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Ecological and Functional Zoning of the Urbanized Environment of Arid Territory as the Basis of Ecological Framework

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Abstract. **The study discusses the prospects of developing a strategy for greening the urbanized environment of the arid territory in the South European part of Russia using the example of Elista, the capital of the Kalmykia Republic. We present the main approaches to designing the ecological framework of an urban area. The main research methods are analytical, desktop and comparative-geographical. This article presents the assessment of the environmental pollution of Elista by motor vehicles and the dust-collecting ability of leaves of trees and shrubs. We have calculated the emissions of pollutants entering the air basin of Elista with the exhaust gases of vehicles. It showed that the maximum concentration of pollutant emissions from vehicles is in places of the greatest car traffic: at bus stops and intersections. We evaluated the dust-collecting ability of the leaves of the main types of trees and shrubs of the city's landscaping system. Using the data obtained, we systematically ranked urban landscapes and the environmental functions from the position of their sustainability. This served as the basis for the ecological and functional zoning of Elista. The article analyses the structure of ecological and functional zoning and its basic elements acting as cores and corridors of the ecological framework. The 26% of unreformed open spaces identified in the city are perspectives reserves for environmental planning to optimize the landscaping system. To improve the quality and increase the level of a person's comfort in an urban environment, we propose measures in the framework of developing a greening strategy.**

Keywords: urbanized environment, arid territory, greening, ecological and functional zoning, ecological framework, Elista city

I. INTRODUCTION

The South European part of Russia has many arid territories. The Republic of Kalmykia occupies their most part. Elista, the administrative and industrial centre of the Kalmykia Republic, belongs to the category of medium-sized cities of the European South with extreme climatic conditions, anthropogenic pressure and depending on many factors. Climate is one of the factors that have a huge impact on human physical and mental health. The problems caused by the hot climate exacerbate air pollution in urban areas. A favourable, comfortable living environment is the most important condition for ensuring environmental safety and achieving sustainable socio-economic development of society.

Urbanization is a global multidimensional process coupled with the active development of all types of transport, the constant acceleration of the urban life rhythm and changes in supporting ecosystem services [1].

This actualizes the most important problem that is preserving and improving the environment and optimizing the ecological and sanitary conditions of citizens [2].

The study of the biodiversity and functioning of urban ecosystems in the post-industrial landscape is a very relevant and new growing direction in environmental research. The main requirements for urban greening are followings: appropriate placement of plantings in free open areas according to landscape elements, buildings, and structures to create favourable environmental and sanitary conditions in the urban environment, its general aesthetic appeal [3].

These conditions create the need to solve environmental, sociocultural, urban planning and other problems in the urbanization process. An ecologically-oriented municipal policy governing the preservation of the natural environment and improvement of living and recreation conditions for the population can provide it. The development of greening projects should maximally consider the general situation for a specific urban area. In this case, it is necessary to apply modern innovative ways to recreate a comfortable urban environment.

On the world and foreign experience model, the concept of the ecological framework of the urban territory (EFUT) is a constructive direction to optimize architectural and landscape planning and territorial management of urban greening [4-6].

According to E. Yu. Kolbovsky: EFUT is a medium-stabilizing territorial system purposefully formed to improve the ecological situation in the city, consisting of landscape elements that are different in type, dimension and function, spatially connected into a single living network of cores, areal blocks, and corridors, linear blocks [7].

The first step of the development and construction of EFUT is the ecological and functional zoning of the territory, the allocation and analysis of structural elements that can act as cores and corridors.

The purpose of the study is to assess the ecological state of the natural components of the urban landscape, to carry out the ecological and functional zoning of Elista and to analyze opportunities of constructing the ecological framework for increasing the comfort level and optimizing the quality of the urban environment.

