Environmental and economic assessment of the impact of oil and gas production on the state of landscape and botanical complexes in the Urals

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Abstract. The article presents the results of environmental and economic assessment of the impact of oil and gas industry objects on the state of landscape and botanical complexes in the Urals. Using the example of two oil and gas fields, the complex impact of the construction and operation of this type of facility is shown. The greatest disturbances to the land are caused by the construction and operation of industrial sites for integrated gas treatment plants and gas distribution networks, wells and service pipelines, crane assemblies and piston start-up and intake assemblies. Despite the fact that according to the point system, the impact of the enterprise on biocenoses is assessed as “weak negative,” the impact of oil and gas production facilities has led to a significant change in landscape and botanical complexes. In addition to changing the geochemical state of landscapes and the redistribution of natural geochemical cycles, a change in the ecological structure of species of edificators, a change in their physiological and morphological functions has been established. This impact directly affects the state of forest ecosystems, water conservation, water regulation, and absorption functions of the forest. Economic damage from the operation of oil and gas production facilities is 137042, 00 rubles.

1. Introduction
Currently, the oil and gas industry is dominant in the economy of the Russian Federation. At the same time, the role of this sector of the economy is significantly enhanced in certain regions in which oil-producing enterprises are concentrated. Orenburg region is one of the leading regions of oil and gas production in Russia [1-5]. The resource potential of the region is huge. On the territory of the region, whose area is 123,702 km², 23 fields are being developed. In total, more than two hundred hydrocarbon deposits have been identified in the region, most of them confined to the western part of the Orenburg region (table 1). At the same time, this type of industry has a significant impact on the state of landscapes both at the construction stage and at the operation stage of industrial facilities [6-7]. Oil and gas production is associated with intense human impact on the environment. In this paper,
an attempt is made to assess the extent of this impact on the example of the Kolgan and Berdyansk deposits.

Table 1. Density of existing oil and gas fields in the territories of the administrative regions of the Orenburg Urals (K.V. Myachina, A.A. Chibilev, 2006).

| District Name        | Number of fields per 100 sq km |
|----------------------|-------------------------------|
| Severnyy             | 0,43                          |
| Buguruslansky        | 0,31                          |
| Abdulinsky           | 0,12                          |
| Asekeyevsky          | 0,43                          |
| Matveevsky           | 0,05                          |
| Ponomarevsky         | 0,05                          |
| Grachevsky           | 0,12                          |
| Krasnogvardeysky     | 0,39                          |
| Alexandrovsky        | 0,07                          |
| Alexandrovsky        | 0,48                          |
| Tosky                | 0,09                          |
| Sorochinsky          | 0,11                          |
| Novosergievsky       | 0,20                          |
| Perevolotsky         | 0,11                          |
| Pervomaisky          | 0,23                          |
| Tashlinsky           | 0,03                          |
| Ileksky              | 0,05                          |
| Sakmarsky            | 0,15                          |
| Orenburgsky          | 0,13                          |
| Sol-Iletsky          | 0,02                          |
| Akbulaksy            | 0,06                          |
| Buzuluksky           | 0,26                          |

2. Experiment

The object of the study was the territory of the Kolgan and Berdyansk oil and gas fields. The territory of the deposits belongs to the subzone of the northern steppe, for which grass-fescue-feather grass communities are characteristic. The forest cover of the study area is insignificant - 0.64%, of which 0.01% is accounted for by artificial stands. The predominant tree species are warty birch, small-leaved linden and common aspen. Phytocenoses of plain and steep-slope real steppes prevail among natural herbaceous plant communities; coenoses of solonetzish, solonetzic and stony steppes, as well as dry steppe low-lying meadows are more rarely and singly dry short-floodplain meadows are discovered. A total of 29 plant modifications were identified in the research area.

