IRSTI 34.01.05

G.A. Sadyrova[1], [2]A.K. Tanybayeva, [3]T.A. Bazarbaeva, [4]G.A. Mukanova, [5]S.M. Jamilova, [6]A.S. Nurmakhanova

[1,2,3,4,6]Al-Farabi Kazakh National University, Almaty, Kazakhstan
[5]Abay Kazakh National Pedagogical University, Almaty, Kazakhstan
(E-mail: [1]gulbanu-s@mail.ru, [2]Ainur.Tanybekova@aznu.edu.kz, [3]Tursynkul.Bazarbaeva@kaznu.kz, [4]Gulzhanat.Mukanova@kaznu.kz, [5]sauka70@mail.ru, [6]akmaral_1976@mail.ru)

Analysis of the ecological state of urban green spaces in the Medeu district of Almaty

Abstract. *This article examines the environmental problems of cities in Kazakhstan using the example of the Almaty metropolis. The importance of green spaces in urbanized areas is very difficult to overestimate. In the city of Almaty, more than 70 species of trees and shrubs recommended by the botanical garden have been introduced into production. Among trees are Phellodendron amurense, Faidherbia albida, Crataegus sanguinea, Crataegus maximowiczii, Crataegus submollis, Crataegus punctata, Ulmus glabra, Aesculus hippocastanum, Acer ginnala, Acer saccharum, Juniperus Virginiana, among shrubs – Syringa josikaea, Spiraea vanhouttei, Spiraea thunbergii, Spiraea japonica and others. A detailed floristic analysis of the tree and shrub flora of the city of Almaty showed that green spaces are represented by 208 species belonging to 58 genera and 34 families. Among tree and shrub species, 54 species (20%) represent the natural flora of Kazakhstan (9 coniferous and 45 deciduous species) from 13 genera and 9 families, and 154 species (80%) are introduced species, i.e. plants grown in soil outside their natural ranged 154 species (80%) are introduced chronologically, i.e. plants grown in soil due to their distribution.*
Key words: *Green spaces, urban environment, Almaty city.*

DOI: https://doi.org/10.32523/2616-6771-2023-145-4-83-92

Introduction

Currently, the influence of various factors of human activity on the environment has led to major changes in the urban flora and vegetation of large cities of the Republic of Kazakhstan. Today, environmental protection, which is regulated by regulations, is of current importance at the state level in the country. The intensification of environmental problems in the cities of Kazakhstan associated with air and soil pollution by road transport, the accumulation of industrial and household waste, the acute problem of drinking water and energy resources have led to a violation of the environmental sustainability, balance and safety of cities and its population. Increasing environmental problems associated with urbanization of territories are becoming key factors in achieving the Sustainable Development Goals. As is known, the urbanized urban system directly has a great impact on the natural environment and adjacent territories, which leads to changes in climate, topography, soil cover, flora, and fauna. Changes in natural environmental conditions through various anthropogenic factors lead to changes in the species composition of urban flora and its ratio. Over the past 20 years, in large and small cities of the republic, there has been an active development of territories with high-rise buildings of entire blocks and large public buildings, which leads to the question of the sustainability of already transformed ecosystems and their functioning in new transformed conditions. Therefore, there is a need to study various aspects of the functioning of urban landscapes in order to prevent the complete destruction

of already changed ecosystems. Today, high air pollution in large metropolitan cities, large migration of the rural population to the city, increasing overpopulation in certain urban areas affect the normal functioning of a person, his health and life expectancy, which in turn affects the environmental sustainability of the functioning of the urban ecosystem. The expansion of urban areas transforms natural landscapes, thereby affecting ecosystems and biodiversity. A city is a socio-economic geotechnogenic system with the local inclusion of ecosystems (biogeocenoses), which include parks, forest parks, preserved areas of meadow vegetation, as well as swamps and reservoirs [1]. Urbanized areas, as part of a broader ecological system, influence other landscapes with which they interact, and in doing so, different choices, and ways of assessing and understanding the impacts of urbanization on human health and the environment can lead to better environmental outcomes. Vegetation is a fundamental component of urban ecosystems and plays a huge role in creating a favorable living environment for the population. It should be noted that living plants perform vital functions. Among them, it should be noted sanitary and hygienic. Just as in natural landscapes, the green plants of cities perform such important work as supplying oxygen, while plants play an important role in clearing the city of dust, gases and smoke that are released into the atmosphere every day. Various substances contained in the soil are also absorbed by plants. Therefore, in a number of countries, especially active absorbent grasses are planted to cleanse soils of heavy metal contamination. It is no coincidence that environmentalists recommend increasing not only the area of green spaces in cities, but also using any other possibilities - organizing lawns ("green carpets"), planting greenery on walls, roofs, and interiors.