II. MATERIALS AND METHODS (THE MODEL)

The object of study is the Elista city. The main research methods are analytical and desk methods. We used the calculation method to assess the traffic load and emissions of pollutants into the atmosphere from road flows in key city areas. [8]. In the same areas, we evaluated the dust-collecting ability of leaves of trees and shrubs. We examined about 300 plants to assess the dust level of the leaves. At the same time, we selected 10 normally developed intact leaves. Then we washed off the dust settled on the leaves, filtered through a paper filter, dried and weighed it on an analytical balance. The mass of dust is expressed in mg on a leaf area of 1 cm^2 of woody-shrubby vegetation. We repeated all studies 3-4 times in the summer months of 2018-2019. The basis of ecological and functional zoning is desk processing of data obtained as a result of collection and analysis of materials about the history of the object, characteristics of its architectural, planning and functional structure. The study also includes the results of scientific researches on the ecological state of the natural components of the urban landscape. Adequacy of the research methods to the assigned tasks, a sufficient volume, and representativeness of the sample ensured the validity of the results.

We performed statistical processing of the data on a computer using the Excel program. The correct use of parametric Student's t-test confirms the reliability of the results [9]. We considered differences in arithmetic mean values reliable at the 95% ($p \leq 0.05$) probability threshold.

III. RESULTS AND DISCUSSION

A. History and natural conditions of the Elista city.

Elista is the capital of the Kalmykia Republic located in the centre of the vast Kalmyk steppes, in the southeastern part of Ergeni. Its history began in the 40s of the 19 century when the Kalmykia steppe plays an important role in establishing relations of the Center of Russia through Tsaritsyn with the North Caucasus, as well as the Lower Volga with the Kuban and Crimea. During this period, the Tsarists Government sent several expeditions to the Kalmyk steppe to select places for founding settlements along the tracts to Astrakhan, Tsaritsyn, and Stavropol. The beginning of afforestation in Yergeny according to the suggestion of the forest department and the Tsar's decree of 1845 also influenced the foundation of the city. The successful afforestation in the Elista beam resulted in the foundation of a small working settlement in 1865. It got its name from the northern slope of the beam consisting of loose sand named Elst that means sandy in Kalmyk. Over time, the settlement grew into a city.

The climate of Elista is typical for the steppes, sharply continental with dry hot summers and little snowy in winters. The climate has an abundance of sun and wind, frequent dust storms lasting up to 40 days a year, with a wind speed of 16 m / s or more. The average July temperature is + 24.4 ° C, and the maximum reaches the level of + 44.0 ° C. Temperatures above + 30 ° C are recorded from April to October inclusive. Droughts in Elista are common as annual rainfall averages just 349 mm.

About 110 thousand people live in Elista which is 40% of the total population of the republic. The total area of the city is 210.45 km^2. The total area of green zones with natural landscapes adjacent to residential development is 67.3 km^2. Based on these values, 32% of the greening level of the total city area is completely insufficient in the conditions of the Russian South.

The modern landscape of the Elista has complex natural and anthropogenic geosystems with varying nature of the relationship between the natural and anthropogenic component. The assessment of the general environmental situation is not favourable.

B. Environmental Assessment of Elista

Since there are no large industrial facilities in Elista, road transport is the main source of environmental pollution. The main consequence of the high level of traffic load is the increase in anthropogenic impact on the environment. The main problem of the city is the dustiness of atmospheric air. This is due to the intensification of deflationary processes in the warm period since Kalmykia is one of the most deflationary dangerous territories.

The sources of pollution of the city's life-support environments: the air basin, water and soil environments, include unauthorized and spontaneous dumps of production and consumption waste.

The city lost the protective role of the green belt around. The expansion of the city, especially in the western, southwestern and northern parts, led to the almost destruction of forest belts. According to N.M. Baktashovoy and S.G. Boskhomdzhieva: the rest of the forest plantations around Elista is depressed, all species: oak, ash, elm, gleditsiya, black locust, ash maple, wild olive, saltsedar, planted in 1927 are in a state of slow growth, drying out and extinction [10].

Due to the transboundary transfer of pollution from the enterprises of the chemical, fuel and energy, metallurgical and agricultural complexes of the Volgograd, Astrakhan regions, Stavropol territory and Dagestan, the load on the environment has increased not only in the city itself but also outside the city limits [11].

