Introduction

Mining operations have a negative effect on the natural environment, braking the landscape and biocenosis existing at this territory.

Photo 1. Quarry under development.
Author: Vladislav Nikulin.

Upon completion of works and recultivation of the depleted areas, the biocenosis partially recovers. Intensity of seral processes depends in many ways on the quality of soil and performance of the fertile layer of recultivated areas, insolation of particular areas and humidity conditions.

This project involved analysis of the biological diversity development based on the example of water basin, located by the quarry, and recommendations were given to boost the development of biological diversity during execution of mining works.

Goals

- Recovery of biological diversity at areas, affected by mining works.
- To convert negative consequences of mining works to positive recovery dynamics and expansion of the biological diversity directly in course of the mining works execution.

Background

Presence of hundreds of flora species and dozens of fauna species is characteristic to adjacent non-affected areas. Mining works break the biological interconnections, huge number of flora species disappear, soil structure changes, aerodynamical and hydrological regime is broken at vast areas (hundreds of hectares). When mining works are under way, products of the mountain massif destruction are relocated for a considerable distance, thus changing the chemical composition of bare soil surface. Violation of the hydrological regime leads either to bog formation or to excessive dewatering of depleted areas. Dynamics of mining works negative influence almost does not allow to launch the secondary succession process. Smart management of mining works and depleted areas may contribute to more active secondary succession even during execution of mining works. Products of technogenesis during the mining of limestone are fine limestone fractions, nitrates and greenhouse gases.

Broken landscape (irregular unorganized overburden disposal) creates local micro-basins of water and temporary storm water streams, thus breaking the hydrology at huge areas. Life is tightly connected to water. Small water basins, temporary water channels, despite of the technogenesis, are places where secondary succession occurs. We see our goal in using natural processes of life recovery at affected areas by creation of "regular" water basins (artificial and organized) for activation of secondary succession processes.

Our studies have been carried out at the water basin located in direct vicinity of the quarry. This basin has been artificially created at early spring during execution of mining works. Round about the basin, due to heavy equipment operations, the upper fertile soil layer has been damaged along with all the flora.

Photo 2, 3. Water basin, appointed for studies. Author: Vladislav Nikulin.

Taking into consideration dark colour of water and its low transparency, we stated that it has low dissolved oxygen value, thus no life was observed in the basin. Besides, no living plants have been present in the area surrounding the basin.

Photo 4. Water condition as of 30.05.2014. Author: Vladislav Nikulin.

As is known, mining works at quarries are carried out using explosives.

Blasting operations create considerable amount of NOx. The orange cloud is clearly seen on the picture, which contains the nitrogen dioxide.

Photo 5. Blasting operations.
Author: Morozova Tatyana.

NOx, being transformed in the atmosphere by local inversions, fall out to the soil surface in the form of nitrate compounds, which are dissolved in the atmospheric water, precipitation and finally enter existing water basins.

Photo 6. Orange cloud, which contains the nitrogen dioxide.
Author: Morozova Tatyana.

Methods

Taking into consideration mining works peculiarities and materials used for mining operations (nitrates, carbonates), it is suggested to activate the secondary succession processes. For this purpose it is necessary to create a relief at recultivated area, where small water basins will develop by means of natural atmospheric precipitation. 3–5 degree slope is sufficient for water to accumulate in relief dips. Furtherafter, due to good insolation values, water supply conditions and utilization of fast-growing species of aquatic flora, a strong foundation may be created for further development of biological diversity even in direct vicinity of the working face.

Program for biological diversity development using small water basins is presented at the photo No. 7.

