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Review

Phytoremediation Possibilities for Contaminated Mining Areas from Romania

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Abstract

Mining activities, which have been carried out in Romania for centuries, resulted in pollution of large areas, affecting negatively the environment and representing a threat for human health. This paper aims to prove that in Romania can host a relatively new, costly efficient and sustainable remediation technique for contaminated mining sites, namely phytoremediation. The applicability of phytoremediation for remediation of contaminated areas was proven by several demonstration projects carried out worldwide. It has a very positive impact on the landscape aesthetics, resulting in a high public acceptability. Moreover, the climate and soil conditions in Romania allow the use of several plant species which can remove contaminants from water and soil. It is therefore concluded that the successful implementation of phytoremediation on contaminated mining sites in Romania can be achieved, but under certain conditions. These conditions include the promotion of this technology by finding appropriate ways to transfer know-how and to build capacity at the level of public institutions and organizations dealing with remediation of the mining areas.

Keywords: mining activities, phytoremediation, environmental impact

1. Introduction

Romania has a long history of mining minerals such as gold, copper, lead, zinc, silver, manganese, salt and coal. However, due to years of environmentally unsound exploitation and extraction technologies, the mines and related ore extraction industries have affected the environment negatively, resulting in an important environmental burden on soil, water, air and ecosystems. Occasionally, the problems had extended far across the country's borders because of migration of pollutants via rivers and prevailing winds [1]. Today, despite the fact that most of mines are closed, the mines and related industries represent a threat to men and environment.

The continuous erosion of mine tailing damps and unprotected mining disposals have a major impact on the environment, threatening large areas due to water contamination with metals and chemical compounds. Similarly, industrial sludge is frequently contaminated with metals or other toxic elements, and sustainable solutions are to be applied [4]. Nowadays, the main research questions analyzed refer to the political, economical and technical capacity of Romania to be host for a sustainable, cost-effective remediation technique, namely phytoremediation, to attack the environmental burdens at abandoned mining sites.

2.Environmental impact of mining activities

In Romania mining activities have been going on for centuries. Geological exploration, extraction and mining metallurgy led to a long-term

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degradation of the environment. The impact of these activities can occur directly or indirectly and the affected areas are characterized by changes in the groundwater flow, residual waters, soil pollution and soil erosion, presence of high quantities of mine waste, disposed especially on tailing dams, degradation of the landscape, air pollution, radioactive pollution, and phonic pollution. All these effects have a long-term negative impact on the environment and measures for risk management and pollution reduction are required.

According to the "Report on the State of the Environment" issued by the National Environmental Protection Agency (NEPA) in 2007 [9], about 35.000 hectares of soil are polluted. The data present in the report were collected during 2004 - 2005 and represent a partial inventory of the affected mining areas. Table 1 shows three types of pollution resulting from mining activities, together with the pollution level and the contaminated surface. Mining exploitation leads to destruction of soil quality, the most important consequence being the deterioration of the fertile soil layer as well as the destruction of agricultural fields and forests. Areas where mining waste was/is disposed are of major concern because of its negative impact on fauna and flora [16]. As the waste sites, tailing dams represent a continuous failure risk, which might result in soil and water contamination with heavy metals, cyanide and other pollutants. The largest surfaces polluted with this kind of pollution are situated in Harghita, Hunedoara and Maramureş

Table 1. Soil pollution resulted from industrial activities (Report on the State of the Environment, NEPA 2007 [9])

Pollution of soil resulting from:	Polluted surface (ha) and pollution level					
	low	medium	strong	very strong	excessive	total
Mining exploitation activities	-	111	255	485	23017,5	23868,5
Waste sites, tailing dams, sterile deposits	180.3	18	157	310	5412	6077.44
Substances carried out by air (SO_2, NOx, chlorides, fluorides)	201832	74660	24818	15530	2.254	319094

county [17]. These impacts continue to affect the environment also after the mining or industrial activities have stopped. The areas of Baia Mare, Copşa Mică and Zlatna are most affected by this kind of pollution. Other kinds of soil pollution resulting from mining activities are inorganic wastes like salts, minerals and acids, which affect in Romania over 4000 ha (Timiş, Maramureş, Galaţi county) and the pollution with radioactive substances affecting approximately 532.9 ha in the Arad, Braşov, Harghita and Suceava county [12].