In the last decade, scientific interest in the study of green spaces in cities has noticeably increased [2,3,4,5,6,7,8, 9]. Megacities have a great influence on the state of the environment and are the driving force of social, economic, environmental changes and ensure the well-being of the urban population. In Kazakhstan, large cities with a population of over 1 million residents include cities such as Almaty, Astana, Shymkent. The city of Almaty is located in the southeast of the Republic of Kazakhstan and is unique in its physical-geographical and natural-climatic characteristics that shape the ecological features of its territory. The total area of the city of Almaty is more than 683.5 square kilometers. The metropolis is located in the valley of the Bolshaya Almatinka and Malaya Almatinka rivers and their tributaries. Currently, the city of Almaty is characterized by a difficult environmental situation not only because of its location in the foothill basin, but also by problems typical of large cities. To meet the oxygen demand of the population of the city of Almaty, more than 30 thousand hectares of green space are needed [10]. However, I would like to note that today, for the current ecological state of Almaty, this figure must be safely doubled, due to the large emissions of pollutants into the atmosphere associated especially with road transport, which accounts for more than 70% of all emissions. This situation is aggravated by the blocking of a number of streets and avenues in the city of Almaty with high-rise buildings, creating additional obstacles to the movement of air flows. In the last decade, the growth of new buildings in the city of Almaty has intensified the processes of anthropogenic impact on urban flora. The existing experience of green construction of the city of Almaty does not fully take into account the specificity of the environmental conditions of various areas of the city and the level of their technogenic pollution, and the issues of the condition of plantings in residential areas and the resistance of vegetation to the effects of the urban environment remain insufficiently studied. In this regard, monitoring of green spaces in the city, including an inventory and assessment of the current state of the flora, seems very relevant. In conditions of weak natural ventilation and a large number of mobile and stationary sources, air pollution is the most pressing environmental problem of the city of Almaty.

The object of our research was the urban flora of the Medeu district of Almaty. Medeu district is the largest administrative, industrial and cultural center of Almaty. The area of Medeu district is 253.4 km² (Table 1). The total area of boulevards, squares and green areas of the Medeu district of Almaty is 32.35 hectares.

Table 1

General characteristics of the studied Medeu district of Almaty

District	Date of foundation	Area km²	Population (thousand people)	Natural area
Medeu	1936	253.4	209,836	forest-steppe

Table 2 below shows the total number of parks, squares, boulevards, and green areas in the Medeu district of Almaty (Table 2).

Table 2

Total number of parks, squares, boulevards, green areas of Medeu district of Almaty

District	Name					
	Parks	Groves	Alleys	Boulevards	Squares	Green areas
Medeu	3	1	2	9	30	7

Materials and Methods

To study the urban flora of the Medeu district of Almaty, generally accepted classical and traditional methods of botanical and floristic research were used: in the field conditions, the traditional route reconnaissance method was used. At various times during the spring, summer and autumn growing seasons (from April to September), walking routes were combined with automobile routes. Places of intensive introduction of adventive plants and pockets of local flora preserved within the city limits were subjected to a detailed examination. The collection and processing of herbarium material was carried out according to the generally accepted method of A.K. Skvortsov [11]. In the process of identifying the herbarium, multi-volume reports were used as sources: "Flora of Kazakhstan" [12], "Trees and shrubs of Kazakhstan" [13], "Plants of Central Asia" [14], "Identifier of plants of Central Asia" [15], "Illustrated guide to plants of Kazakhstan" [16] and others. To clarify species and generic names, the latest reports by S.K. Cherepanov [17], S.A. Abdulina [18]. The types of life forms were carried out according to the classification of I.G. Serebryakov, K. Raunkier [19]. Our route studies covered various ecotopes of the Medeu district of Almaty (streets, cars, residential areas of multi-storey buildings and the private sector, city lawns, playgrounds, sports complexes, etc.). To conduct floristic research, generally accepted traditional methods were used. The urban flora of Almaty includes plant species that spontaneously grow within the administrative boundaries of the city, as well as cultivated trees and shrubs. Herbarium material was collected throughout the growing season; the same places were visited repeatedly to collect herbarium specimens as completely as possible. To conduct a systematic, ecological, geographical analysis, the morphological-geographical method was used. We carried out an inventory of the urban flora of the Medeu district of Almaty within the administrative boundaries of the cities.

