Industrial site rehabilitation: design and challenges

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Abstract. The article is devoted to the design of reclamation works after completion of construction works on the construction/reconstruction of the railway line of the enterprise. The authors described the current regulatory framework, as well as types of reclamation works and stages of project implementation. Within the premises of the experimental area after the construction and installation works were completed the authors conducted the survey and design of reclamation procedures, which included planning, construction of a drainage ditch (as part of the technical stage), landscaping (as part of the biological stage). The authors, after analyzing the survey materials and comparing design solutions, believe that the designers superficially reacted to the task at hand, they did not sufficiently take into account the impact of atmospheric and surface water on the site under consideration. Since the site is located in an urban area, the identified problem will definitely require a solution in the future.

1 Introduction

We can say that the urgency of land reclamation is due to the following reasons:
− the increasing size of the area of disturbed land;
− scooped up reserves of potentially suitable land for agriculture;
− growing food shortage.

Recultivation issues in the Russian Federation began to be dealt with in the first and second half of the 20th century. Since the 1990s, the Decree of the Government of the Russian...
2 Materials and methods

[The text is not legible due to the image quality. It appears to discuss various types of reclamation methods, including sanitary and hygienic, water management, recreational, forestry, agricultural, and construction site reclamation methods.]
Construction reclamation (excavation, drainage, relief planning) is aimed at creating conditions for the construction of buildings for various purposes on the site of disturbed land. Thus, when designing reclamation works, depending on the permitted use, it is possible to choose the optimal type of reclamation and make the disturbed land plots suitable for use, or restore the original natural landscapes with natural biological diversity. Legal entities and individuals using land plots are obliged to implement measures to protect land and other natural resources, prevent pollution, depletion, degradation, damage, destruction of land and soil, and other negative impact on land and soil. The use of land plots is carried out in accordance with their intended purpose in ways that should not harm the environment, according to the Land Code of the Russian Federation [5]. Decree of the Government of the Russian Federation No. 800 specifies that a land reclamation project is prepared as part of the project documentation for the construction or reconstruction of a capital construction object, if such construction or reconstruction will lead to land degradation or reduce the fertility of agricultural land, or as a separate document in other cases [3]. Control is assigned to the State Land Supervision Service [6].

A set of reclamation works is a multi-stage system of interrelated activities, structured according to the level of tasks to be solved and technological execution, within which several stages can be distinguished:

1. Preparatory stage - survey of disturbed territories, determination of the direction of recultivation, drawing up a recultivation project.
2. The tyrannical stage - implementation of the engineering and technical part of the land restoration project;
3. Biological stage - landscaping, forest construction, biological cleaning of soils, measures, aimed at restoring the processes of soil formation.

3 Results and discussion

As an object of research, we took the project of recultivation of site No. 3 on JSC Sredneuralsky Copper Smelter (JCS SUMZ), which is located on the territory of the enterprise and is located on the outskirts of the municipal formation "City District of Revda" in the Sverdlovsk region (Fig. 1) [7]. There are no specially protected areas. Site No. 3 under study belongs to the category of "land of populated areas". Information on the nature of land use for the placement of a work site – Land plot No. 3 is classified as industrial land by the type of permitted use. The factor, that caused land disturbance, is the impact of running systems and machinery units during construction work. The site is bounded by unpaved roads and railways. In the immediate vicinity there is a landfill of solid household waste. The site under consideration is the site with the natural topography which was severely degraded as a result of man-made processes which are as follows:

− rubble mounds, littering the territory that arose during the operation of the access railway;
− massive disturbance of the soil layer which was formed as a result of unsystematic operation of heavy road and transport equipment (danger of deformation).
The area under study has lost its productivity as a result of being used as a temporary right-of-way for construction work. The territory of the site is experiencing a rather significant anthropogenic impact due to the proximity of a large industrial enterprise, a solid waste landfill, and infrastructure facilities. The condition of the site surface is characterized by the absence of a fertile layer of land, a large number of inclusions of crushed stone, and ravine formation (Figure 2).
For the development of vegetation, humus (the main organic substance of the soil) is necessary, containing the nutrients necessary for plants. Indicators of the humus content in the soil of the study area, determined in the Laboratory of Physical and Chemical Methods of Research and Control of Raw Materials of the Ural State Mining University, and their comparison with the requirements for the characteristics of the soil layer are given in Table 1.

Table 1. Mass fraction of humus in the studied area (required fraction of at least 2 %)

<table>
<thead>
<tr>
<th>Depth of soil sampling, m</th>
<th>Mass fraction of humus according to GOST 26213-84, %</th>
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<tbody>
<tr>
<td>0,2</td>
<td>0,7</td>
</tr>
<tr>
<td>0,5</td>
<td>0,67</td>
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<tr>
<td>1,0</td>
<td>0,48</td>
</tr>
<tr>
<td>1,5</td>
<td>0,3</td>
</tr>
<tr>
<td>2,0</td>
<td>0,21</td>
</tr>
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</table>

We can see that the proportion of humus at the entire depth studied does not allow vegetation to develop on the site. On the geological section of the site (Fig. 3) we observed 0.2 m thick soil-vegetation layer \(h_Q\), which is preserved in the southern part of the study area, but the main part of the site is formed by technogenic bulk soil \(t_Q\). In the study area, the soil was filled out unorganized, heterogeneous in composition, method of filling in depth represented displaced local soil. In the report of geological pre-project surveys, it is recorded that the top layer of the site is composed of "disturbed soil and vegetation layer with locally unorganized crushed stone, represented by displaced local soil (loam, loam with crushed stone; crushed stone). The ground was caked, compacted in some areas from 0.2 to 0.7 m". Layers lying at a greater depth \(d_Q\) and lower) are not damaged, but due to the great depth, they do not participate in soil formation.
Fig. 3. Geological section of the studied area

The analyzed reclamation project for site No. 3 of Sredneuralsky Copper Smelter OJSC provides for a number of measures to stop the degradation of the site's soil cover, eliminate the consequences of destruction, add nutrients, and create conditions for landscaping.