3.Environmental measures token for remediation of water and soil in mining areas and regulations towards future

Romania has only a relatively recent history of environmental protection. Starting from 2000, when it became candidate for membership of the European Union, the Government started undertaking various measures to comply with it standards in regard to the environment. At the end of 2006 almost all important European regulations were not only transposed but also started to implemented. To ensure their efficiency, measures were undertaken at different levels, resulting in the development of partnerships, initiation of training programs and participation in bilateral projects.

As a part of Romania's accession to the European Union, in April 2004, the Government approved the "2004-2010 Mining Sector Strategy" aiming to reform this sector and respond to EU accession rules. Also, a lot of regulations were adopted, like as Mining Law n° 85/2003, repealing the Mining Law No. 61/1998, GD n° 644/2007, GD n° 1403/11.19.2007, GD n° 1408/11.19.2007, etc. [18]. On European frame, in September 2006 the European Commission adopted a comprehensive EU strategy dedicated to soil protection and a directive proposal establishing a framework directive for the protection of the soil [12]. The strategy is based on two guiding principles: first, the prevention of further degradation of soil and the preservation of its functions, and second, the restoration of degraded soil to a level of functionality consistent at least with current and intended use. Proposal for a Directive on industrial emissions was adopted by the Commission on December 2007. The co-decision procedure for this Proposal is on-going. Romania, like a Member State, has to implement the EU directives [17].

4.Capacity in Romania regarding phytoremediation of contaminated mining areas

The investigation of the capacity in Romania for remediation of contaminated mining areas starts with a description of the environmental actors and their activities in this field. The most important actors for soil remediation in Romania are public institutions such as ministries and national agencies. They play a key role in the formulation and the implementation of the environmental policy. Nevertheless, there are NGOs and private companies which are active in the mining sector by developing projects for mine rehabilitation, including soil and water remediation projects. The influence of media and civil society and their role for mining areas remediation will be briefly discussed. The universities and researches institutes are more importance in training, education, analyse, implementation and long term monitoring environmental activities [5, 11].

But ecological remediation is more difficult in mining areas. The acid soils and their high content of heavy metals do not allow the use for agriculture or forestry. Soil erosion, ground sliding and leaching processes occur and the resulted negative effects have a strong impact on all environmental factors. The vegetation cannot grow on such type of soils; water from rain is washing toxic elements and leads to leaching [6].

For the remediation of these areas a lot of research is done and there is promising technology for environmental remediation suggests the use of plants for removing pollutants from the environment [10]. Thanks to their characteristics, a relatively new technology for soil remediation known as phytoremediation is becoming a current environmental friendly cleanup technology, which attracts with its elegance considerable scientific and commercial attention.

The applicability of phytoremediation for remediation of contaminated areas was proven by several demonstration projects carried out worldwide. Successful results were obtained in the U.S., as well as in Europe where substantial funding has been allocated to phytoremediation research. Examples of phytoremediation projects successfully carried out in Europe indicate the applicability of phytoremediation for cleanup of sites contaminated with heavy metals and organic compounds. But the state of research shows not only successful results, so, there is still need for more research and demonstration projects.

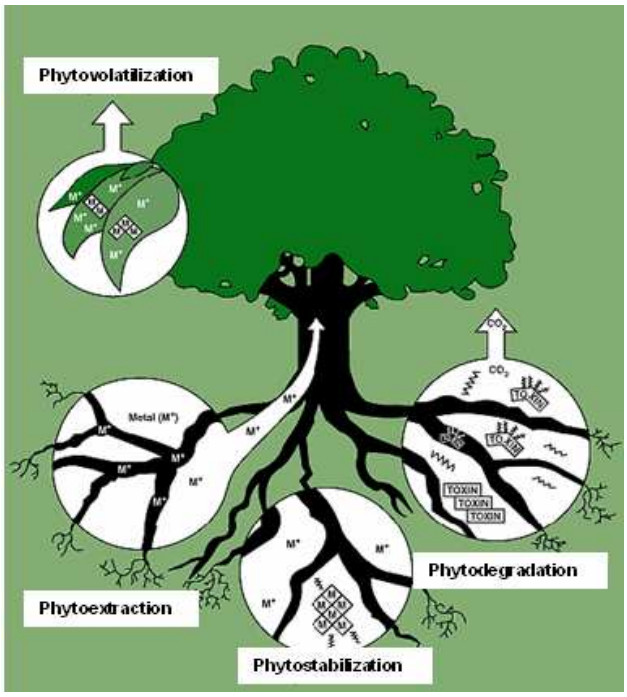

Figure 1. Phytoremediation (Sursa:http://quasimodo. versailles.inra.fr/inapg /phytoremed/nuls/comment.htm [19])

5.Favouring factors for phytoremediation

Phytoremediation has a very positive impact on the landscape aesthetics, resulting in a high public acceptability. Moreover, the climate and soil conditions in Romania allow the use of several plant species which can remove contaminants from water and soil [3].