Results and Discussion

As a result of the research, a comprehensive inventory was carried out and characteristics of the floras of boulevards, squares and green areas of the urbanized areas of the Medeu district of Almaty were given. Analysis of the urban flora of squares, boulevards and green areas of the Medeu district of Almaty revealed 217 species belonging to 129 genera and 52 families. The

largest number of species falls on 11 families: 110 species out of 217 plant species, which is 34%. The spectrum of the leading families of the flora of the Medeu region showed that the largest families are: *Poaceae* (15; 13.7%), *Asteraceae* (15; 13.7%), *Rosaceae* (8; 7.3%), *Brassicaceae* (6; 5.5%), *Fabaceae* (5; 4.5%), *Pinaceae* (5; 4.5%), *Oleaceae* (4; 3.6%), *Aceraceae* (4; 3.6%), *Salicaceae* (3; 2.7%), *Chenopodiaceae* (3; 2.7%), *Ulmaceae* (3; 2.7%). These 11 families account for 34.0% (74 species) of the entire flora of the Medeu region. An analysis of the largest genera of urban flora in the Medeu district of Almaty showed that the largest genera of the park are: *Acer* (5; 3.6%), *Picea* (5; 3.6%), *Ulmus* (3; 3.3%), *Artemisia* (3; 3.3%), *Poa* (3; 3.3%). The following 10 genera each contain 2 species: *Tilia, Fraxinus, Trifolium, Festuca, Plantago, Pinus, Populus, Arctium, Urtica, Chenopodium*. These fifteen genera (26 species) account for 39.3% of the total urban flora of the Medeu region. The remaining 73 genera contain one species each. An analysis of the life forms of the flora of the Medeu district of Almaty showed that herbaceous plants are in first place, of which there are 97 species or 44.7% (See Figure 1).

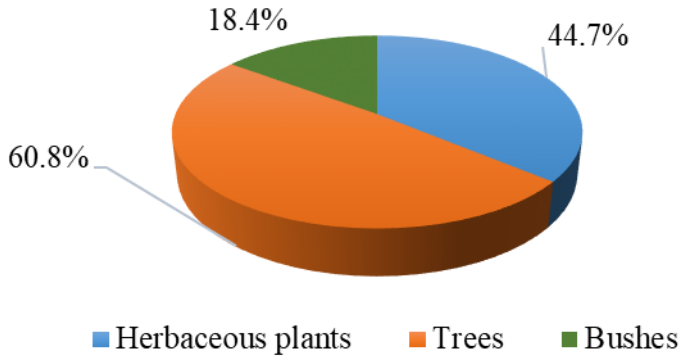

Figure 1. Correlation of life forms of the flora of the Medeu region

In second place are trees. There are 90 species of tree species in the Medeu district of Almaty (41.4%), and the third place is occupied by shrubs - 30 species or 13.8% of the total species composition of the studied flora. Trees in the Medeu district of Almaty are widely represented in the families *Rosaceae* (12 species), *Salicaceae* (6 species), *Pinaceae* (11 species), *Cupressaceae* (3 species), *Aceraceae* (7 species), *Moraceae* (2 species), *Fagaceae* (2 species). Among tree and shrub species, 24 species (11.0%) represent the natural flora of Kazakhstan (9 coniferous and 15 deciduous species) from 13 genera and 19 families, and 66 species (30.4%) are introduced species, i.e. plants grown in soil outside their natural distribution range (See Figure 2). Of the introduced species, 12 are coniferous, and 54 deciduous species from 11 genera and 24 families.