To determine the concentrations of gaseous toxicants and soot entering the Elista air basin, we used the calculation method and recorded vehicles traffic in different directions in key areas of the city. The recording time was on weekdays during rush hours from 8 to 10 hours and 17 to 19 hours on the central highways of citywide significance: Lenin, Dzhangar, Pushkin, Rokchinsky, Klykov, at the intersections: Lenin and Pushkin streets, Lenin and Gerasimenko, Lenin and Dzhangar, Lenin and Gubarevich, Klykov and Gubarevich, Pushkin and Rokchinsky and the local area.

As expected the maximum traffic load falls on the central highways of the city, especially at the street intersections (Fig. 1).

In the adjacent territories, the transport load is much less but it is quite noticeable.

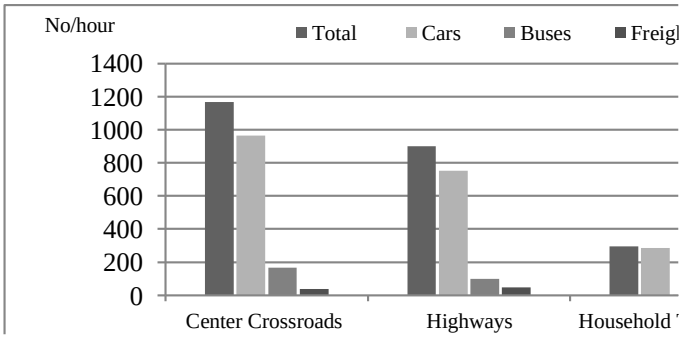

Fig. 1. The number of traffic by groups in Elista

We calculated the level of transport emissions in the areas with the highest traffic load: the intersections of the centre and the highway in comparison with the adjacent territories. To estimate the specific values of the emissions of automobile transport in different zones of the city, we used the recorded data of moving traffic flow by groups and calculated the emission rate of the following harmful substances entering the atmosphere with car exhaust: carbon black, carbon monoxide, sulfur dioxide, nitrogen oxides (in terms of nitrogen dioxide), hydrocarbons, formaldehyde, benzo[a]pyrene.

The level of gas pollution of the studied territories greatly depends on the traffic intensity and type of vehicles, the width and topography of the street, and wind speed. The high traffic flow and narrow street widths determined a higher level of automobile emissions at intersections and central highways (Fig. 2).

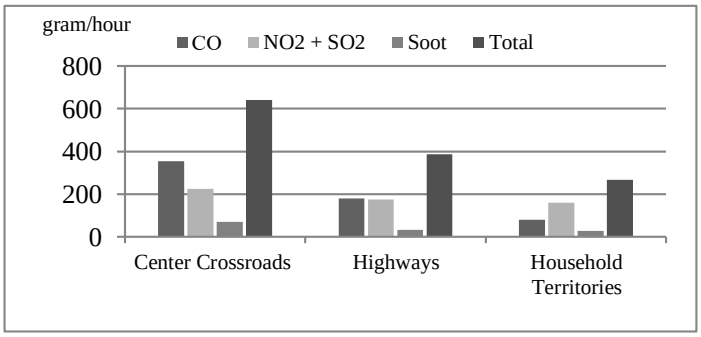

Fig. 2. Specific values of automobile emissions in Elista

Residents experience the most harmful effect of polluted air in the surface layer of the atmosphere of pedestrian crossings located at intersections. More low specific values of motor vehicle emissions on highways come from their dispersion under the wind. Despite the low quantitative indicators of vehicles due to the small dispersion of pollution in the adjacent territories, their inhabitants also experience the harmful effects of polluted air.

Comparison of the obtained data with the maximum permissible concentrations (MPC) of motor vehicle pollution showed that the concentration of carbon monoxide at the intersections is 0.8 MPC, on the highways, it is 0.7 MPC, and in the adjacent territories it is 0.52 MPC. The sum of nitrogen dioxide and sulfur dioxide also does not exceed the maximum permissible concentration and makes up 0.75 in the studied areas; 0.55 and 0.25, respectively.

Thus, transport emissions of polluting substances do not exceed the maximum permissible concentrations but are largely close to them. It is also necessary to consider that the air basin of Elista is polluted due to other sources indicated earlier. The air basin of the city contains significant concentrations of sulfur dioxide, hydrocarbons and other toxicants.