Almost all industrial facilities operating in these fields are located among the arable land, which makes up more than half of the farmland. Some non-plowed territories have been preserved, confined in most cases to the inconvenience associated with dissected areas of relief, outcrops of bedrock, as well as ravine slopes. But even in such areas, natural vegetation has undergone significant changes. There are also disturbed lands, partially or completely devoid of vegetation, which have a disturbed or buried soil profile. These sites are either under construction, or are the lands of transport or industry
and are covered with asphalt or other hard surface. All this led to a certain technogenic change in the landscapes of the territory in question.

Severely disturbed lands include lands under residential development of settlements, as well as industrial lands occupied by industrial sites of integrated gas treatment plants (GTP) and gas distribution networks (GDN). Such sites for the most part have a protective asphalt coating, eliminating or minimizing soil contact with the atmosphere. Pipes are laid underground on the GDN, making up its contour, excavation and soil movement during their laying also violates the soil layer. The result is the degeneration of the buried soil profile with a sharp deterioration in the water-thermal regime of the soil. Such soil gradually loses zonal features and stands out as a separate class - urban soil complexes, the classification of which is currently being developed. Similar heavily disturbed objects are the land of transport - roads and railways. The difference is the geometric shape of the objects: if the industrial sites have the same length and width and are areal objects, then the roads have a length (length) that is orders of magnitude greater than the width of the roadway, i.e. are linear objects. Point objects are industrial well sites and service centers for product pipelines, crane assemblies and piston start-up and intake assemblies.

The main impact on atmospheric air during the exploitation of oil producing wells is pollution of the air basin with emissions of harmful substances: carbon monoxide, nitrogen oxides, soot, dioxinsulfur, formaldehyde, benz(a)pyrene, vanadium pentoxide, saturated hydrocarbons \( \text{C}_{12-19} \) (unburned particles of diesel fuel and fuel oil), and \( \text{C}_1-\text{C}_5 \) (undurned associated gas components in the torch), hydrogen sulfide and saturated hydrocarbons \( \text{C}_{12-19} \) (contained in diesel fuel and fuel oil) (table 2).

### Table 2. Maximum concentrations of harmful substances in the air of the nearest settlements.

| Ingredients | The concentrations, proportion of MPC |
|-------------|-------------------------------------|
| Sulfur dioxide + hydrogen sulfide | 0,54 |
| Hydrogen sulfide + formaldehyde | 0,5 |
| Hydrogen sulphide | 0,5 |
| Carbon oxide | 0,41 |
| Nitrogen dioxide + nitric oxide + sulfur dioxide + vanadium pentoxide | 0,3 |
| Nitrogen dioxide + sulfur dioxide | 0,29 |
| Nitrogen dioxide | 0,25 |
| Limit hydrocarbons \( \text{C}_1-\text{C}_3 \) | 0,06 |
| Vanadium pentoxide + sulfur dioxide | 0,04 |
| Sulphur dioxide | 0,04 |
| Soot | 0,03 |

An assessment of the impact of the activities of oil producing enterprises in the study area on the correspondence of pollutant contents to MPC values indicates that the emissions of these components are insignificant and do not significantly affect the overall picture of air pollution. The value of surface concentrations of the maximum pollutant emitted by sources (the sum group of sulfur dioxide + hydrogen sulfide) is up to 54% of maximum permissible concentration.

The impact on surface water and the geological environment during the operation of oil and gas production facilities is associated with pollution and withdrawal of water resources. As a result of filtration, various organic substances, chlorides, sulphates and bicarbonates of calcium and magnesium enter both surface waters and the geological environment. Pollution and disturbance of the geological environment “from below” from the rock mass during construction and operation of wells may be associated with overflows of formation fluids into underground horizons, absorption of drilling fluid
during drilling, with uncontrolled gas and oil occurrences, with collapse of the walls of wells and the formation of caverns and etc. In the case of interstratal overflows, abnormal hydrochemical zones may form in the upper aquifers, in which the hydraulic displacement of the waters of a given horizon by a pollutant (mineralized water, oil) from other aquifers is recorded.