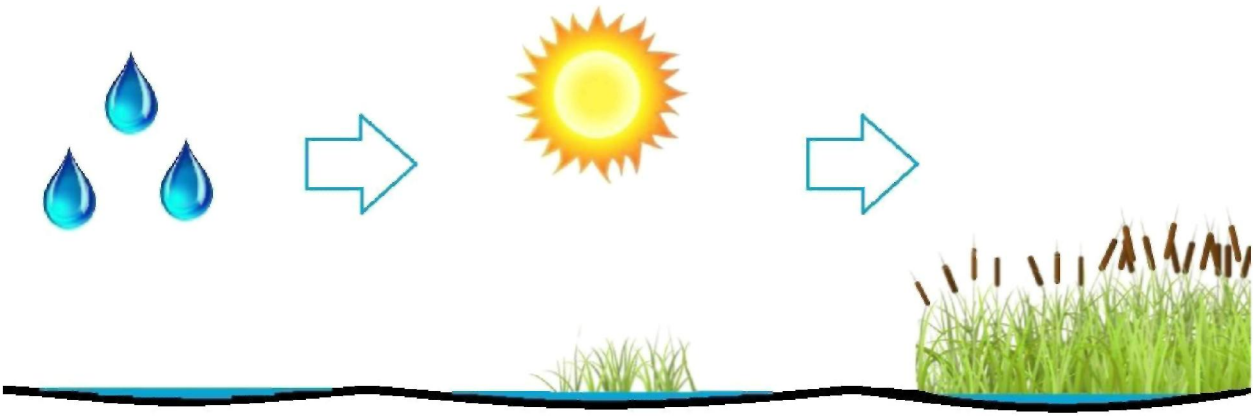


Photo 7. Program for biological diversity development using small water basins. Author: Vladislav Nikulin.

We decided to boost the growth of plants in the area surrounding the water basin by planting the cattail, which is not whimmy and easily sustains transplanting.

Cattail was planted in stripes spaced with an interval of 0.7–0.8 m.

Photo 8. Cattail planting. Author: Vladislav Nikulin.

Plants with good nitrate absorption performance are required to remove nitrates from the water. These include: waterweed, water hyacinth and hornweed.

Photo 9. Water hyacinth.
Author: http://novaielena.blogspot.ru

Photo 10. Hornweed.
Author: http://moiryby.ru/rogolist.nik.html

Photo 11. Waterweed.
Author: Christian Fischer

Results

Cattail we replanted easily naturalized and its new shoots have developed. New plants have also developed, such as: duckweed, alisma plantago-aquatica, spargánium and bog violet.

Photo 12. 13. Naturalized cattail and its shoots. Author: Vladislav Nikulin.

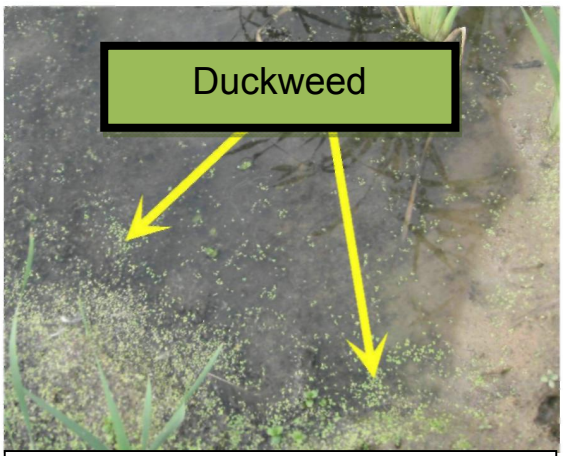


Photo 13. Duckweed.
Author: Vladislav Nikulin.

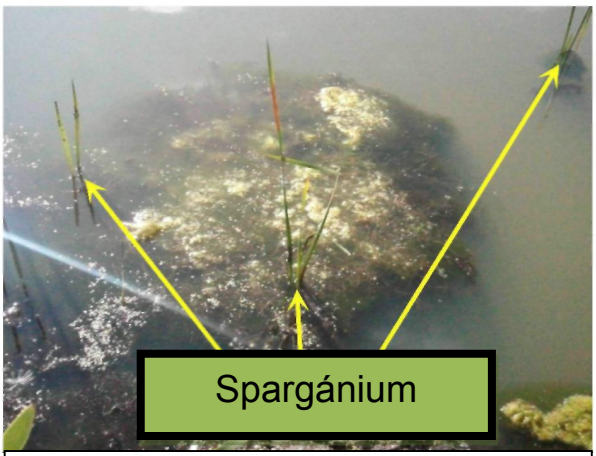


Photo 14. Spargánium.
Author: Vladislav Nikulin.