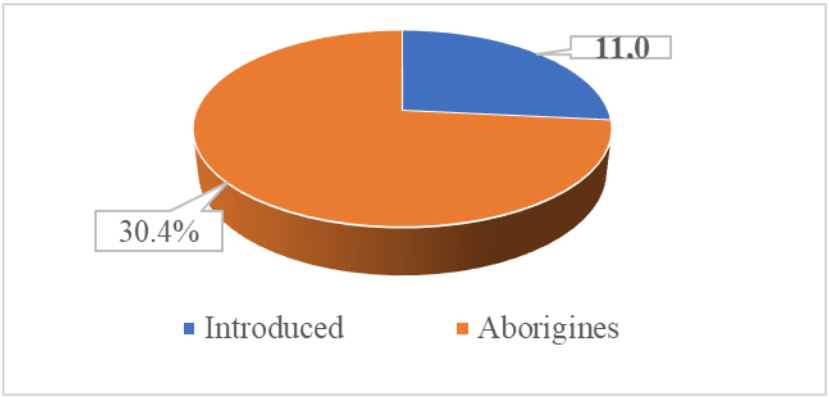

Figure 2. Distribution of introduced and native species among tree and shrub species in Medeu district of Almaty

In the flora of the Medeu district of Almaty, among the introduced species, tree and shrub plant species are represented by 66 species belonging to 37 genera and 18 families. The ratio of introduced species (66; 24.8%) between the occurring tree and shrub life forms is presented in Figure 3, and is 54 species (trees) (24.8%) and 12 species (shrubs) or 5.50%, respectively (See Figure 3).

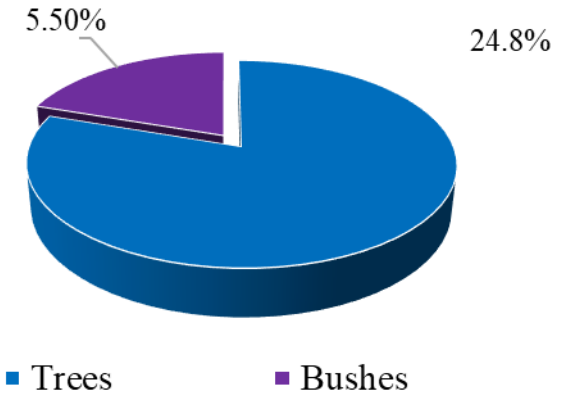

Figure 3. The ratio of introduced tree and shrub forms in the Medeu district of Almaty

As our research has shown, introduced species found in tree and shrub plantations of the Medeu district of Almaty have different centers of origin. Among the tree and shrub introduced species that stand out sharply in terms of species richness are species from Asia (27.0%) (*Ailanthus altissima, Phellodendron amurense, Salix matsudana, Acer ginnala, Kerria japonica, Cotoneaster lucidus, Cerasus tomentosa, Chaenomeles speciosa, Salix babylonica, Juglans mandshurica, Forsythia intermedia*), North America (17.0%) (*Acacia albida, Acer saccharinum, Acer negundo, Crataegus horrida, Populus deltoides, Populus balsamifera, Juglans nigra, Juglans cinerea, Mahonia aquifolium, Picea glauca, Picea pungens, Picea engelmannii, Pseudotsuga menziesii, Pinus sponderosa, Tsuga Canadensis, Fraxinus lanceolata*), Europe (13.8%) (*Euonymus europaea, Acer pseudoplatanus, Sorbus aucuparia, Crataegus monogina, Tilia platyphyllos, Tilia cordata, Picea abies, Pinus mugo)* and Palearctic (6.2%) (*Viburnum opulus, Spiraea vanhouttei, Padus avium, Salix alba, Populus alba, Populus nigra, Buxus sempervirens, Sambucus nigra, Cotinus coggygria* and others). A small percentage of species belong to Eurasia (3.7%) (*Cornus alba, Frangula alnus, Acer mono, Acer platanoides, Populus italica*), the Caucasus and Crimea (1.2%) (*Pinus pallasiana, Amelanchier spicata*), the Mediterranean (3.1%) (*Pinus nigra, Fraxinus excelsior, Fraxinus rotundifolia, Ligustrum vulgare, Syringa vulgaris*) and the Holarctic (2.5%) (*Swida alba, Aesculus hippocastanum, Grossularia uva-crispa*).