Greening is one of the main factors in creating a favourable ecological environment in the city and is hugely important in the southern regions with an arid climate.

Leaves of trees and shrubs trap all pollutants along with dust. The functional significance of greening in a city is to clean the air of dust and various pollutants, ensure gas exchange, regulate the ratio of carbon dioxide and oxygen, and reduce city noise. Thus, greening contributes to the improvement of the microclimate both in local areas and in the whole air basin of the city and leads to environmental conditions acceptable for human life.

In this case, the filtration ability of plant leaves, its mechanical retention of atmospheric dust and chemical compounds from the environment, makes great sense.

Our assessment of the dust-collecting capacity of leaves of the main landscaping objects in the city from different key areas showed statistically significant differences in their filtration function depending on the biological characteristics of plants. Among the studied species of trees and shrubs, elm, poplar, ash, maple, lilac, thuja and pine have the best dust-collecting ability (Table 1).

TABLE I. COMPARATIVE DUST MASS DATA (MG) CALCULATED FOR THE LEAF AREA (1 CM^2) OF TREES AND SHRUBS VEGETATION

№	Species of tree and shrub vegetation	City Zone		
		I[a]	*II*[b]	*III*[c]
1	Balsamic poplar	65,0±1,3	41,2±1,4	18,8±0,91
2	Box elder	60,0±3,2	48,2±2,1	13,5±0,56
3	Black locust	51,3±2,3	45,3±1,2	15,3±0,23
4	Elm	65,5±2,3	50,3±2,2	19,3±1,2
5	English oak	-	-	10,3±0,2
6	Common lilac	48,0±3,2	45,3±1,2	11,3±0,4
7	Honey locust	45,3±1,2	30,3±1,1	12,3±0,4
8	Wild olive	-	45,3±1,2	11,3±0,2
9	Scotch pine	60,3±2,2	40,2±1,5	10,3±0,1
10	Hardy catalpa	-	45,6±2,2	12,3±0,5
11	Northern white-cedar	65,6±2,2	38,3±2,2	15,3±0,5
12	Juniper common	68,6±2,2	40,2±1,9	16,3±0,7

[a] Intersections;

[b] Highways;

[c] Building adjacent territories.

It was revealed that the mass of dust on the leaves of individual plants depends on the place of their growth, the presence or absence of a nearby polluting object.

Moreover, dust pollution due to the relative severity of dust particles mainly manifests itself near the pollution source. The main sources of dust in the city are roads, especially intersections. It was found that the average amount of dust precipitated by the leaves of urban trees is significantly higher than in the building adjoining territories of the city.

In Elista, historically, there are mainly perennial plantings (50-60 years) of elm, maple, and poplar along the highways. With good filtration, they also have the ability to phytoremediation. Phytoremediation as a method of reclamation of soils contaminated with heavy metals is increasingly gaining interest and understanding of the physiological reactions of plants to heavy metals [12].

Several plants including elm, poplar, maple, intensively absorb many elements from the soil including arsenic, cadmium, chromium, mercury and lead which are toxic even at low concentrations, accumulate them, and thus, exclude contact with the food chain [13].

The greening of the urban environment contributing to the solution of the environmental problems of territories intended for the building is an integral part of landscape architecture: gardening art and urban planning.

For a long time, Elista was built up and landscaped chaotically. The architectural, planning and functional structure of Elista has existed for less than 100 years. However, greening did not have a scientific and environmentally sound design. The current General Plan of the Urban District of the Elista city created in 2008 is insufficient and determines only the direction of development, reconstruction and building of the city [14].

Elista, as well as other urban areas of the Kalmykia Republic, has low species diversity of trees and shrubs in greening. The main limiting factor in the growth and development of trees and shrubs is moisture deficiency, high temperatures, and salinization of soil. Under these conditions, modern innovative methods of greening and landscaping have great prospects for enhancing the system of the urban environment of arid territories.

C. Ecological and functional zoning of Elista

As world experience shows, green strategies based on EFUT solve the problems of landscaping the streets of urbanized territories and most fully meet modern requirements for ensuring the quality of the urban environment [1, 2].