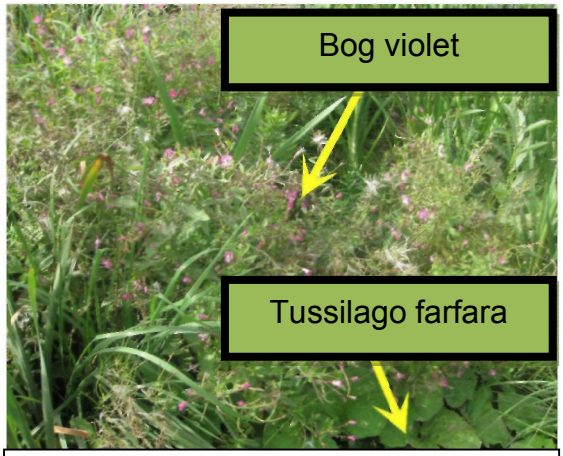


Photo 15. Tussilago farfara, Bog violet. Author: Vladislav Nikulin.

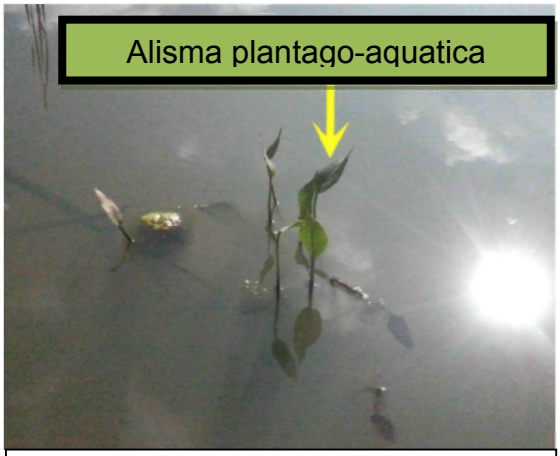
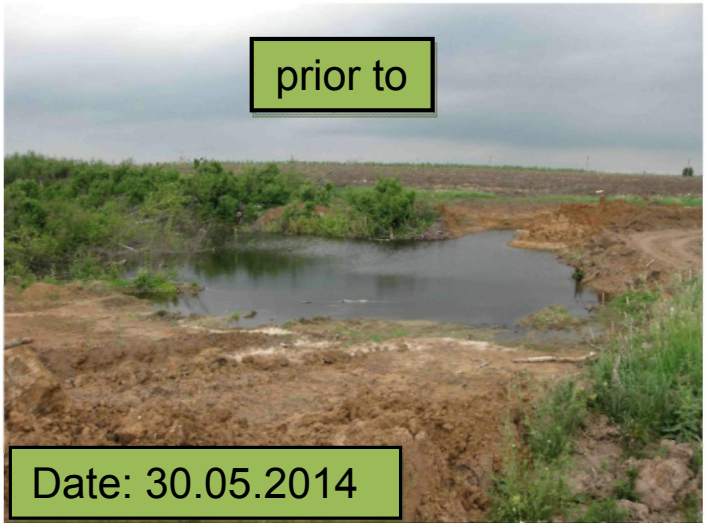


Photo 16. Alisma plantago-aquatica. Author: Vladislav Nikulin.

Amount of plants in the adjacent area increased significantly by natural means.



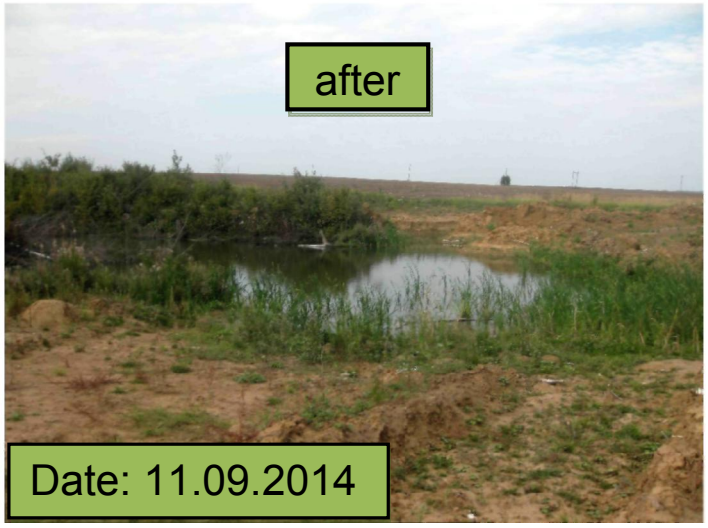


Photo 17, 18. Water basin prior to and after studies. Author: Vladislav Nikulin.

Water condition has also changed significantly. Water became more transparent, new species of alga have developed: Spirogyra, Ulothrix.