Phytoremediation can be a good solution for cleaning contaminated mining sites in Romania and for several reasons, like as its cost efficiency as compared to classic remediation technologies. This is a major advantage because reduced financial resources for ecological restoration of mining areas are needed. Other favouring factors are relatively easy to implement and does not involve the need for highly specialized personnel, analyzes and tests can be done in the university laboratories, research institutes or private laboratories, and sophisticated technologies for cultivating hyper accumulating plants is not necessary.

Another positive factor is that Romania has the human resources for implementing phytoremediation. Personnel of public institutions could be informed and trained about different phytoremediation techniques and the implementation procedures, for example by organizing workshops and seminars [13, 14].

In some cases (e.g. phytoremediation with trees) financial benefits can be achieved, recovering the investment costs. Harvested trees can be used

for paper production, as source of energy (biofuels), small furniture production, etc.

Romanian universities, though their scientific departments, could collaborate with other institutions by providing assistance for developing phytoremediation projects, as phytoremediation is more popular through scientists and researchers [15].

6.Constraints factors for phytoremediation

Even though phytoremediation would be a feasible solution for the cleaning of contaminated mining sites, there are still some factors which constrain its applicability in Romania. The results of different studies show that phytoremediation was implemented in Romania only some small-scale experiments were carried out by research institutes and universities. Phytoremediation is thus relatively unknown at the level of public institutions and companies dealing with ecological remediation.

Another factor which could possibly hinder the implementation of phytoremediation is the time. In fact, the remediation process takes longer as compared to classic techniques. But, taking into account that the present financial situation of the mining sector does not allow big investments for ecological remediation, it could be preferred to apply sustainable and low cost techniques, like phytoremediation.

Some problems may occur after implementation of phytoremediation on a contaminated site. Most of the mining areas are situated near small cities or villages. These area are affected by serious social problems, such as unemployment (most of the citizens of these areas worked before mine closure in the mining industry) and low life quality (e.g. low income; high rate of diseases - most probably due to the pollution in the areas). These problems can result in impropriate behaviour of the local population regarding phytoremediation sites. For example, there is a risk that the trees used for a phytoremediation site are harvested by the local population and used as fuel or sold at low price [2].

Another risk can occur if the plants used for phytoremediation are ingested by cattle, sheep or other domestically animals which graze on the site, leading to intoxications or diseases among the animals and local population, and therefore influencing in a negative way the outcome of the phytoremediation project. These situations are possible because the people do not always respect rules and legislation, and are often not aware of the risks they are exposed to. Furthermore, the contaminated mining sites look in generally abandoned, like belonging to nobody, resulting in another reason for the locals to use it for their needs [16].

After implementing phytoremediation it is of high importance to carry out corresponding monitoring measures. This problem associated with ecological remediation is the lack of appropriate monitoring, which may lead to reduced achievements and therefore to financial losses. Monitoring is a frequently neglected issue, most of the time resulting from reduced financial resources or structural problems like as insufficient communication between the parties involved in a project, overlap of responsibilities, insufficient organisation [8].

The risks and negative results which can occur when the rules are not respected should be clearly listed. This goal can be achieved by organizing workshops and seminars, publishing articles in the media, and informing the NGOs, which have in generally a good network for information dissemination.

7.Conclusions - recommendations for successful implementation of phytoremediation in Romania

Mining activities, which have been carried out in Romania for centuries, resulted in pollution of large areas, affecting negatively the environment and representing a threat for human health. One of the major challenges in the reformation is the environmental remediation of mining areas.

This actual situation regarding rehabilitation of mining areas, the environmental regulations, the important actors which play an important role in this field considered that phytoremediation is as being a relatively new, low cost, environmental friendly and sustainable remediation technique, which can be applied on the mining contaminated sites for risk reduction and improvement of the visual impact on the landscape. It is therefore concluded that the successful implementation of phytoremediation on contaminated mining sites in Romania can be achieved, but under certain conditions. These conditions include the promotion of this technology by finding appropriate ways to transfer know-how and to build capacity at the level of public institutions and organizations dealing with remediation of the mining areas. Information of the civil society about phytoremediation, its advantages and disadvantages, must be undertaken prior during the implementation of a phytoremediation project.

The phytoremediation implementation rules must be set up in every project areas and population must be informed accordingly for a clear and realistic image of phytoremediation.

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