The main principle of green strategies is the continuity of the ecological framework of the city. To fulfil these requirements, it is necessary to connect area objects, cores, with linear objects, corridors. The development of such projects should be strictly individual for each city. It is necessary to consider all the features of a particular territory. In extremely arid conditions with high summer air temperatures, it is especially significant to optimize the gardening system considering the indicated requirements for the design of the ecological framework.

We used a systematic approach as the basis of EFUT for the ecological and functional zoning of the urban area of Elista [15].

We ranked urban landscapes in terms of their sustainability, combined with performed environmental functions.

The main stages of the ecological and functional zoning of the urban area of Elista:

1. we studied sections of the landscape functional complex of Elista, identified the elements and functions of the environment-forming and environment-stabilizing ecological zones and established their areas;

2. we revealed that among urban landscapes there is a significant area of the environmentally destabilizing zone, vulnerable areas of the city, which needs stabilization and justification for their reconstruction in terms of the ecological and geographical component;

3. we determined that the total area of open unreconstructed spaces in the city is 26% and is promising reserve territories for ecological planning of green construction.

The analysis of the urban landscape and the existing landscaping system in Elista city distinguished 4 ecological and functional zones according to the performed functions (Table 2).

TABLE II. CHARACTERISTICS OF THE STRUCTURE OF ECOLOGICAL AND FUNCTIONAL ZONES OF ELISTA

Ecological and functional zone	**The structural elements of ecological and functional zone**	**Functions**
Environmentally-forming is 20% of the total area of the city.	Landscaping and recreational areas: Druzhba Park, Pobeda Park, City Park, Alley of Heroes, boulevards, squares, protected sanitary and green zones of enterprises, school and preschool institutions, secondary and higher educational institutions	Biodiversity conservation; aesthetic; sanitary and hygienic functions, microclimate formation; conservation of natural ecosystems, soil biota
Environmentally-stabilizing is 12% of the total area of the city.	Square near the monument to O. Gorodovikov, protection zones along highways, water protection zone along the river Elistinka, building adjoining and internal green areas	Aesthetic, erosion-stabilizing functions; ensuring a normal hydrological regime; stabilizing gas exchange in the air; regulating temperature and wind
Environmentally destabilizing or vulnerable is 12% of the total area of the city.	Gullies, ash dumps, wasteland, industrial wasteland, landfills, quarries, areas of talus and landslides	Destruction of natural and natural-anthropogenic complexes as a result of erosion and geological processes; dust formation
Anthropogenic and technogenic is 56% of the total area of the city.	Residential, industrial, agricultural areas; linear and nodal systems of urban infrastructure. Among them open unreformed spaces is 26%	Ensuring the life of citizens. Prospective reserve territories of ecological planning of the greening system.

A study of the structure and basic elements of the ecological and functional zoning of Elista identified a large territory of the environment-forming (12%) and environment-stabilizing zones (12%) of the city. The environment-forming and environment-stabilizing zones determine the stabilization processes according to the normative parameters and the functional significance of the structural elements of the ecological and functional zones.

Elements of these zones represent a set of objects acting as the main cores and corridirs of ecological framework First of all, it is Drujba Park, City Park, Pobeda Park Also, modern squares can act as cores. Druzhba Park has perennial wood and shrub plantings of the mid-late 19th century and requires serious reconstruction and renovation.

Alleys and green spaces along city highways can serve as the main corridors.

We found the destruction areas of natural and natural-anthropogenic complexes as a result of erosion and geological processes: gullies, ash dumps, wasteland, industrial wasteland, landfills, quarries, areas of talus and landslides They represent a significant territory of the environment of a destabilizing vulnerable zone, 12% of the total area of the city. They require the closest attention and development of special events for transformation into cultural landscapes.

Elista does not fulfil the mandatory requirements for the landscaping system in the city: uniformity and continuity. Along the city highways, there are unreformed territories deprived of tree and shrub vegetation, its area reaches a significant value of 26%. It significantly affects the hygienic condition of the air basin of the city. Such sites may act as reserve territories for ecological planning of the city's greening strategy.

There are insufficiently optimized sanitary-protective and green zones of boiler houses and industrial enterprises, unreformed spaces of anthropogenic and technogenic zones. The city maintains a certain degree of biodiversity of tree-shrub vegetation which is a complex array of individual species and needs significant adjustment.

