction and ecological rehabilitation of degraded land

After exploitation works, the land must be released from its technological tasks and of the decommissioned constructions at risk of collapse or that can not be used in future economic activities.

Before the land is reused, its rehabilitation and recovery is necessary, through a complex process that involves insurance of physical, chemical and biological stability of the degraded land, reshaping the land in order to increase the stability of the pit and waste dumps slopes and its reintegration in the adjacent landscape, deposition of a layer of topsoil and its amendment in order to improve soil quality and, not least, revegetation of the land depending on the type of reuse.

Recovery and rehabilitation of land in the mining area of Rosia de Jiu open pit, for the development of a photovoltaic park, does not require special environmental conditions. There are needed stabilization, leveling, reshaping and terracing works to reduce the inclination of the open pit's and dump's slopes, so that rolling or collapse of rocks are not be triggered, and at the same time to ensure the location and optimal operation of photovoltaic panels. Minimal recovery processes are sufficient, which involves improving environmental quality, so that adjacent ecosystems and local communities are not affected.

Taking into account the proposals for future activities, it is recommended grassing of the land with an important role in erosion control and soil binding. However, in marginal areas, it is recommended the plantation of vegetation curtains for land protection against wind erosion, land stabilization and improvement of water regime. Revegetation is made after a layer of topsoil is deposited and amended order to improve quality and ensure optimal conditions for maintaining the vegetation.

To restore the hydrostatic level of groundwater in adjacent areas and to protect the remaining hole in which the photovoltaic park will be constructed it is suggested the construction of waterproof screens around the mining perimeter (fig. 2). Recovery of the hydrostatic level by natural means may take a long time, but there is the possibility of accelerating this process by injecting water behind the impermeable screens, through a reverse dewatering process. [8]

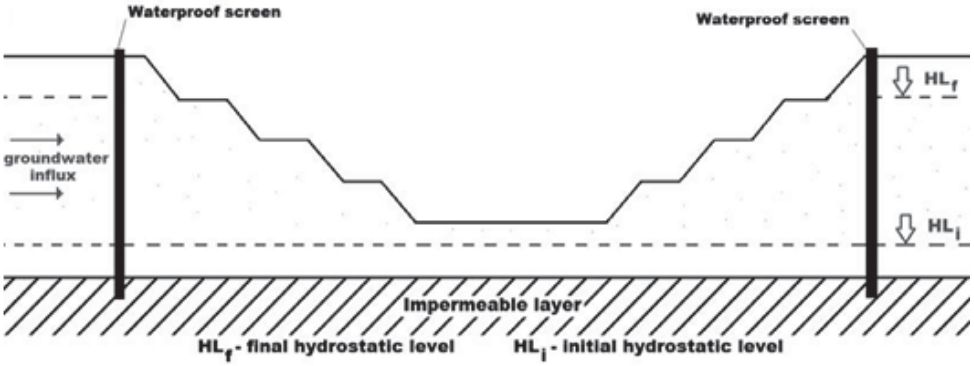

Fig. 2. *Restoration of hydrostatic level of groundwater using waterproof screens*

After the land is recovered, it requires maintenance and its necessary to monitor the environmental components, to determine and eliminate potential sources of pollution and their negative impacts.

3.2 Construction of a photovoltaic park

Lignite exploitation was the basis for production of electricity, at national level, by its integration in the National Energy System, for supply of industry and population. With the closure of Rosia de Jiu open pit, but also from other lignite open pits in the country which have reserves available for the next 20-40 years (as a result of the mining sector restructuring process), reduces the amount of lignite extracted and thus the amount of electricity produced from it.

Solar energy is the energy produced directly by the transfer of light energy radiated by the Sun and can be used both for domestic consumption to generate electricity or to heat the air inside buildings and nationally, through the occupation of large areas of land in order to supply the National Energy System. Solar panels generate electricity and, at the same time they store energy in batteries to be used when solar energy is inefficient.

Given that solar potential in Romania has remarkable values and that in most developed countries in Europe (even in those with solar potential lower than in Romania) electricity production based on energy of sunlight is successful, it can be stated that the development of a large photovoltaic park in our country, would be a major step towards sustainability. In this regard, an

important aspect is the represented by the insurance of environmental and community protection.

