

Phytoremediation of Excavation in Eastern Siberia

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Abstract. The paper deals with prospects and applicability of phytoremediation technology in the conditions of Eastern Siberia as applied to gypsum stone extraction of Zalarinsky deposit in Irkutsk region. It analyses dust intensity for different technological processes of the deposit and evaluates the dust loading on the workers of the deposit. The selection of plantings that have potential to neutralize the dust loading produced by the plot "Severnii" is carried out.

1. Introduction

At the present time increasingly greater attention is paid to the creation and introduction of the bioremediation technology represented a battery of methods of a purification of water, soil and atmosphere applying such biological objects as mushrooms, plants, worms, insects and other organisms [1].

There are three fundamental approaches to the soil bioremediation that operate by using microorganisms:

- biostimulation – the development of indigenous microflora in the polluted areas;
- bioorange – the introduction to soil biological preparations and microorganisms which contribute to degrade the pollutant;
- phytostimulation – the stimulation of the microorganisms' development with plants.

Microorganisms are important in the degradation of the pollutants. Plants are biofilters that create the environment, contribute to the soil loosening and provide oxygen. This technology begins to be applied in mining particularly the methods of phytoremediation are widely used.

Phytoremediation is an energy-efficient aesthetic way to restore an area with low or medium level of pollution. Plants can accumulate heavy metals by gathering them in the leaves from polluted soils; sorb on the leaves' surface a fine-dispersed dust emitted during industrial processes; strengthen the surface of the depleted pits; prevent soil erosion, reduce noise, etc.

In [2] the review scheme of phytoremediation is shown (Figure 1). Filtration function of the green plantations consists of the mechanical retarding of the dust and chemical compounds from the natural environment and thereby the air purifies from pollutants.

The methods of phytoremediation are devising and applying actively in Bulgaria, the USA, the UK, Spain, Canada, China, Mexico, New Zealand and several other countries [3–4].

For example, it was calculated that in Beijing (China) 772 tons of dust are removed by trees annually in the city core [5]. In Shanghai (China) the decreasing of the dust concentrations by 9.1% was observed. MacDonald and others [6] have demonstrated that planting trees in the West Midlands (the UK) from 3.7% to 54% of the accessible land can involve the decreasing of the dust concentrations in the air by 26%; it means that the removal of dust is about 200 tons per year. In



Chicago the trees that occupy 11% of the city area remove approximately 234 tons of dust per year [7], in the USA in general trees and bushes of urban areas absorb about 215000 tons of dust per year.

In Russia the introduction of the nature conservation technology has been impeded extensively by a necessity to search the plants peculiar to our soil and climatic conditions. By now the facts about abilities of single species of wild plants as well as cultivated tree and shrubby plants along with herbaceous plants are accumulated and a wide range of plants that are suitable for soils' phytoremediation of different type pollutants is revealed.

The purpose of the research is to evaluate prospects and applicability of phytoremediation technology in the conditions of Eastern Siberia as applied to gypsum stone extraction of Zalarinsky deposit in Irkutsk region.

