Monitoring of soil and plant complexes on forest fund lands in the area of influence of Orenburg oil and gas condensate field

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Abstract. At the current stage of Russia's development one of the priorities is to ensure the protection of the environment and the rational use of natural resources. In the Framework of State Policy on Environmental Development of the Russian Federation for the period up to 2030 the ecological situation in the country is characterized by a high level of anthropogenic impact on the natural environment and significant environmental consequences of past economic activities. The problem of improving the legal regulation and organization of environmental activities of industrial enterprises as polluting objects of the environment is particularly relevant. The main pollutants emitted by Orenburg oil and gas condensate field are nitrogen dioxide, sulfur dioxide, hydrogen sulfide, carbon monoxide, hydrogen carbon and other compounds. When pollutants enter the atmosphere their physical and chemical changes occur during movement and propagation in space, turbulent diffusion and dilution.

1. Introduction

In order to ensure the implementation of measures in the course of economic and other activities for the protection of the environment rational use and recovery of natural resources, in particular phyto- and pedocenoses, the research was carried out on the condition of soil cover and plant complexes in the area of impact of the main industrial facilities of the Orenburg oil and gas condensate field (OOGCF) on the territory of the lands of the forest fund of the Orenburg district [1-2].

The purpose of ecological-legal regulation of environmental activities of industrial enterprises is to realize the rights of citizens to a favorable environment, reliable information about its condition, compensation for damage caused to their health or property by an ecological offence. Consequently, industrial development should not be detrimental to the rights and legitimate interests of both current citizens and future generations [3-4].

The improvement of ecological-legal regulation and organization of environmental activities of industrial enterprises should be directed to the introduction of low-waste and non-waste technologies, resource-saving methods of work. The current state of soil and plant complexes in the area of man-
made impact was considered on the example of the Orenburg oil and gas condensate field, whose production activity also affects the lands of the forest fund [5-7].

2. Material and methods of research

In accordance with the results of the dispersion calculations of the pollutants given in this work the most powerful sources of emissions of OOGCF, which have a constant impact on the atmosphere (and as a result on soil-plant complexes) are located at the integrated gas treatment plants (IGTP). The maximum man-made load is on areas of soil and vegetation cover located in zones of strong and medium impact of IGTP in the dominant wind directions. In this connection, the following control areas were selected for investigation: No. 1 - in the area of IGTP -14 impact, No. 2 - in the area of IGTP -12 impact, No. 3 - in the area of IGTP -2 and DKS-2 joint impact, No. 4 - in the area of IGTP -10 impact. To assess the condition of the soil cover, soil sampling was carried out according to the requirements of State Standard Specification (SSS) 17.4.1.02, SSS 17.4.3.01 and SSS 17.4.4.02. Soil samples were analyzed for their content: pH, dense residue, carbonates, bicarbonate, chlorides, sulfates, humus, petroleum products, calcium, magnesium.

Geobotanic research was guided by generally accepted methods as well as guidelines and forest-traction guides. Route surveys were conducted during the spring-summer season of the year. During the spring-summer period wood and shrub vegetation were in the stage of intensive growth and diversity was in the stage of flowering.

3. Results of the research.

The state of ground vegetation qualitatively characterizes the pollution of the air basin and soil cover in the area of industrial enterprises. With increased levels of pollution there is oppression of vegetation cover, falling out of certain species, dry coniferous trees, accompanied in some cases by degradation of soil cover. The extreme effects of gas-dust emissions eventually lead to vegetation death, erosion and soil deflation. The floristic composition of different types of vegetation is also significantly altered by atmospheric pollution. In this regard the state and floristic composition of vegetation in the area of influence of the objects under study was assessed.

The species composition, biological diversity and biological productivity of the surveyed sites in the impact area of OOGCF facilities characterizes the state of plant communities as little sustainable. There is a decrease in the proportion of projective coating, the fall of certain species of plants from the composition of communities, the depletion of species composition of vegetation and the replacement of meadow-steppes species with ruderal (weed) or synanthropic vegetation.

