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The Assessment Of The Anthropogenic Impact Of The Oil-And-Gas Industry Transportation Lines On The Structure Indices Of Plant Communities Of The Steppe Zone.

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ABSTRACT

The development, exploration and exploitation of hydrocarbon deposits is a significant factor violating the integrity of the steppe landscapes. The construction of large pipelines for the transportation of oil and gas leads to a severe reduction in natural phytocoenosis and biodiversity loss. Due to increased loads resulting from long-term pipeline servicing (more than 50 years), biodiversity on site of compressor stations and access roads decreased, manifesting in a decline in the species richness of communities by an average of more than 3 to 4 times, and also the reduction of the projective cover.
Keywords: α-diversity of plant communities, β-diversity of plant communities, technogenic landscape

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INTRODUCTION

With the continuous increase in production, transportation and storage of hydrocarbon deposits, it is important to preserve the quality of the natural environment [1-5]. During the development, exploration and exploitation of hydrocarbon deposits, adjoining territories are significantly affected. Vegetation within a radius of 200-400 m around the drilling rigs and compressor stations is destroyed by 70-80%. The main pipeline systems crossing the region from east to west are a significant factor violating the integrity of the steppe landscapes. The allocation of areas for gas field development, as well as the construction of large pipelines for their transportation, leads to a sharp reduction in natural phytocoenosis, and, as a result, to loss of biodiversity and the genetic erosion of plants. The main type of impact taking place during the construction of pipelines is mechanical. It leads to a change in surface topography, disturbance of topsoil and vegetation, as a result of trenching, construction of access roads, and the frequent passage of equipment. In addition to environmental damage, these systems significantly undermine the feed supplies for pasture farming, activate degradation processes in vegetation by initiating tallweedovergrowth. Such intervention in steppe ecosystems is fraught with the genetic erosion of rare and endangered plant species of the region.

The florocenotic feature of disturbed habitats is that they have constantly functioning sources of seeds, fruits, and vegetative primordials of various weedspecies. Most researchers believe that transport routes play a significant role in the formation and maintenance of weed flora. Thus, the anthropogenic factor introduces significant changes in natural ecosystems within the limits of the passage of main trunk pipeline systems. This necessitates a comprehensive scientific study of the degradation processes in disturbed areas and the development of scientifically based methods for the restoration of disturbed territories.

In this context, the purpose of our work was to study the biological diversity of vegetation of anthropogenically disturbed habitats in the northern part of the Stavropol Upland in the area affected by the gas transmission system.

MATERIALS AND METHODS

The study area is located at the base of the Stavropol Upland in the region of the Quaternary plains and plateaux, with a northward declivity to the region of the Primanychskaya lowland; it is 200-300meters above the sea level. The objects of study were areas of vegetation disturbed by the main gas pipeline systems, the gas compressor station territoriesand areas of the virgin steppe (standard). To study the impact of anthropogenic factors on the structure of plant communities and biodiversity, we used the transect(of profiles) method. The transect was laid from the place of the severe impact (of the compressor station) in the direction of more remote sections of the virgin steppe. Changes in vegetation were studied on the example of three types of plant communities: the first type - the territories of gas-distributing compressor stations subjected to the maximum mechanical impact during the entire service life of thegas pipeline (more than 50 years); the second type - sections along the gas pipeline route, access roads; the third type of communities - remote sites in the virgin steppe. Sample plots of 100 $m^2$and 0.25 m^2 were described on 10 m long transects, with an interval of 10m. Complete geobotanical descriptions were performed at each site.

In this paper, the choice of methods for assessing biological diversity was based on the synthesis of two approaches: resource and environmental. Such an approach implies comprehensive work on the analysis of textual sources and field research data to determine the taxonomic richness of floras, species evenness, productivity, and the stage of involvement in metabolic processes. Research methods - stationary, semi-stationary, expeditionary and cameral.

The theoretical study of modern phytocenology on the interconnection and interdependence of abiotic and biotic factors operating within specific geological systems formed the methodological basis of the work. The quantitative abundance of one or another type of flowering plants was taken into account according to the generally accepted O. Drude scale. The abundance of components in the process of geobotanical description was established by eye and was subsequently translated into numerical value. The assessment of vegetation biodiversity included:

1) determination of species saturation at the sites of fixed size. Plotting species richness (λ-diversity) curves. α-diversity characterizes the richness of species of individual communities. The two main indicators of

α-diversity of vegetation are species richness - the total number of species in the community; species saturation - the average number of species per unit area.