The study of urban flora and its biomorphological structure reflects the nature of plant adaptation to a set of environmental conditions prevailing in certain ecotopes. Therefore, its analysis is the main tool in understanding the ecology of plant habitats. The basis for the analysis of life forms in our research was the system of life forms by K. Raunkier [19]. An analysis of the life forms of K Raunkier showed that among the tree and shrub flora of the Medeu district of Almaty, phanerophytes and chamephytes dominate – 53.7%. The group of phanerophytes is well represented in the families *Oleaceae* (5 species), *Rosaceae* (12 species), *Ulmaceae* (5 species), *Pinaceae* (11 species), *Salicaceae* (6 species), *Aceraceae* (7 species), *Betulaceae* (3 species), *Fabaceae* (4 species), *Elaeagnaceae* (4 species), *Juglandaceae* (3 species), *Anacardiaceae* (3 species). Among them, about 20 species are cultivated - this *Berberis vulgaris, Grossularia uva-crispa, Malus domestica, Fraxinus pensylvanica* and others. The group of chamephytes in the urban flora of the Medeu district of Almaty is widely found in the families *Rosaceae* (5 species), *Berberidaceae* (3 species), *Cupressaceae* (8 species), *Oleaceae* (5 species), *Grossulariaceae* (4 species), *Caprifoliaceae* (4 species), *Fabaceae* (4 types). Among gymnosperms *Picea schrenkiana, P. obovate, Abies sibirica Pinus sylvestris, Larix sibirica, Juniperus sabina, J. communis, J. turkestanica* and *J. sibirica* are native i.e. local, and

the remaining 26 (6.5%) species are represented by cultivated plants: *Pinus pallasiana, Pinus nigra, Pinus mugo, Picea glauca, Picea punpens, Thuja occidentalis, Juniperus scopulorum, Juniperus virginiana, Pseudotsuga menziesii, Larix gmelinii* and others.

Below are photographs of the squares and boulevards of the Medeu district of Almaty (See Figure 4).

4.1 Square near the monument to Sh. Ualikhanov

4.2 Square near the Pushkin monument

4.3 Square near the Gani Muratbaev Memorial

4.4 Square near the former Alatau cinema

4.5 Square near the Monument to Zhambyl Zhabayev

4.6 Boulevard on Tolebaev street

Figure 4. Boulevards and squares of Medeu district of Almaty

Conclusion

As a result of the study, it was revealed that only 20% of the species diversity of local tree and shrub plants is used in landscaping among the green spaces of the tree and shrub flora of the Medeu district of Almaty, 80% are represented by introduced species. The natural and climatic conditions of the city of Almaty make it possible to significantly expand the range of landscaping for the city, both due to local and introduced tree and shrub plants. It should be noted that today

the weak points of landscaping in Almaty are its monotony, i.e. landscaping is dominated mainly by northern species of mass assortment and there is no assortment of plants with local southern flavor, which should become the main goal of landscapers in the future when creating new and reconstructing old plantings; lack of special landscape solutions for landscaping highways at the entrance to the city, as well as new areas where local ornamental grasses, flowering shrubs (for example, species, varieties and forms *Spiraea hypericifolia, Berberis iliensis, Berberis heteropoda, Lonicera altmanni, Lonicera alberti, Caragana turkestanica*) and trees (*Armeniaca vulgaris, Cerasus tianschanica, Cerasus erythrocarpa, Prunus sogdiana*) will give a special color scheme and emphasize the southern flavor of the landscape complex of the city of Almaty.