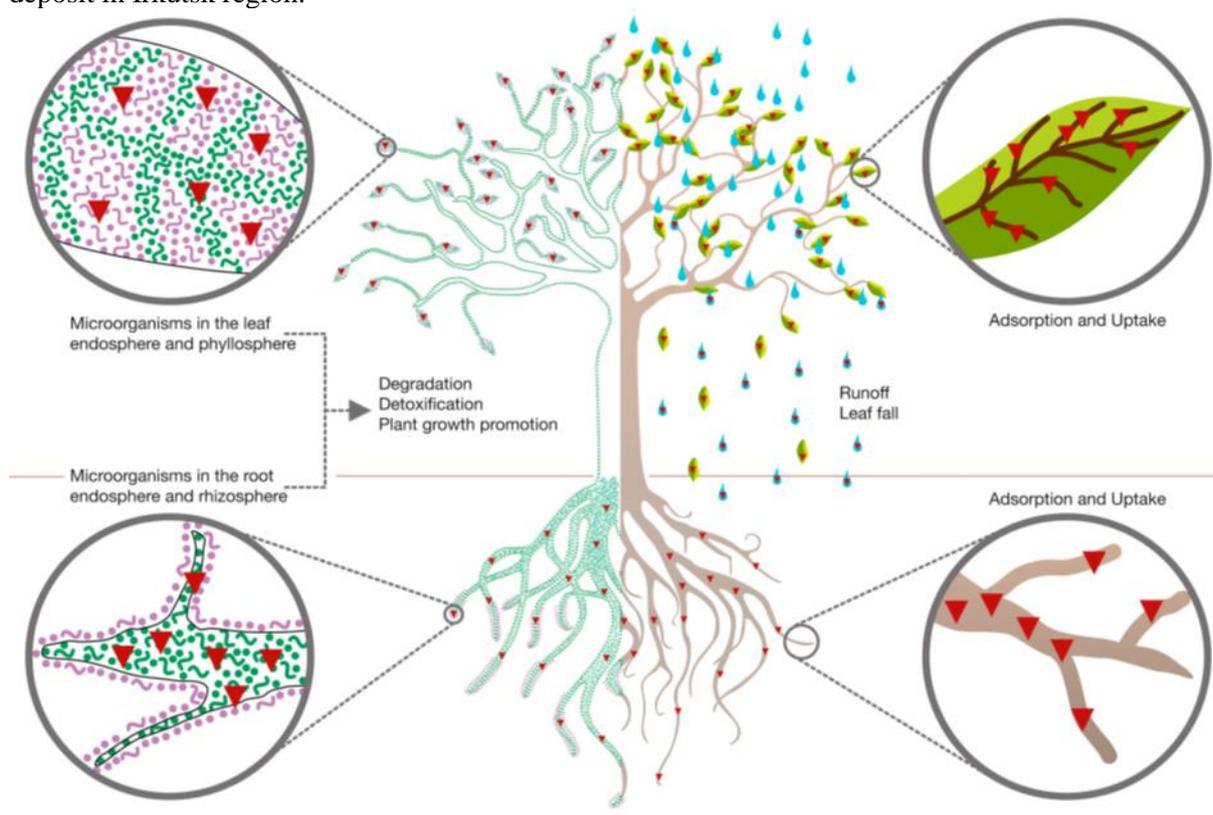


Figure 1. The review scheme of air pollution phyto-treatment.

On the basis of the production activities analysis of domestic enterprises of mining and processing of non-metallic materials we have come to a conclusion that enterprises have exactly the same technological processes such as mining, drilling-and-blasting and crushing. These technological processes are accompanied by dust emission, noise and vibration as well as a significant impact on the environment. Therefore, for the analysis and calculation Zalarinsky gypsum deposit was chosen as it is one of the leading deposit for the gypsum stone excavation. The deposit is the youngest and most promising in Eastern Siberia. Reserves of gypsum will be enough for at least 50 years. Zalarinsky gypsum deposit is exploited by the German company KNAUF.

The plot "Severnii" of Zalarinsky gypsum deposit is located in Nukutskiy district of Irkutsk region 20 km from Zalari railway station. The purpose of the enterprise is a preparation, mining and extraction of gypsum stone of Zalarinsky gypsum deposit by open-cut and split method [8].

The analysis of the dust intensity for different technological processes is carried out and the applicability of phytoremediation technology to neutralize the negative impact of the enterprise on the environment.

2. Results and discussion

The dust content in the air was evaluated by the gravimetric method by means of glasses that were displayed during the day both close to operation zones of manufacturing equipment and the industrial area outside the plot. It has been found experimentally that the maximum dusting is fixed during crushing, loading and transportation of mass (Table 1). About 62 % of all emissions at the open pit is inorganic dust with silicon dioxide.

Table 1. The dust intensity for different technological processes of extraction of gypsum stone on plot "Severnii" of Zalarinsky deposit.

Technological process	Dust intensity, gps	Mass of emitted dust, t/a
Drilling-and-blasting operations	0.0002	0.0056293
Crushing	0.062	1.95718
Loading operations	0.056	1.74589
Transportation	0.031	0.97154
The area outside the plot	0.35	11.07318

Outside the plot the dust content in the air ranges from 15 to 30 mg/m³. The emission of the fine-dispersed inorganic dust with SiO₂ into the atmosphere generated in the process of mining and crushing of gypsum stone amounts to more than 16 tons per year.

Table 2 shows the results of the dust load calculation of the workers who work for the crushing plot of the gypsum stone of Zalarinsky deposit.