For the case study of Rosia de Jiu open pit, it can be considered as an advantage the possibility of occupying a large area of land, approximately 1,000 hectares (considering the space available currently and extension until closure), given that one of the largest solar parks in Romania occupies an area of approximately 150 ha (near Sebiș, Arad county), and the largest photovoltaic park in the world, located in the Mojave desert, California, occupies an area of 1600 ha.

Each element of the complex that constitutes the photovoltaic park has a well defined role:

- photovoltaic panels capture solar energy;
- energy is taken up by a junction box from a series of panels;
- the generator connection box takes energy from more junction boxes;
- energy is transformed from DC to AC by a triphasic inverter;
- through an electrical station the energy is transmitted to the National Energy System. [7]

The construction of the photovoltaic park involves the following: construction of access roads for maintenance processes and enclosure fences, installation of steel structures, cables and panels, mounting connecting stations and transforming stations with inverters.

In 2011, the company BoDean operating in quarrying, was the first company in the world that functioned entirely on electricity produced by its own system of photovoltaic panels mounted on the closed and recovered steps of the open pit. [9]

Starting from this idea, for Rosia de Jiu open pit is proposed installing the panels on the steps exposed to the south, where the incidence of sunlight is highest, and on the interior waste dump so that solar radiation is perpendicular on the solar collector. On slopes with northern exposure are recommended to fit the connecting stations and transforming stations with inverters, and the unoccupied surfaces should be grassed or even planted with trees or shrubs, if they do not jeopardize the smooth operation of photovoltaic panels (fig. 3)

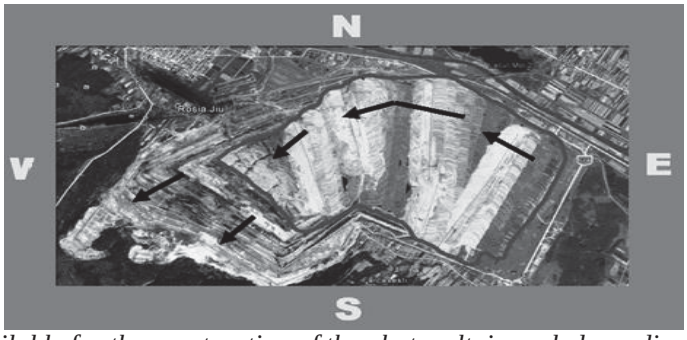

Fig. 3. *Surfaces available for the construction of the photovoltaic park depending on their orientation*

Given the approximately 1,000 hectares at disposal, and taking into account both the variability worldwide of the percentage of actual occupation of the land by panels and other structures necessary for the development and optimal operation of the park, namely 35 - 90%, and morphological conditions of the land occupied by Rosia de Jiu open pit, it is proposed the minimum effective occupation of the land (with the possibility of increasing the occupancy) as follows:

- ≈300 ha - photovoltaic panels;
- ≈50 ha - connecting station, substation and inverters, driveways for maintenance works and fences;
- ≈650 ha - green spaces.

Recently in Romania, in Timis county, was built a photovoltaic park on an area of 44.14 ha (located within the locality Bencecu de Sus) which consists of 84,480 photovoltaic panels, with an installed capacity of 20 MW, the contribution to the National Energy System is estimated at 25,628 MWh/year (25.6 GWh/year). Compared to these values, results that the area available in Rosia de Jiu mining perimeter (1000 ha, of which 255 ha actually filled with panels), involves the installation of approximately 1.7 million photovoltaic panels with an installed capacity of 374 MW, which under a clear sky at a rate of 40-50% per year and an average of 9 hours of light per day, would allow to supply the National Energy System with approximately 500-600 GWh/year.

The advantages are considerable and include: regenerative capacity of the resource, production of electricity without negative environmental impacts, long life, easy operation, high resistance.

The disadvantages are represented by the impossibility to provide constant energy due to the alternation of day and night or on cloudy days, the high cost of installation (with the advantage of generating free of costs electricity through the system's lifecycle) and occupation of large areas of land.

Even if initial investments are impressive, such a project can provide large amounts of electricity, and the costs can be balanced over time. This system significantly reduces harmful gas emissions resulting from electricity generation in traditional power plants and, not least, being clean energy, participates and supports the sustainable development of the society.