References

1. Рысин Л.П., Рысин С.Л. Урболесоведение. – Москва, 2012. – 240 с.
2. Abhijith K.V., Kumar P. Evaluation of respiratory deposition doses in the presence of green infrastructure Air Quality //Atmosphere & Health. – 2021. - Vol. 14 (6). - P. 911-924. DOI: 10.1007/s11869-021-00989-w.
3. Angel S., Parent J., Civco D.L., Blei A., Potere D. The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050 //Progress in Planning. – 2011. - Vol. 75 (2).-P. 53-107. DOI: 10.1016/j.progress.2011.04.001.
4. Arias-Pérez R.D., Taborda N.A., Gómez D.M., Narvaez J.F., Porras J., Hernandez J.C. Inflammatory effects of particulate matter air pollution Environmental Science and Pollution Research //Environmental Protection Agency. – 2020. - Vol. 27 (34). - P. 42390-42404. DOI: 10.1007/s11356-020-10574-w.
5. Baldauf R. Roadside vegetation design characteristics that can improve local, near-road air quality //Transportation Research Part D. – 2017. - Vol. 52. – P. 354-36. DOI: 10.1016/j.trd.2017.03.013.
6. Bloemsma L.D., Wijga A.H., Klompmaker J.O., Koppelman, et al. The associations of air pollution, traffic noise and green space with overweight throughout childhood: The PIAMA birth cohort study // Environmental Research. - 2019. - Vol. 169. - P. 348-356. DOI: 10.1016/j.envres.
7. Collins R.M., Spake R., Brown K.A., et al. A systematic map of research exploring the effect of greenspace on mental health //Landscape Urban Planning. – 2020. - Vol. 201. - P. 03823-103913. DOI: 10.1016/j.landurbplan.
8. Khaled Hashad, Jiajun Gu, Bo Yang, Morena Rong, Edric Chen, Xiaoxin Ma, et al. Designing roadside green infrastructure to mitigate traffic-related air pollution using machine learning //Science of The Total Environment. - 2021. - Vol. 773. - P. 144760 DOI: 10.1016/j.scitotenv.
9. Yuhan Huang, Chengwang Lei, Chun-Ho Liu, Pascal Perez, Hugh Forehead, Shaofei Kong, et al. A review of strategies for mitigating roadside air pollution in urban street canyons //Environmental Pollution. – 2021. - Vol. 280. - P. 116971. DOI:10.1016/j.envpol.2021.116971.
10. Бессчетнов П.П., Голощапов Г.В. Садово-парковое строительство Казахстана. - Алма-Ата, 1988. - 222 с.
11. Скворцов А.К. Гербарий. – Москва, 1977. – 199 с.
12. Флора Казахстана. - Алма-Ата, 1956-1966. Т.Т. 1 – 9.
13. Деревья и кустарники Казахстана. – Алма-Ата, Т.Т. 1-2. -1966.
14. Растения Центральной Азии //под ред. В.И. Грубова. – М.:–Л., 1963-1989. Т.Т. 1-9.
15. Определитель растений Средней Азии. – Ташкент: ФАН, 1968-1993. Т.Т. 1-10.
16. Иллюстрированный определитель растений Казахстана. – Алма-Ата, 1962-1975. Т.Т. 1-2.
17. Черепанов С.К. Сосудистые растения СССР. - Ленинград, 1981. - 509 с.
18. Абдулина С.А. Сосудистые растения Казахстана. - Алматы, 1998. – 188 с.
19. Серебряков И.Г. Экологическая морфология растений. – Москва, 1962. – 378 с.

Г.А. Садырова, А.К. Таныбаева, Т.А. Базарбаева, Г.А. Муканова, С.М. Джамилова[1], А.С. Нурмаханова

Әл-Фараби атындағы Қазақ Ұлттық университеті, Алматы, Қазақстан
[1]Абай атындағы Қазақ ұлттық педагогикалық университеті, Алматы, Қазақстан

Алматы қаласы Медеу ауданындағы қалалық жасыл желектердің экологиялық жағдайын талдау

Аңдатпа. Бұл мақалада Алматы мегаполисін мысалға ала отырып, Қазақстан қалаларының экологиялық проблемалары талқыланады. Урбанизация процесінің дамуымен қалалардың табиғи ортасы айтарлықтай өзгереді. Олар табиғи қауымдастықтарға тән емес заттар мен энергия айналымының ерекше түрі бар нақты экологиялық ортамен сипатталады. Қалалық жерлерде жасыл кеңістіктер маңызды. Жасыл өсімдіктер үлкен қалалардың тұрғындарын шаңнан, түтіннен және зиянды газдардан қорғауда үлкен рөл атқарады. Алматы қаласында ботаникалық бақ ұсынған ағаштар мен бұталардың 70-тен астам түрі өндіріске енгізілді. Ағаштардан бұл - Phellodendron amurense, Faidherbia albida, Crataegus sanguinea, Crataegus maximowiczii, Crataegus submollis, Crataegus punctata, Crataegus chrysocarpa, Ulmus laevis, Ulmus glabra, Gleditsia triacanthos, Catalpa bignonioides, Aesculus hippocastanum, Acer ginnala, Acer platanoides, Acer saccharum, Juniperus virginiana, Juglans mandshurica, Padus maackii, из кустарников - Amorpha fruticosa, Swida alba, Syringa josikaea, Spiraea vanhouttei, Spiraea thunbergii, Spiraea japonica және басқалар. Алматы қаласының ағаш-бұта флорасына флористикалық талдау жасау жасыл алқаптар 58 туыстар мен 34 тұқымдасқа жататын 208 түрмен ұсынылғанын көрсетті. Ағаш және бұта түрлерінің ішінде Қазақстанның табиғи флорасын 13 туыстар пен 9 тұқымдастың 54 түрі (20%) құрайды (9 қылқанжапырақты және 45 жапырақты түр). 154 түрі (80%) интродукцияланған, бұл табиғи таралу аймағынан тыс топырақта өсетін өсімдіктер.