Ruderal vegetation is naturally present in places close to the industrial zone, along roads and limited along crop rotation fields. Open land is occupied by crops of grain crops - wheat and rye, mainly spring.

With regard to the condition of wood vegetation in the forest fund its condition is not the same in the territory of the study. Woodlands made more favourable impression due to the lack of toppings in old lakes, dry stand, valet and other forest waste. During field research of the territory in the forest fund there were traces of fires, presence of dry bed, undelivered cutting residues.

The natural vegetation available on the territory of the study is represented by the following phytocenoses: steppe, meadow, shrub, forest, agrophytocenoses of arable land and forest protection bands.

Among the steppe phytocenoses can be distinguished communities: lowland real and dry steppes, steep slope real and dry steppes. Among the meadow phytocenoses there are communities: short-ground meadows, dry grated meadows, marsh meadows.

Among shrubs there are communities: shrubs on the watershed, floodplain shrubs.

In addition to the listed communities the area under consideration has plant communities of floodwaters, sand shavel and co vegetation, ravines and beams.

Visual examination at control sites revealed different levels of disorders of assimilation tissues of wood plants, changes in the flow of phenological phases in indicator species of plants, but mass
suppression of vegetation was not detected, this was due to the duration of the factor and the development of adaptation reactions in species - edifiers that form the basis of phytocenosis.

Control section № 1. The territory of the site under consideration is located IGTP-14 the zone of influence of the region, on the above-ground terrace and in the floodplain of the Ural River. Soil cover is formed mainly by blackheads of common carbonate, blackheads of southern carbonate and residual-meadow soils.

In the flood of the Ural River, in the north direction relative to the IGTP-14, there are mainly hard tree rocks: oak is cherry-shaped, maple, elm. The tree of forest bands make up a maple of yasenelistic, elm of small-leaf, loch of silver, golden currant. In the composition of the undercoat there is a poplar trembling, alder black, wasp. The shrubbery tier is represented by cherry steppe, urban spiraea, rosehips, turf, potassium, hawthorn, blackberry, Russian broom.

Control section № 2. The investigated area is laid in the zone of influence of the IGTP-12, is located in the flood of the Ural River, in the development band of alluvial democouple soils from medium- to heavy-carbon varieties.

Vegetation of control site No. 2 is characterized by representatives of floodwood consisting of wood and grass tiers. In the hundred-meter zone to the east of the IGTP-12, the vegetation of the wood tier is represented mainly by the poplar black and osier-bed. In the composition of the undercoat there are noted: a maple of yasenelistic, clear, a poplar of shivering (donkey), oak of cherries. Shrub vegetation is represented by rosehips, turf, wild cherries. The herbal is abundant, includes such species as common harp, large shovel, borschchatka, chamomile non-groovy, dandelion large, ground wavy, etc.

In the five-hundred meter zone from IGTP-12 forest vegetation is replaced by shrub overgrowth and floodplain meadows. Shrubs consist of rosehips, cherries, spireas, turn, and simmering. The grass cover of floodplain meadows is represented by a variety of tracts: horse sorrel, planter large, low hollow, bone-free, mint meadow.

Predominantly forest vegetation prevails in the kilometer zone and as it IGTP-12 from the east to the east. The wood vegetation is represented by plain pine, poplar and clove. The scaffolding is made up of cherry, rosehips, golden currant, turn. Herbaceous vegetation is represented by pollen and mint associations. The average grass height at the time of the survey was 30-35 cm.

Control section № 3 is located in the zone of influence of IGTP-2 and DKS-2. The soil cover of the control site is formed mainly by the black southern middle weight on deluvial carbonate clays and heavy loams. Most of the territory of the control section is open. Along the fields of crop rotation there are forest strips consisting of a knit of small-leaf, a maple of yasenelistic, a pine of plain, a burning of Tatar, currants of golden.