The preservation of functioning green spaces in the city and the expansion of the species diversity of trees and shrubs ensures the comfortable and safe urban environment. As part of the design strategy for EFUT of Elista, it is necessary to increase the level of greenery in the central areas of the city by introducing highly functional and partially new communities. Functional diversity can affect ecosystem health more than species richness.

The modern urban development policy of building multistory buildings in the city requires greening of public yards based on the selection of new types of trees and shrubs with good aesthetic and decorative characteristics, as well as resistance to adverse conditions.

Such species, first, include conifers playing a significant role in the landscaping of urban areas. In recent years, there has been an active planting of thujas, pines, and junipers along the central highways, streets of Lenin, Pushkin and others.

Conifers have high filtration, hygienic and aesthetic characteristics and fit well into the architectural and planning structure of the city.

It is rational to place them in squares, parks, as well as greening the territories of school and preschool institutions, higher educational institutions, sections near houses and courtyard areas.

Such green spaces are one of the means of improving the environment, have a high evaporation capacity and influence on temperature and humidity in the summer. They provide wind and snow protection, prevent the movement of cold air, regulate it and, as a result, provide a good microclimate in these areas.

It is also necessary to provide normative greening of sanitary protection zones of enterprises and communal facilities.

Thus, for a comprehensive solution of the environmental problems of urbanized territories of the arid zone associated with ecosystem pollution, an important step is to improve the landscaping of the city based on ecological and functional zoning in the framework of EFUT design.

IV. CONCLUSION

A. The modern landscape of Elista has an unfavourable environmental situation. The main source of air pollution is motor vehicles. The transboundary transfer of industrial pollution from neighbouring territories also pollutes the Elista air basin. The level of greening is 32% of the total area of the city which is insufficient in arid conditions of the Russian South. The species diversity and the state of the green infrastructure of the city do not meet modern requirements for ensuring the hygienic quality of the urban environment. Improving the urban greening system can provide the development of a greening strategy as part of the design of EFUT.

B. Ecological and functional zoning as the basis of EFUT made it possible to assess the functional significance of the identified zones, to identify elements that can act as cores and corridors of the ecological framework. The design of EFUT will develop a landscaping strategy and carrying out a set of measures to streamline urban development of public recreation areas: Druzhba Park, Pobeda Park, squares are cores of EFUT. It is necessary to improve the existing streets and alleys as linear landscaping objects, ecological framework corridors which are necessary for the urban environment since they connect the cores.

C. Creating a green strategy based on EFUT with modern innovative methods of greening and landscaping should include expanding the species and functional diversity of trees and shrubs which have decorative properties and are resistant to the extreme conditions of arid territories. It will contribute to the creation of new green areas, firstly, considering all modern architectural and environmental standards, and secondly, the forecasting of the future situation of the urbanized environment of the arid territory.

REFERENCES

[1] T. S. Pickett, M. L Cadenasso, and J. M. Grove, “Resilient cities: meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms”, in Landscape and urban planning, vol. 69, no. 4, pp. 369-384, 2004. URL: https://scholar.google.ru/citations?user=qUoblbkAAAAJ&hl=ru#d=gs_md_citad&u=%2Fcitations%3Fview_op%3Dview_citation%26hl%3Dru%26user%3DqUoblbkAAAAJ%26citation_for_view%3DqUoblbkAAAAJ%3AqjMakFHDy7sC%26tzom%3D-180 (date of access: 01.09.2019)

[2] T.S. Yarmosh, and O.V. Mihina, “Sociokul'turnye principy proektirovaniya zhiloj sredy”, in Vestnik BGTU im. V.G. Shuhova, no. 5, pp. 254-258, 2014.