Particularly great damage to the environment is caused by accidental emissions and gushing by underground fluids, especially oil. At the same time, groundwater is primarily contaminated. Oil penetrates the soil layer and aeration zone, moving under the influence of gravity. Meeting with a mirror of underground waters, it can actively spread over horizons and pollute large areas.

As a result of the operation of oil and gas facilities, the negative impact on biological resources is expressed:

- in the destruction of steppe vegetation in the area seized for the construction of oil and gas production facilities, which leads to a reduction in the food supply of wild animals;
- in the impact on biocenoses of atmospheric emissions;
- in noise, vibration, light and other types of anthropogenic impact on animals that cause their concern, while the most vulnerable are rare species listed in the Red Book of the Orenburg Region.

According to the point system, the enterprise’s impact on biocenoses is assessed as “weak negative”. However, to assess the environmental impact of industrial enterprises, sanitary and hygienic standards are used, established by the degree of harmfulness to the human body.

In the study of taxation indicators of forest stands, using the example of the Myasnikovskaya grove, differences were revealed between the distribution of trees by thickness steps, which are due to the competitive growth strategy of the species and growing conditions. For the birch, the curve has a wider base, however, the undergrowth is practically absent; for the common aspen and small-leaved linden, intensive formation of undergrowth is noted. However, in the distribution series of aspen and linden, a complete loss of some thickness steps was noted, which indicates some instability of the populations.

The magnitude of the fluctuating asymmetry in all the main parameters of the birch leaf blade is indicative of intense anthropogenic impact (development stability coefficient - 0.0514, development stability score - 4). This is due to the toxic effect of pollutants in atmospheric air.

Nitrogen dioxide acting on plants causes peripheral damage to the leaves, twisting them inward, the appearance of a brown color at the final stage of leaf development. The toxicity of nitrogen dioxide is much higher for young plants. A discoloration of the undergrowth of Aspen vulgaris (to light red) was noted.

Fluorine compounds, which have a phytotoxic effect in small concentrations (less than 0.6 μg / m³), are a great danger to plants: the formation of chlorotic spots, accompanied by necrosis and tissue drying. Sulfur gas, damaging plants, contributes to the weakening of their stability to various environmental factors, diseases, pests. Signs of damage to plants by hydrogen sulfide are for the loss of turgor, the appearance of light yellow and brown-black spots, burns mainly in the middle of the leaf blade. In the process of studying the surface of the leaf, 5 types of damage were revealed: spot and spotted necrosis, the dead edge of the leaf and the dead tip, and the change in the shape of the leaf.

Observing the change in leaf shape, an increase in deformed leaves was found in plants in the contamination zone. It is known that sheet deformation is associated with the action of ethylene. The difference between the degree of various damage to the vegetative organs of the experimental and control plants was 90.04%.

For the purpose of determining the environmental and economic indicators, the degree of drying out, loss of growth was determined. With the predicted loss of green mass on average for common aspen, linden small-leaved, birch 83%, the average loss of growth will make up 127%.

The water conservation functions of the forest are determined by the increase in the water content of underground sources due to surface water. The damage from the total or partial loss of forests, estimated through a decrease in the replenishment of surface water from underground sources, amounted to 43 562, 00 rubles.
The water-regulating properties of forests are manifested in an increase in water-bearing capacity, a decrease in salinization and pollution of water bodies and rivers with sewage, gutter, and erosion products.

The loss of water-regulating properties as a result of drying of 15.3% of the stands of the above species of woody plants amounted to 17,424,619.00 rubles.

Under the absorptive properties of forests, we usually mean the absorption of harmful emissions into the atmosphere of industrial enterprises, transport, agricultural production, etc. The surface of the soil and plants is the main absorber of impurities entering the underground ecosystems. Pollution charge standards have been established. Calculations showed that the average cost of substances absorbed by a tree on average per year is 1000 rubles. The area affected by forest stands is 53.0 ha. The average number of trees per 1 ha is 1690 pcs., We take 1% of the suburban area. The drying out of 15.3% of their number gives economic damage of 137,042.00 rubles.