Control section № 4 is laid in the area of IGTP-10 influence. The territory of the site is characterized by a plain relief with characteristic steppe vegetation. The soil cover of the site is folded with black surfaces of southern carbonate low-power and black surfaces of southern carbonate weakly washed on deluvial carbonate clays and heavy loam.

In the east and north-east directions the area is occupied by crops. Along the fields there are artificial forest bands, represented mainly by clove-like, knit-like, flock-like silver.

The condition of the soil cover of the control sites was studied.

The results of analyzes of soil samples from control section No. 1 show that the concentration of petroleum products was below the limit of determination of the method (< 0.005 mg/g) and therefore below the permissible level of petroleum products in soils. The pH of the soil solution corresponds to the neutral - low-thickness interval and in the spring-autumn period was 7.08-7.95 u pH, with a background value of 7.7 u pH. These values are characteristic of black soil type.

Content of the major anions of soil solution - NSO$_3^-$, Cl$^-$, SO$_2^-$ corresponded to background values. Content of hydrogen carbonate-ion in spring-summer period was 0.021-0.048 wt%, in summer-autumn period - 0.017-0.041 wt%. The chloride-ion mass fraction was stable throughout the examination period and was 0.003-0.005 wt% at a background value of 0.005 wt%. The content of the sulfate ion
varied in the range of 0.002-0.018% mass at the value of the background sample 0.013% mass Carbonate ions were not present in the soil of the control site.

Thus the level of anion content in the soil solution characterizes soils as undisturbed, which is also confirmed by the values of the weight fraction of the dense residue (0.044–0.094%), which does not exceed the background level (0.094% by weight).

Calcium ions with mass fraction of 0.005-0.013 wt% and background content of 0.014 wt% were determined among cations in the soil solution. The magnesium ion content was generally below the method definition limit (< 0.001%).

The humus content of the control site soil was 1.69-4.08% (which characterized the soils as small and medium-humused), with a background value of 4.01%.

Humus content depends to a large extent on granulometric and mineralogical composition of soil-forming rocks.

During the survey of control section No. 2 the pH of the soil solution was 7.04-7.68 units. Thus, the pH values were in the neutral to slightly alkaline range and correspond to the background value (7.61 units).

Variations in humus content in soils of different control sites are due to soil cover. The interval of humus content during the period of examination hardly changed and amounted to 1.05-4.75% mass, with background content of 4.01% mass. Humus content characterizes the soils of the control site as weakly-medium-humused.

No salt accumulation was observed in the control site soil. Mass fraction of sulfate ion was in the range of 0.003-0.013 wt%, chloride ion - 0.003-0.006 wt%, at background values of 0.011 and 0.006 wt%, respectively. Content of hydrogen carbonate ions was 0.018-0.041 wt%, which corresponds to background value equal to 0.035 wt%. The mass fraction of the dense residue during the examination was 0.039-0.066%, in summer-autumn - 0.052-0.080%. The results were at the background level (0.076%), which characterizes soils as unpaved. Calcium ion content was 0.004-0.010 wt% during examination period and 0.005-0.011 wt% at background values of 0.007 wt%. The magnesium ion content of most control points was below the method definition limit (< 0.001%). The mass fraction of petroleum products in the soil of the control site was below the permissible level of petroleum products content in soils. Carbonate ions were not present in the soil of the control site.