Түйін сөздер: Жасыл желектер, қалалық урбанизацияланған орта, Алматы қаласы.

Г.А. Садырова, А.К. Таныбаева, Т.А. Базарбаева, Г.А. Муканова, С.М. Джамилова[1], А.С. Нурмаханова

Казахский национальный университет им. аль-Фараби, Алматы, Казахстан
[1]Казахский национальный педагогический университет имени Абая, Алматы, Казахстан

Анализ экологического состояния городских зеленых насаждений Медеуского района города Алматы

Аннотация. В данной статье на примере мегаполиса Алматы рассматриваются экологические проблемы городов Казахстана, где с развитием процесса урбанизации естественная природная среда в городах очень сильно изменяется, для которой характерна специфическая экологическая среда с особым типом круговорота веществ и энергии, не свойственной природным сообществам. Значение зеленых насаждений на урбанизированных территориях очень трудно переоценить. Большую роль зеленые растения оказывают в защите населения крупных городов от пыли, дыма и вредных газов. В городе Алматы более 70 видов деревьев и кустарников, рекомендованных ботаническим садом, были внедрены в производство. Из деревьев это - Phellodendron amurense, Faidherbia albida, Crataegus sanguinea, Crataegus maximowiczii, Crataegus submollis, Crataegus punctata, Crataegus chrysocarpa, Ulmus laevis, Ulmus glabra, Gleditsia triacanthos, Catalpa bignonioides, Aesculus hippocastanum, Acer ginnala, Acer platanoides, Acer saccharum, Juniperus virginiana, Juglans mandshurica, Padus maackii, из кустарников - Amorpha fruticosa, Swida alba, Syringa josikaea, Spiraea vanhouttei, Spiraea thunbergii, Spiraea japonica и другие. Подробный флористический анализ древесно-кустарниковой флоры города Алматы показал, что зеленые насаждения представлены 208 видами, относящихся к 58 родам и 34 семействам. Среди древесно-кустарниковых видов - 54 вида (20%) представляют природную флору Казахстана (9 хвойных и 45 лиственных пород) из 13 родов и 9 семейств, и 154 видов (80%) являются интродуцентами, т.е. растения, выращенные в грунте за пределами ареала их природного распространения.

Ключевые слова: зеленые насаждения, урбанизированная среда, город Алматы.

References

1. Rysin L.P., Rysin S.L. Urbolesovedeniye [Urban forestry] (Moscow, 2012, 240 p.) [in Russian]

2. Abhijith K.V., Kumar P. Evaluation of respiratory deposition doses in the presence of green infrastructure Air Quality, Atmosphere & Health, 14 (6), 911-924 (2021). DOI: 10.1007/s11869-021-00989-w.

3. Angel S., Parent J., Civco D.L., Blei A., Potere D. The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050. Progress in Planning, 75 (2), 53-107 (2011). DOI: 10.1016/j.progress.2011.04.001.

4. Arias-Pérez R.D., Taborda N.A., Gómez D.M., Narvaez J.F., Porras J., Hernandez J.C. Inflammatory effects of particulate matter air pollution Environmental Science and Pollution Research, 27 (34), 42390-42404 (2020). DOI: 10.1007/s11356-020-10574-w.

5. Baldauf R. Roadside vegetation design characteristics that can improve local, near-road air quality Transportation Research Part D. 52, 354-361 (2017). DOI: 10.1016/j.trd.2017.03.013.

6. Bloemsma L.D., Wijga A.H., Klompmaker J.O., Koppelman, et al. The associations of air pollution, traffic noise and green space with overweight throughout childhood: The PIAMA birth cohort study. Environmental Research, 169, 348-356 (2019). DOI: 10.1016/j.envres.

7. Collins R.M., Spake R., Brown K.A., et al. A systematic map of research exploring the effect of greenspace on mental health Landscape Urban Planning. 201, 03823-103913 (2020). DOI: 10.1016/j. landurbplan.

8. Khaled Hashad, Jiajun Gu, Bo Yang, Morena Rong, Edric Chen, Xiaoxin Ma, et al. Designing roadside green infrastructure to mitigate traffic-related air pollution using machine learning Science of The Total Environment. 773, 144760 (2021). DOI: 10.1016/j.scitotenv.