2) the study of the species composition and structure of communities in the quadrats, the determination of the intensity of changes in the species composition, i.e. β-diversity. Beta diversity characterizes the variability of α-diversity indicators in space - according to the gradients of environmental factors or when moving from one community type to another. Usually, β-diversity is estimated through similarity and heterogeneity indices. Ranges of vegetation variation along the first axes of ordination diagrams, expressed in standard deviations, are used as an indicator of β-diversity of vegetation. However, it should be noted that such an assessment is to a large extent only indicative, since the first axes with any ordination method account for no more than 60–70% of the total variation of vegetation. The two main groups of similarity indices of species composition include: 1) the presence or absence of species 2) indicators of the abundance of species. The first group provides estimates of the diversity of the floristic composition of various communities; and the second assesses the diversity of species interrelationships in communities. The Whittaker index (heterogeneity index) - β_W, calculated on the basis of the ratio of species richness and the average species saturation of vegetation within the community, was used to determine β-diversity in the studied area:

$$\beta_W = \frac{S}{a-1}$$

where **S** is the species richness, the total number of species registered in the system; **a -** is the average species saturation of a community or the average number of species in standard value samples [6].

An assessment of the floristic similarity of communities using Jaccard's coefficient (K_j) demonstrates, above all, a low level of similarity in general [6].

$$K_J = \frac{N_{AB}}{(N_A + N_B - N_{AB})}$$

where N_{AB} - is the number of common species in communities A and B; N_A - is the number of species in community A; N_B - the number of species in the community B.

RESULTS AND DISCUSSION

As a result of geobotanical descriptions during a field study of the territory on the three types of plots, we registered 51 species of vascular plants. The kinds of *Poaceae, Asteraceae* are abundantly represented. Most kinds are represented by one, two species: *Linaceae, Brassicaceae, Hyacinthaceae,* etc. The weed components account for more than 60% of the flora.

The first type of cenosis. The vegetation described on the territory of compressor and gas distribution stations (*Ass. Ambrosia artemisiifolia + miscellaneous herbs*) has a strong degree of disturbance, determined by the complete change of soil and vegetation cover and the invasion of the synanthropic components of the flora. The area is heavily downed. The projective vegetation cover is45%. The community is mostly represented by weeds. The vegetation distribution is extremely uneven.

The species richness of such plant community is 10 species, with the abundance from 55 to 5% (*Ambrosia artemisiifolia* - 55%, *Achillea setacea, Convolvulus arvensis* - 40; *Artemisia absinthium, Chichorium intybus* - 30; *Polygonum aviculare* - 10; *Medicago minima, Euphorbia stepposa, Festuca valesiaca, F.rupicola* - 5%. Five species (the indicator of the species saturation) are found in more than 50% of descriptions in this community (in the 50×50 cm transect areas) and areassigned to the right kinds of disturbed habitats: *Achillea setacea, Ambrosia artemisiifolia, Chichorium intybus*, *Convolvulus arvensis*, *Polygonum aviculare*. This type of cenosis is characterized by an incomplete composition, high degree of openness to invasions of segetal and ruderal components, with the blockaded entry of the rudiments of species from the surrounding virgin areas of the steppe. Thus, only two species characteristic of virgin communities, but with a very low relative abundance (5%) were found in the area: *Festuca valesiaca, F. rupicola*, which probably ended up there as a result of accidental transportation of seeds from the surrounding virgin steppe.