According to the results of the study of soil samples at control section No. 3, the pH was 7.88-7.97 units. These values correspond to the background level (7.89 u pH), did not exceed the maximum value characteristic of the soil type in question, the soil medium response was within the neutral alkaline range. The mass fraction of the dense residue during the examination periods was stable and amounted to 0.067-0.078% with a background value of 0.072%. These values of dense residue value characterize soils as undisturbed. Content of sulfate and chloride ions was 0.003-0.013 wt% for sulfate ion and 0.006 wt% for chloride ion. Weight fraction of hydrogen carbonate ion in soil of control sites remained stable and amounted to 0.037-0.049 wt% with background content of 0.039 wt%. Content of calcium ions in soil was 0.009-0.013 wt%, which corresponds to background value equal to 0.011 wt%. The mass fraction of humus of the soils of the control site practically did not change during the survey periods and amounted to 1.76-3.76% (small and medium-humused soils) at a background value of 2.58%. In the soil of the control site the content of petroleum products was below the method definition limit (< 0.005 mg/g) and below the permissible level of petroleum products in the soil. Carbonate ions were not present in the control site soil and the magnesium ion content was below the method definition limit (< 0.001%). The results of analyzes of soil samples from control section No. 4 show that the concentration of petroleum products was below the limit of determination of the method (< 0.005 mg/g), only on CP 4-2 the content of petroleum products was 0.011 mg/g, which is below the permissible level of petroleum products in soils. The pH of the soil solution was equal to the neutral low temperature range and was 7.69-8.21 units of pH at a background value of 8.04 units of pH. These values were at the level of maximum for soils of black type. Content of the major anions of soil solution Cl-, SO42-NSO3-withreplied background values. Mass fraction of chloride-ion was stable during the whole period of examination and amounted to 0.003-0.007 wt% at background value of
Content of sulfate ion fluctuated in the range of 0.003-0.012 wt% at value of background sample of 0.004 wt%. Contents gidrokarbonat-Ion is 0.037-0.037 wt%.

Thus the level of anion content in the soil solution characterizes soils as unpaved, which is also confirmed by the values of the weight fraction of the dense residue (0.046- 0.098%), the background value was 0.082% by weight. Carbonate ions were not present in the soil of the control site. Calcium ions with mass fraction of 0.005-0.010 wt% with background level of 0.011 wt% were determined among cations in soil solution. The magnesium ion content was below the method definition limit (< 0.001%).

The humus content of the control site soil was 2.55-5.47%, with a background value of 5.51%. The content of humus in the soil depends on the mechanical composition and in the area under consideration is characterized by a small to a strong degree of humidity.

According to SSS 17.4.1.02-83 soil classification by degree of contamination is carried out according to the maximum permissible amounts (MPA) of chemicals in soils, in the absence of MPA background contents are used. Due to the fact that no MPA is currently established for the list of defined components in this work, soil classification by degree of contamination was carried out by background content. According to the calculation of the concentration factor soils at control sections No. 1-4 can be classified as non-contaminated, as the concentration factor almost everywhere did not exceed 1. However, CS No. 4 noted double the excess for sulfate ion and petroleum products and three-fold on sulfate ion.

4. Conclusion

The analysis of the obtained results shows that the main indicators of the state of soil cover in the zones of air-technical impact of IGTP on the lands of the forest fund are within the established standards and are comparable to the background level of their content in the soil, which indicates the permissible level of man-made load. Exceeding a number of chemical indicators at control section No. 4 necessitates additional reclamation work.

Visual examinations of plants revealed damage of the above-ground part in species of bioindicators, in particular in coniferous and hygrophytic plants of herbaceous form (chlorose from 5 to 35%, necrotic spots on the surface of sheet plates made from 3 to 15% of the surface of the sheet, manifestation of modification of the sheet plate - twisting). Conifers at the study sites are represented by one species - common pine, gigrophyte plants are small for the study sites and account for less than 15% of the total number of species. However, the distinctive manifestation of sensitivity to aerotechnogenic pollutants determines further scientific interest for the study of anatom-physiological features and their use as marker species in monitoring. Mesophytic and xerophytic plants of the investigated sites dominate phytocenosis and exhibit increased vitality and seminal productivity, which determines their adaptation potential to the aerotechnogenic impact factor.

In general, it should be noted that the studied soil-plant complexes of the OOGCF impact zone on the lands of the forest fund show high tolerance and in most cases are resistant to aerotechnogenic effects, presumably low-resistance species have changed more stable. This effect is likely to have developed over a long period of time and is related to the consistency of the chemical composition and concentration of substances, the radius of action of the IGTP.

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