3.3 Construction of a municipal waste recycling center

Increasing recycling of reusable materials reduces the consumption of natural resources and, therefore, the level of pollution of the environment. Municipal wastes consist of: paper, cardboard, plastic, glass, aluminum, wood, electrical and electronic equipments, waste from parks and gardens, biodegradable fractions and waste from construction and demolition.

Recycling from waste involves an intermediate processing of materials (sorting, shredding and/or compaction), transport, recovery of materials and final processing.

The center for municipal waste recycling will occupy the existing premises and will manage waste from nearby localities. Premises available from Rosia de Jiu open pit occupy about 6 ha and can be used in carrying out sorting, crushing and baling.

Transporting them to entrepreneurs specializing in recovery and final processing of waste can be done by rail or road. Development of the collecting infrastructure must be made so that the value of recovered materials to cover the costs of collecting, processing and transport.

To increase the degree of recycling is recommended to implement efficient systems or centers of selective collection of municipal waste in each locality, as well as educating, encouraging and empowering people regarding the need for recycling.

Waste collection can be done by taking waste directly from the manufacturer (collected on categories) by a company that processes them, either by transporting waste to collection centers by the producers themselves.

The main advantages consist in conservation of natural resources and reduction of waste storage facilities.

A complex center for collection and recycling of household waste can contribute to the sustainable development of society through the application of appropriate management and waste processing practices, having positive effects on the environment, community and local and even national economy.

3.4 Alternative solutions for land reuse

Implementing the solutions listed above is a correct and rational choice, allowing the reuse of the land affected, bringing benefits to local communities through the production of renewable energy, replacing the amount of energy produced from lignite, when mining operations in Rosia de Jiu open pit will stop, but also by encouraging recycling and reusing of waste, actively participating in resources conservation and reduction of municipal waste deposited.

A major problem is that the mining basin is part of an agricultural area with high productivity while being an area with high potential of solar energy. Conditions in the location and morphology of the land, the adjacent ecosystems and communities, allows reusing the land for other purposes. Here are some alternatives:

- Productive reuse. The land affected by mining is part of highly productive farmland. Before starting lignite exploitation activities, the mining area was occupied lands destined for forestry and agriculture (arable and grassland), so when the approved of exploitation rates are achieved, the land may be remodeled and reconstructed, so it may go back into the productive economic cycle.
- Recovery for recreation and leisure. The land, being near inhabited areas, can be reused for recreation and leisure. The residual hole of the open pit will be filled with water to create a mirror of water (lake) and in parallel with the construction of specific structures for the upcoming destinations (which can be a place of picnic, camping, sports etc.) will recreate the natural landscape with green areas, forests, positive landforms and various elements necessary in shaping the landscape. In this case, the construction of underground waterproof screens is no longer required.
- Recovery for controlled landfill. Uncontrolled growth in the quantity of household and/or industrial waste requires the allocation of new spaces for storage. Storing waste on land areas already degraded is a rational choice, especially where there is a residual hole, whose physical, chemical and biological characteristics allow its use for this purpose in conditions of maximum security for the environment and community. [4]

So choosing the best solution requires numerous ecological, economic and technical analyzes and studies, consultation of local communities being essential, so that the type of reuse chosen to have the capacity to meet their needs, bringing long-term benefits.

4. Conclusions

Sustainable development aims at the constant improvement of quality of life and well being of present and future generations by empowering society, creation of sustainable communities able to manage rationally natural resources and promoting the reduction of the ecological footprint. This can be accomplished by encouraging reduction of resource consumption, increasing recycling and reuse of waste and minimize the extent of damage and pollution of the environment by applying the best practices of mining and management of natural resource.

A mining exploitation must be efficient in terms of resource management, so it needs a mining management team composed of experts from different fields to work together in adapting, changing and modernizing technologies and current practices, leading the development of a eco-efficient mining, satisfactory in terms of profitability and gentle in terms of environment and community.

For choosing solutions to reuse lands affected by mining there are necessary ecological, economical and technical analyzes and surveys, to establish exactly what is the best solution. For the reuse of land it is essential to consult local communities, so that the type of reuse will have the ability to meet their needs, bringing long-term benefits. The solutions presented are fair and reasonable options that can be applied globally, allowing exploitation of mineral resources by applying sustainable industrial practices and recovery and reuse of land, after reaching operating quotas, for activities capable of reaching the primary objective: sustainable development.

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