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The second type of cenosis (*Ass. Taraxacum officinale + miscellaneous herbs*) was studied along the route of the gas pipeline, which, according to surveying data, was completed at the end of the 20th century. The vegetation overgrowth processes take place on carbonate medium - humic chernozem soils. Plant micro-communities cover 30-40% of the area. Species richness (λ-diversity) - 31 species, with an abundance from 85 to 5% : *Taraxacum officinale*- 85%, *Centaurea diffusa, Achillea setacea, Geranium molle* - 80; *Convolvulus arvensis* - 55; *Ambrosia artemisiifolia*, *Acinos arvensis* -50; *Setaria pumila*, *Brachipodium rupestre* - 45; *Bothriochloa ischaemum*, *Cichorium intybus*, *Festica valesiaca, F.rupicola - 40; Artemisia absinthium - 35; Cirsium ciliatum, Cleistogenes bulgarica -25; Alyssum desertorum, Cirsium ciliatum, Eryngium campestre, Plantago lanceoata - 20; Agrimonia eupatoria, Daucus carota, Muscari neglectum, Poterium polygamum, Thlaspi arvense 10; Ajuga chia, Carum carvi, Medicago minima*, *Polygala caucasica, Securigera varia, Stipa capillata* - 5%. In the community, 11 species are found in more than 50% of descriptions (in the 50×50 cm transect areas): *Acinos arvensis, Achillea cetaceae, Ambrosia artemisiifolia, Brachipodium rupestre*, *Centaurea diffusa, Festuca valesiaca, Geranium molle, Cichorium intybus, Convolvulus arvensis, Setaria pumila, Taraxacum officinale.*

The third type of cenosis is *Ass. Achilea setaceae + miscellaneous herbs*. The projective vegetation cover is 80%. As the impact on the vegetation cover decreases, as a result of the passage of equipment, the indicators of species richness and species saturation increase (48 and 14 species, respectively), with an abundance from 100 to 5% % (*Achillea setacea -100%, Cichorium intybus, Taraxacum officinale, Convolvulus arvensis, Plantago lanceolata - 80%; Artemisia vulgaris, Brachipodium rupestre, Centaurea diffusa - 60%; Cleistogenes bulgarica, Festuca rupicola, Marrubium praecox -50%; Cirsium ciliatum -40%; Acinos arvensis, Daucus carota - 35%; Agrimonia eupatoria, Festuca valesiaca, Stipa lessingiana - 25%; Alyssum desertorum, Astragalus austriacus, Veronica filifolia, Stipa capillata - 20%; Eryngium campestre, Medicago minima - 15%; Ambrosia artemisiifolia, Bothriochloa ischaemum, Euphorbia stepposa, Linum austriacum, Stipa pennata, Teucrium chamaedrys, T. polium, Thlaspi arvense, Veronica longiflia - 10%; Ajuga chia, A. genevensis, Carum carvi, Euphorbia iberica, E. virgata, Filipendula vulgaris, Linum nervosum, Medicago romanica, M. neglectum, Plantago lanceolata, P.major, Polygala caucasica, Poterium polygamum, Sclerochloa dura, Securigera varia, Veronica verna -5%.* The proportion of species characteristic of the steppe virgin plant communities is increasing: *Astragalus austriacus, Festuca valesiaca, F. rupicola, Filipendula vulgaris, Stipa capillata, Stipa lessingiana, Stipa pennata* (Table 1).

In analyzing the α-diversity of the studied communities, a graphical analysis was applied in order to identify patterns of species distribution in the community through abundance and evenness (Figure 1). The X axis is the species rank (the ordinal number ranged by the species abundance). The Y axis is the abundance of the species (%).

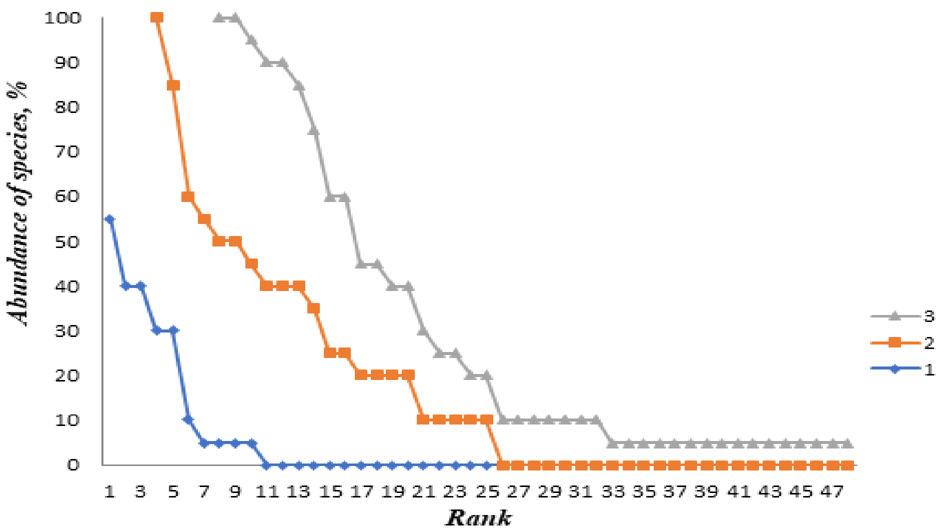

Fig.1. Diversity of plant communities
1 - the territory of the gas distribution station (severe impact); 2 - gas pipeline route (moderate impact); 3 - a remote area in the steppe (control).