The predicted drying of the plantings of the species under study can be up to 15.3% (8.1 ha). In accordance with the “Consolidated estimated calculation for the implementation of measures for the reproduction of forests” of the Ministry of Forestry and Hunting of the Orenburg Region, 201301.11 rubles are required per 1 ha.

3. Conclusion

In order to prevent the development of undesirable processes leading to irreversible changes in the landscape and vegetation, it is proposed to carry out monitoring studies of the impact area, as well as apply modern effective technical devices to minimize impacts.

The basis for the development of any systems for assessing the state of landscapes is monitoring, which includes a monitoring system and a forecast of ongoing changes in the components of the functioning of the geosystem (topography, soil and vegetation cover) of their geochemical characteristics [7]. Conducting such studies, carried out according to the same methodology and on a single topographic basis, will subsequently allow a qualitative and quantitative analysis of the functioning of the system and will reveal all changes in the environmental components (vegetation, soils and landscapes), as well as establish trends in their dynamics in the near future [8-9].

Since the main exogenous processes that affect landscape instability and the degree of environmental risk of the research area are planar, linear, lateral erosion, the landscape monitoring program should include the following sections:

- monitoring the erosion activity of the most vulnerable areas, which includes the creation of runoff sites, measuring and calculating runoff of water and sediment from slopes during the spring flood and rainfall in the summer-autumn period. Particular attention should be paid to the slopes of the southern exposure, where the processes of slope erosion proceed most intensively;
- monitoring of siltation of small riverbeds (measuring water flow and turbidity of watercourses) to prevent disturbance of the ground feeding regime;
- control over the implementation of a set of measures for the restoration of disturbed lands.

Creation of monitoring sites confined to various landscape types. Permanent areal monitoring (long-term observations) of the dynamics of the functioning of natural complexes, including various components of the horizontal and vertical landscape structure (topography and land cover).

The phytomonitoring research program of the survey area as a whole should include the following blocks: phytocenotic monitoring, monitoring of vegetation, monitoring lichen indication studies and geochemical monitoring of the vegetation cover.

Monitoring studies of flora are carried out in 3 directions: monitoring the status and dynamics of populations of rare plants listed in the Red Books of various ranks, relics, endemic species. In this case, one should observe the number of species of similar categories and the number of populations of these species. Observations of the ratio of phytocenotic groups will make it possible to note the general change in ecological systems under the influence of factors accompanying the extraction and transport of commercial products, as well as to reveal trends in the dynamics of vegetation cover.
(including synanthropization of vegetation, changes in the ecological and floristic composition of communities, etc.).

Monitoring studies of plant species and populations of special economic importance (medicinal, ornamental, fodder, etc.) will make it possible to assess their condition and directions of use. Monitoring the state of vegetation involves laying a network of monitoring geobotanical areas in various types of plant communities in the study area. Annual descriptions of these areas should be carried out with the definition of the following indicators: species composition; biological productivity; tiers; total projective coverage; projective cover of each species in the community (projective abundance); abundance of species (on the Drude scale); physiognomy of each species in the community.

Monitoring lichen indicative studies include systematic monitoring of morphological changes, the living state of various species of lichens and the dynamics of lichen flora. Since lichen flora is not resistant to dust and gas emissions, it can be used as indicators of air pollution and the likelihood of negative effects of emissions on higher plants.

Geochemical monitoring of the vegetation cover will make it possible to assess the content and presence or absence of biogenic accumulation of chemical elements in plants. The results will be the most important information showing the presence and level of anthropogenic impact on the environment, and will also help to identify the presence, nature and direction of the compensation processes occurring in the main blocks of the natural complex, helping to balance the effects of industrial pressure on ecosystems.

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