Table 2. The results of the allowed active time of the workers who work for the crushing plot of the gypsum stone of Zalarinsky deposit.

The name of a profession	Dust concentration, [mg/m ³]	MPC, [mg/m ³]	Control dust loading	Dust loading	Allowed active time, years
An equipment operator of mining and crushing	4.1	2	124 000	254 200	12.2
The engineer of crushing station	7.2	2	124 000	446 400	6.5
The engineer of belt	4.1	2	124 000	254 200	12.2

It has been established that the active time without showing any pathological changes in the lungs for described professions is at least 6.5 years.

In order to reduce the dust from fugitive sources the selection of plantings that have potential to neutralize the dust loading produced by the plot "Severnii" is carried out on the basis of literature data analysis on the composition of trees and bushes that grown in the climatic conditions of the studying region [9–10].

Minimization of dust and air pollution by green plantations is in the result of the abeyance of the polluted stream movement rate in the woodland the dust fall and inhibition takes place on the surface of leaves, shafts and branches [11]. The rain or water filament washes away caked dust during irrigation of green plantations.

The studying plot "Severnii" of Zalarinsky gypsum deposit relates to the Balagansk-Nukutskiy district (Central Siberian forest-steppe province) where low power chernozem soils, carbonate and solonetzic, gray forest and caespitose-calcareous soils are distributed.

As a promising phytoremediators of this area it is possible to recommend the black poplar – a tree of the first rank reaching 30–35 m in height and 1–2 feet in shaft diameter. Black poplar is propagated by seeds, stool shoots and root stalks.

Black poplar is a rapid-growing tree which strikes root very well in different climatic zones. In addition to it black poplar stands up well prolonged inundation because the tree can absorb a lot of moisture from the soil.

For the vegetation period growing black poplar precipitates about 44 pounds of dust, white poplar - 53 kg; white willow and ash-leaved maple 34, 30 pounds respectively. One hectare of spruce forest precipitates 32 tons of dust per year [9].

Black poplar is the most widespread species of woody plants which is mainly used in biological recultivation, strengthening banks, river banks and for landscaping of bald populated areas. The reason is that it is very frost-resisting, rapid-growing and can withstand deep pruning along with it is wind-firm, environmentally flexible and steady to dust, smoke and gas. For the vegetation period one poplar dusts the atmosphere from 20–30 kg of dust or soot [9].

As phytoremediators of this site one can also plant the common lilac.

Lilac is a genus of plants of the olive family. These are low deciduous shrubs with entire-kind leaves [12]. This shrub is very resistant to drought, frost, industrial gas. Lilac emits volatile oils which have antibacterial properties. Young leaves of lilac hold five times more dust than leaves of birch. The best dedusting species of lilacs are Amur lilac, hairy and Japanese lilacs, but unfortunately, they are not introduced in the region.

As additional fitoremediation we have evaluated the possibility of using hydroseeding of herbs which can grow on sandy soils low in nutrients. Red clover and alfalfa can be the most unpretentious and perspective.

Red clover is a perennial undemanding herbaceous plant of the pea family in height up to 50 cm. It grows in meadows, along roadsides and also it can be found in the field, on slopes, along rivers [13].

Alfalfa is a perennial wild or sowing plant that belongs to the pea family. It has a thick strong stem, oval leaves and can grow in height up from 20 to 100 cm [14]. Its strong assemblage of rootlets spreads out large areas thus improving the structure and air permeability of the soil.

Alfalfa has useful properties due to its rich balanced composition and the presence of scarce amino acids and chemicals valuable to human health. As alfalfa assemblage of rootlets is from 15-20 meters in depth it pulls valuable nutrients (trace elements, minerals, etc.) from deep layers of the soil that are inaccessible to other plants.

The choice of plants arises from several reasons. First, these plants have a high productivity. Second, these plants form quickly a sod and thus protect the surface from wind and water erosion. Another reason is that in most cases these plants are not in need of soil fertility and most species withstand the lack of moisture in the soil. Finally, in the new economic conditions, the great advantages of these plants application are the availability of seed, simple sowing technology, minimal labour inputs.

3. Summary

Thus, the investigation of the dust intensity on plot "Severnii" of Zalarinsky gypsum deposit and the evaluation of prospects of phytoremediation technology suggested the application of this promising technology in the whole mining industry. At present the first experimental plantings of lilac and red clover have been conducted.

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