[3] F.J. Gallagher, N. M. Goodey, D. Hagmann, J. P. Singh, C. Holzapfel, M. Litwhiler, and J. A. Krumins, “Urban Re-Greening: A Case Study in Multi-Trophic Biodiversity and Ecosystem Functioning in a Post-Industrial Landscape”, in Diversity, vol. 10, no. 119, 2018. DOI: 10.3390/d10040119, URL: https://www.mdpi.com/1424-2818/10/4/119 (date of access: 01.09.2019)

[4] Z.G. Mirzekhanova, “Obespechenie ekologicheskogo ravnovesiya – osnova ustojchivogo razvitiya territorii”, Territoriya: problemy ekologicheskoj stabil'nosti (Amurskij rajon v aspekte ekologo-geograficheskoj ekspertizy), Habarovsk: Dal'nauka, 1998, pp. 144-152. URL: https://cyberleninka.ru/article/n/ekologicheskiy-karkas-urbanizirovannyh-territoriy-na-primere-goroda-birobidzhana (date of access: 05.09.2019).

[5] V.B. Kalmanova, “Ekologicheskij karkas urbanizirovannyh territorij (na primere goroda Birobidzhana)”, in Izvestiya Samarskogo nauchnogo centra Rossijskoj akademii nauk. vol. 18, no 2, 2016.

[6] D.Tilman, J. Knops, D. Wedin, P. Reich, M. Ritchie, and E. Siemann, “The Influence of Functional Diversity and Composition on Ecosystem Processes”, in Science, vol. 277, pp. 1300-1302, 1997.

[7] E.Y. Kolbovskij, “Gorodskoj landshaft i konstruirovanie ekologicheskogo karkasa goroda”, in Inzhenernaya geografiya. Ekologiya urbanizirovannyh territorij: Dokl. IV Mezhdun. konf., Yaroslavl': Izd-vo YAGPU, pp. 78-83, 1999.

[8] “Metodika rascheta opredeleniya vybrosov avtotransporta dlya provedeniya svodnyh raschetov zagryazneniya atmosfery gorodov”, M., 1999. URL: https://files.stroyinf.ru/Data1/45/45343/index.htm (date of access: 01.9.2019).

[9] V.P. Borovikov, “Statistica. Iskusstvo analiza dannyh na komp'yutere”, 2-e izdanie SPb.: PITER, 2003, 688 p.

[10] N.M. Baktashova, and S.G. Boskhomdzhieva, “Osnovnye kriterii uspeshnogo lesorazvedeniya v usloviyah Ergeninskoj vozvyshennosti”, in Vestnik Kalmyckogo gosuniversiteta, vol. 15, no. 3, pp. 10-12, 2012.

[11] G. E. Nastinova, and D. A. Emel'yanenko, “Vliyanie zagryazneniya atmosfernogo vozduha vzveshennymi veshchestvami na sostoyanie zdorov'ya naseleniya Respubliki Kalmykiya”, in Geologiya, geografiya i global'naya energiya, vol. 51, no. 4, pp. 113-121, 2013.

[12] D. Radwanski, F.J.Gallagher, D.W. Vanderklein, and K.V.R. Schafer, “Physiology and carbon allocation of two co-occurring poplar species (Populus 1 deltoides and 2 Populus tremuloides) in an urban brownfield”, in Environ. Pollut., vol. 28, no. 1, pp. 92-102, 2019. URL: https://link.springer.com/article/10.1007%2Fs10646-018-2003-8 (date of access: 01.09.2019).

[13] J.R. Peralta-Videa, M.L. Lopez, M. Narayan, G. Saupe, and J. Gardea-Torresdey, “The biochemistry of environmental heavy metal uptake by plants: implications for the food chain”, in Int. J. Biochem. Cell Biol., Vol. 41, pp. 1665–1677, 2006. URL: https://www.ncbi.nlm.nih.gov/pubmed/19433308.nz (date of access: 01.9.2019)

[14] “General'nyj plan g. Elisty. Polozhenie o territorial'nom planirovanii”, Obshchestvo s ogranichennoj otvetstvennost'yu «Nauchno-proektnaya organizaciya YUzhnyj gradostroitel'nyj centr» («NPO YURGC»), Elista – Rostov n/D., 2008, 54 p.

[15] V. B. Kalmanova, “Ekologicheskij karkas urbanizirovannyh territorij (na primere goroda Birobidzhana)”, in Izvestiya Samarskogo nauchnogo centra Rossijskoj akademii nauk, vol. 18, no. 2, 2016.