The recultivation work is divided into two stages:

1) tyrannical stage. Elimination of soil cover violations.
   - creation of smoothed landforms and surfaces with favorable environmental conditions for planting plants (removing excess rubble with an excavator, planning and forming the surface of the territory with a bulldozer);
   - installation of a drainage ditch with length of 500 m;
   - dismantling of technological equipment and structural elements installed on the site (performed at the final stage);

2) biologic stage. Planting of plants from the flora of the Ural natural and climatic zone, including biologically valuable plant species.
   - spiking up;
   - liming;
   - settling of perennial grasses.

In our opinion, when developing the project, insufficient attention was paid to the issues of water disposal. The study of the water regime of the site makes a significant contribution to the decision on the choice of type of reclamation, as it affects the cost of labor, construction materials, machinery and mechanisms and, as a result, the cost of project implementation.
According to the theory, hydrotechnical solutions within the framework of a reclamation project should solve three tasks:

1. Water supply of mechanization equipment, dredgers, industrial units and installations;
2. Drainage of flood waters from the developed areas, taking into account the hydrological situation of the area;
3. Rational use of water resources, their protection from pollution.

Let's compare the analyzed reclamation project with these tasks. The first task is not considered in the project, because the site of reclamation works is located outside the water protection zone of the Chusovaya River and does not fall within the territory of sanitary protection zones for drinking water sources or areas that are given for the organization of centralized drinking water supply, which meets the requirements of the Water Code of the Russian Federation.

In order to fulfill the second and third tasks, the project included only two activities:

- The organization of water flow from the site territory both during the work period and after its completion;
- The device of a special drainage ditch with a length of 510 m, allowing it to fix fertilizers without washing them out. The construction of the ditch is provided from local soil and a clay layer of 0.2 m as a "clay castle". The parameters of the drainage ditch are calculated taking into account the discharge of 100% of storm runoff. The ditch will be located on the eastern side of the study area, with the flow direction to the northern part in the neighboring area.

Let's consider the materials of geological and hydrological pre-project surveys. The researchers note that the lithological composition of the complex is heterogeneous in area and section. The thickness of the effectively permeable fractured weathering zone in these rocks averages 40-50 m. As a rule, higher thickness values are associated with narrowly local zones of increased fracturing of various origins. The water is mostly unpressurized. The natural regime of underground waters fully reflects the conditions of precipitation infiltration and the water content of the season. The background water content of the array is insignificant. By chemical composition, the underground waters of the complex are mainly calcium-magnesium bicarbonate with a mineralization of 0.1 to 0.3 g/l. The level of underground water lies at depths of 4.47-18.0 m. The chemical composition of underground water within the improvement area is sulfate, bicarbonate-sulfate, calcium-magnesium cations, and water with relatively high mineralization.

There are no existing or projected water intake wells or explored deposits of underground water for domestic drinking purposes directly within the landscaping site and downstream from it. Water flow to the site will be formed due to the flow of meltwater and liquid precipitation. Thus, the drainage of surface stormwater under the project is carried out in two ways (planning and ditch separation). However, there may be several problems with their implementation.

1. Due to the fact that the site has a large area (about 3.4 hectares), with a very rough terrain, a simple layout of the territory will not give the necessary result. We need a comprehensive solution for organizing the terrain with the formation of a slope to the ditch.
2. The ditch, despite the approval of the designers, does not guarantee 100% acceptance of stormwater runoff, since, as can be seen from the survey materials, fractured rocks lie at a depth of up to 50 meters, underground water levels are marked at a depth of 4.5 to 18 meters, and there are no solid waterproofing coatings on the surface that prevent water from penetrating deeper and diverting water to the ditch. The layer of regenerated soil slows down the surface flow and also contributes to the penetration of water into the ground. All this eventually allows water to reach the aquifers, bypassing the ditch.
3. Penetrating deep, water passes through a man-made layer, the analysis of the composition of which was not carried out. Considering that the site belongs to a copper smelter, it is possible to pollute the water with carcinogenic substances. To forecast the qualitative and quantitative characteristics of runoff, it is necessary to obtain actual data on the flow rate and concentrations in certain channels in different periods of the year, especially highlighting the spring flood.

4. The measures provided for in the project provide for a simple discharge of water outside the site, the stormwater discharge point on the terrain is not worked out, which is fraught with further erosion and contamination of the adjacent area.

4 Conclusions

Thus, the technical reclamation of industrial areas is being expanded both in the Urals and in the Russian Federation as a whole: abandoned quarries, technical roads, construction sites are being restored, and landscaping is being expanded. However, there are obvious problems. So, designers and customers often do not consider the reclamation of the territory as a complex measure, being limited to the boundaries of a strictly defined site. In addition, the impact of surface and underground waters on the operation of ground massifs is not sufficiently taken into account. Finally, when implementing large-scale projects, it is necessary to approach the issues of research and forecasting in more detail.

References