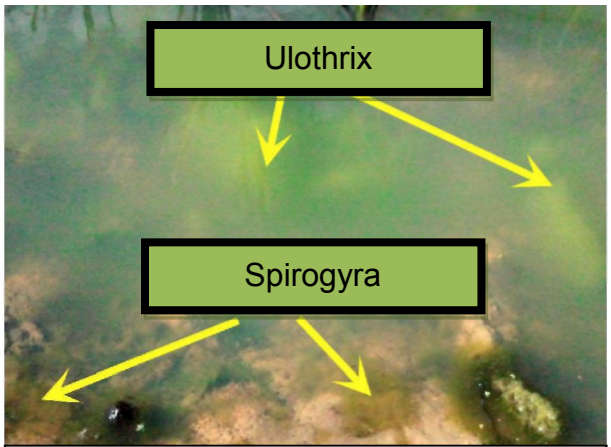


Photo 19. Alga in the water basin: Ulothrix, Spirogyra. Author: Vladislav Nikulin.

Based on the tracks observed, animals started to use this basin as watering place, which has never been observed earlier.

Photo 20. Animal tracks by the basin.

Author: Vladislav Nikulin.

Soil samples have been analysed, that had been taken by the basin, for presence of nitrates by colorimetric method with disulfophenolic acid. Sampling depth is 5–15 cm.

The following data has been gathered as the result:

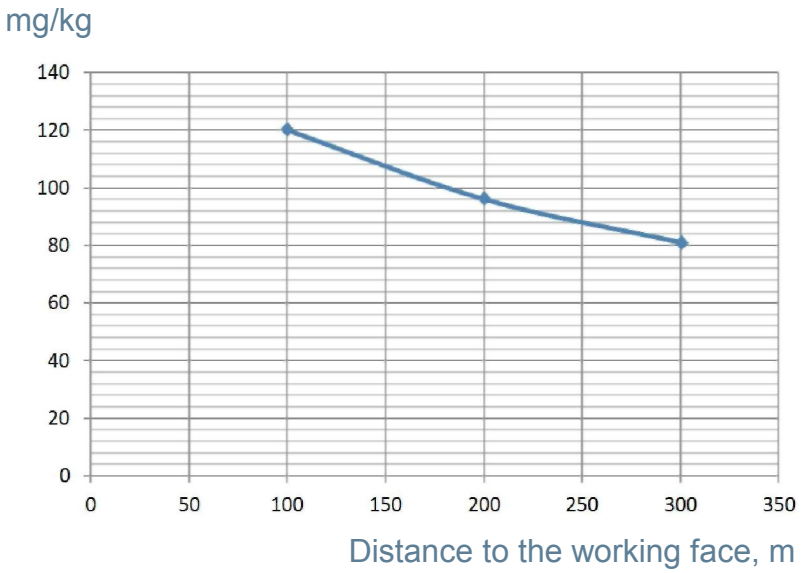


Diagram 1. Change in nitrates concentration versus distance to blasting operations site.

100 m from explosion point: concentration 120 mg/kg;

200 m from explosion point: concentration 96 mg/kg;

300 m from explosion point: concentration 81 mg/kg.

Thus we have evidenced the change in nitrates concentration in proportion to distance from the working face. Atmospheric precipitation washes nitrates out and accumulate it in small water basins.

Studies of plants development intensity proved that there is a clear relation between the concentration of nitrates in water basins and the density of plants.

Besides, the water from this basin has been analysed for nitrates content by photometric method.

The following data has been gathered as the result:

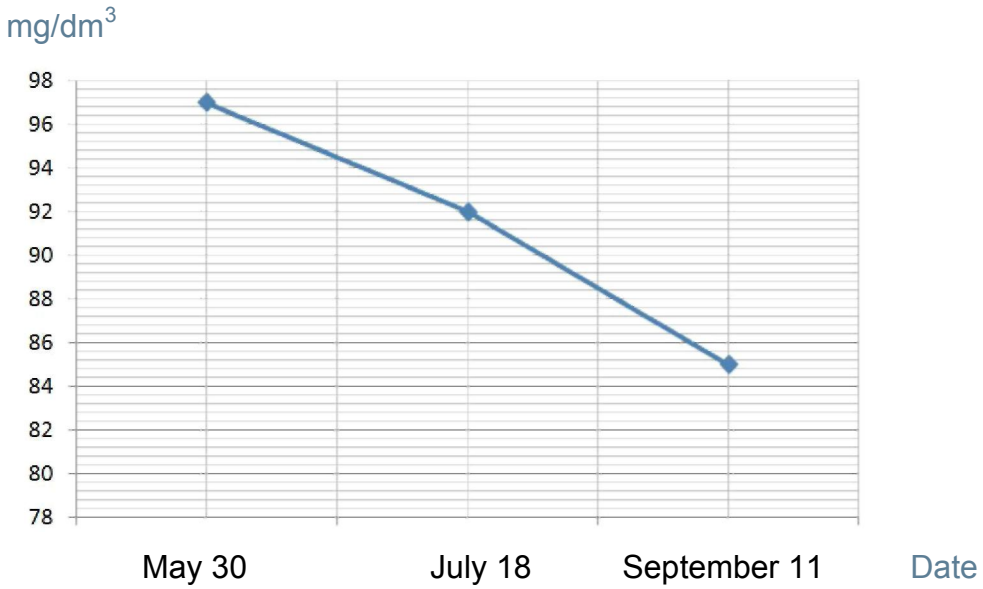


Diagram 2. Results of water analysis for nitrates content.

May 30: concentration 97 mg/dm^3;

July 18: concentration 92 mg/dm^3;

September 11: concentration 85 mg/dm^3.

Organics decomposition process took place in the basin during one season with development of ammonia and ammonia compounds at first stage and further nitrification process with creation and recovery of nitrates.

As is clearly seen on the diagram, nitrates recovery process at first stage was less active. Possible causes of this process include combination of such factors as early nitrification process and additional nitrates ingress due to continued blasting operations.

The process went more active during the active nitrification stage and biomass development, and we may expect further reduction of nitrates content to 40–48 mg/dm3 (natural concentration).

Theoretical background

Spotty appearance of the recovered landscape is clearly seen at exhausted surface of the brick-earth quarry, where plants are alternating, which are typical for water-adjacent and bogharic (dry-land) areas.

Photo 21. Exhausted surface of the brick-earth quarry. Author: Arkady Simankin.

Studies of flora at recovered (recultivated) areas prove that the process runs most actively at areas provided with thick fertile layer and water availability.

Photo 22. Dense grass cover and high biological diversity. Author: Arkady Simankin.

Dense grass cover and high biological diversity are clearly seen on the Photo No. 22. It is worth noting that insolation of the area is low due to its northern orientation.

Areas with disturbed fertile layer or with complete absence of this layer, despite of good insolation, present significantly weaker plant formation, species diversity is very low (Photo 23).

Photo 23. Areas with disturbed fertile layer. Author: Arkady Simankin.

Presence of biogenous substance, stimulating the growth of plants, is of primary importance. Such biogenous substances include for organics and nitrogen compounds. Nitrogen compounds, based on multiple observations, contribute to the growth of plants, especially during the first stage of vegetation. Plants receiving nitrogen are characterized by faster growth cycle with nitrogen transition to different compounds.

That is the reason we decided to convert negative consequences of mining works to positive recovery dynamics and expansion of the biological diversity.

Thus we may point out the following virtues:

- the process of biological diversity recovery goes directly during execution of mining works;
- an efficient strategy will be developed for maintenace of the optimal biological diversity level at water basins and adjacent areas;
- voney saving due to lowering amount of recultivation works required at exhausted areas;
- environmental education and attitude development among the community after depletion of the quarry, by means of recreation at recultivated territory.

Statement

If create the necessary conditions, chemical substances polluting on the surrounding areas after blasting works can become additional favorable factor, which promote the restoration processes and biodiversity enhancement on quarries.

This project seems perspective, as its implementation does not require considerable expenses and complicated technical solutions.

Management of soil dumps surface, alternating of stripping areas and areas with recoverable plant complex, usage of aquatic and ground-covering plants will contribute not only to rapid recovery of plant complex, but to creation of new biological pyramids.

Recultivated areas will provide a good research basis, as the project implementation may attract people, carrying out research activities including planting various species of plants and observing its growth. In due course it will allow to determine most appropriate species to be further used for recultivation of exhausted quarry areas.

Finally, we will see the real triumph of nature at disturbed lands.