9. Yuhan Huang, Chengwang Lei, Chun-Ho Liu, Pascal Perez, Hugh Forehead, Shaofei Kong, et al. A review of strategies for mitigating roadside air pollution in urban street canyons Environmental Pollution, 280, 116971 (2021). DOI:10.1016/j.envpol.2021.116971.

10. Besschetnov P.P., Goloshchapov G.V. Landscape construction in Kazakhstan, A-Ata, 22-32 (1988).

11. Skvortsov A.K. Gerbariy [Herbarium] (M., 1977, 199 p.) [in Russian]

12. Flora Kazakhstana [Flora of Kazakhstan] (Alma-Ata, V.V. 1-9 (1956 – 1966). [in Russian]

13. Derev'ya i kustarniki Kazakhstana [Trees and shrubs of Kazakhstan] (Alma-Ata, V.V. 1-2 (1966). [in Russian]

14. Rasteniya Tsentral'noy Azii //pod red. V.I. Grubova [Plants of Central Asia / Edited by V.I. Grubov] (M.–L, V.V. 1-9 (1963 – 1989). [in Russian]

15. Opredelitel' rasteniy Sredney Azii [Key to plants of Middle Asia] (Tashkent: FAN, V.V. 1-10 (1968-1993). [in Russian]

16. Illyustrirovannyy opredelitel' rasteniy Kazakhstana [Illustrated guide to plants of Kazakhstan] (Alma-Ata, V.V. 1-2 (1962-1975). [in Russian]

17. Cherepanov S.K. Sosudistyye rasteniya Rossii i sopredel'nykh gosudarstv (v predelakh byvshego SSSR) [Vascular plants of Russia and neighboring states (within the former USSR)] S.-Pb, 990 p. 1995) [in Russian]

18. Abdulina S.A. Sosudistyye rasteniya Kazakhstana [Vascular plants of Kazakhstan] (Almaty, 1998, 188 p.) [in Russian]

19. Serebryakov I. G. Ekologicheskaya morfologiya rasteniy [Ecological morphology of plants] (M., 1962, 378 p.) [in Russian]

Information about authors:

Sadyrova G.A. – corresponding author, Doctor of Biological Sciences, Al-Farabi Kazakh National University, 71 Al-Farabi Avenue, Almaty, Kazakhstan.

Tanybayev A. K. – Candidate of Chemical Sciences, Al-Farabi Kazakh National University, 71 Al-Farabi Avenue, Almaty, Kazakhstan.

Bazarbaeva T.A. – Candidate of Geographical Sciences, Al-Farabi Kazakh National University, 71 Al-Farabi Avenue, Almaty, Kazakhstan.

Mukanova G.A. – Candidate of Biological Sciences, Al-Farabi Kazakh National University, 71 Al-Farabi Avenue, Almaty, Kazakhstan.

Jamilova S.M. **–** Master of Science, Senior Lecturer, Department of Biology, Abay Kazakh National University, 13 Dostyk Avenue, Almaty, Kazakhstan.

Nurmakhanova A. S. – PhD, Al-Farabi Kazakh National University, 71 Al-Farabi Avenue, Almaty, Kazakhstan.

Садырова Г.А. – автор для корреспонденции, биология ғылымдарының докторы, әл-Фараби атындағы Қазақ ұлттық университеті, әл-Фараби даңғылы, 71, Алматы, Қазақстан.

Таныбаева А.Қ. – химия ғылымдарының кандидаты әл-Фараби атындағы Қазақ ұлттық университеті, әл -Фараби даңғылы, 71, Алматы, Қазақстан.

Базарбаева Т.А. – география ғылымдарының кандидаты әл-Фараби атындағы Қазақ ұлттық университеті, әл-Фараби даңғылы, 71, Алматы, Қазақстан.

Мұқанова Г.А. – биология ғылымдарының кандидаты әл-Фараби атындағы Қазақ ұлттық университеті, әл-Фараби даңғылы 71, Алматы, Қазақстан.

Джамилова С.М. – ғылым магистрі, ҚазҰУ биология кафедрасының аға оқытушысы, Абай атындағы Қазақ ұлттық педагогикалық университеті, Достық даңғылы, 13, Алматы, Қазақстан.

Нурмаханова А.С. – PhD, әл-Фараби атындағы Қазақ ұлттық университеті, әл-Фараби даңғылы, 71, Алматы, Қазақстан.