Table 1. - Indicators of α-diversity in various communities

Alpha Diversity Indicators	Community names		
	Ass. Ambrosia artemisiifolia + miscellaneous herbs	Ass. Taraxacum officinale+ miscellaneous herbs	Ass. Achilea setacea+ miscellaneous herbs
Species richness	10	31	48
Species saturation	5	11	14

It can be seen that due to increased loads resulting from long-term pipeline servicing (more than 50 years), biodiversity of plant communities onsite of compressor stations and access roads decreased, manifesting in a decline in the species richness of communities (α-diversity) by an average of more than 3 - 4 times, and also the reduction of the projective cover.

Changes in the syntaxonomic spectrum of communities took place: the proportion of natural steppe species of the *Festuco-Brometea* classes decreased, and the synantropization level increased due to the presence of ruderal communities of tall biennial and perennial species (*Artemisiatea vulgaris, Polygono-Artemisiatea austriacae, Molinio-Arrhenatheretea*), therophyte communities, which indicate the initial stages of the progressive succession of disturbances and field weed communities (*Chenopodietea*), dwarf communities, mesophytes resistant to trampling and grazing (*Plantaginetea majoris*).

The Whittaker index, β_W, is directly proportional to the species richness of α-diversity. The highest values of the index are characterized by communities of the remote steppe area (β_W = 3.6), and the smallest values - the gas distribution station territory experiencing heavy anthropogenic loads (β_W, = 2.5).

A comparison of the obtained Jaccard's coefficients shows that as the third plot moves away from the first and second, the similarity of the species composition decreases. For plots 1 and 2, the Jaccard's coefficient of similarity amounts to 0.20, then this figure gradually decreases and, when comparing sections I and III, it amounts to 0.18. Due to the increasing load on the plant communities observed on the territory of the gas distribution station, the intensity of the succession of species increases and therefore the similarity of the neighboring areas decreases [Table 2].

Table 2. - Floristic similarity of communities, Jaccard's coefficient

Community types	Point 1. Ass. Ambrosia artemisiifolia + miscellaneous herbs	Point 2. Ass. Taraxacum officinale+ miscellaneous herbs	Point 3. Ass. Achilea setacea+ miscellaneous herbs
Point 1. Ass. Ambrosia artemisiifolia + miscellaneous herbs	1	0,20	0,18
Point 2. Ass. Taraxacum officinale+ miscellaneous herbs		1	0,55
Point 3. Ass. Achillea setacea + miscellaneous herbs			1

CONCLUSION

An assessment of the anthropogenic impact of oil and gas facilities on the biodiversity indicators and the structure of plant communities in the steppe zone demonstrated:

1. α-diversity indicators of the studied communities, characterizing the species richness and species saturation, show a significant depletion of biological diversity in the areas of gas-distributing compressor

stations and access roads, due to increased mechanical and anthropogenic loads as a result of servicing the gas pipeline route.

2. The Whittaker (heterogeneity) index calculated on the basis of the ratio of species richness and average species saturation of vegetation within a community is directly proportional to the species richness of α - diversity. The highest values of the index are characterized by the communities of the remote area of the virgin steppe, and the smallest values - the territory of the gas distribution station, which is experiencing strong anthropogenic pressures.

3. The evaluation of the floristic similarity of communities using the Jaccard's coefficient demonstrates a low level of similarity of plant communities in general. With an increasing load on plant communities observed on the territory of the gas distribution station and access roads, the intensity of the species succession increases, and therefore, the similarity of neighboring areas decreases.

4. Changes in the syntaxonomic spectrum of communities took place: the proportion of natural steppe species of the *Festuco-Brometea* classes decreased, and the synantropization level increased due to the presence of ruderal communities of tall biennial and perennial species (*Artemisiatea vulgaris, Polygono-Artemisiatea austriacae, Molinio-Arrhenatheretea*), therophyte communities, which indicate the initial stages of the progressive succession of disturbances and field weed communities, dwarf communities, mesophytes resistant to trampling and grazing.

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