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THE ASSESSMENT OF CONDITION AND ENVIRONMENTAL FUNCTIONALITY OF GREEN INFRASTRUCTURE AT THE DNIPROVSKY DISTRICT OF KYIV CITY

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The role of green infrastructure in urban ecosystems is considered in the paper. The critical analysis of available research results shows that urban green spaces or green infrastructure make crucial contribution into ecosystem and human health, as well as formation of sustainable urban communities. The optimization of green areas exploitation is defined to be an important element of increasing the level of living standards for city inhabitants. The Dniprovsky district is one of the largest districts in Kiev, densely populated and loaded with municipal and industrial facilities, resulting in high anthropogenic pressure on the environment. The study of the Kyiv Dniprovsky district green infrastructure has been conducted to evaluate the ability of the given phytocenosis to perform their environmental functions. The general condition and functionality of the district green infrastructure are satisfactory, but it needs additional support and maintenance, which should be balanced in favor of environmental function provision, instead of aesthetic, organizational or economic.

Keywords: green infrastructure, environmental functions, urban ecosystem, environmental condition.

ОЦІНКА СТАНУ ТА ЕКОЛОГІЧНОЇ ФУНКЦІОНАЛЬНОСТІ ЗЕЛЕНИХ НАСАДЖЕНЬ ДНІПРОВСЬКОГО РАЙОНУ МІСТА КИЄВА

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Розглянуто роль зелених насаджень у міських екосистемах. Критичний аналіз наявних результатів досліджень показує, що міські зелені насадження роблять вирішальний внесок у здоров'я екосистем і людини, а також формування стійких міських спільнот. Визначено, що оптимізація експлуатації зелених зон є важливою складовою підвищення якості життя міських мешканців. Дніпровський район є одним з найбільших районів у Києві, густонаселений і завантажений комунальними та промисловими об'єктами, що призводить до підвищеного антропогенного навантаження на навколишнє середовище. Було проведено дослідження стану зелених насаджень Дніпровського району міста Києва для оцінювання здатності фітоценозів виконувати свої екологічні функції. Загальний стан і функціональність районних зелених насаджень є задовільними, але вони потребують додаткової підтримки і обслуговування, які повинні бути збалансовані у бік забезпечення екологічних функцій, а не естетичних, організаційних чи економічних вимог.

Ключові слова: зелені насадження, екологічні функції, міська екосистема, стан навколишнього середовища.

PROBLEM STATEMENT. State and local communities efforts to preserve the natural environment are mainly invested in conservation of unique or typical diverse and virgin ecosystems. Much less attention is usually paid to the parts of nature close to residential and working areas within cities and towns, i.e. to urban parks and squares. Increasing empirical evidence, however, indicates that the presence of natural areas contributes to the quality of life in many ways. Besides many environmental and ecological services, urban nature provides important social and psychological benefits to human societies, which enrich human life with meanings and emotions [1]. The main concern of this paper is to address the condition of green plantations within one of Kyiv areas.

The role of green infrastructure in urban ecosystem.

Ukraine is a highly urbanized country. The consequent loss and degradation of urban and semi-urban green space could adversely affect ecosystems as well as human health and well-being [2]. The experience of nature in urban environment is source of positive feelings and beneficial services, which fulfill important immaterial and non-consumptive human needs. The critical review of possible contributions of urban and

semi-urban green space systems, or green infrastructure, on both ecosystem and human health shows that they are the necessary and integral component of sustainable urban communities.

In the era of urban development due to increasing populations in urban environments, it is important for cities to maintain the appropriate levels and quality of green space to keep up with the growth. Various studies indicate many benefits that urban green space provides. Four major benefits of city parks are health strengthening, social connection, aid the environment and have significant positive impacts on the local economy.

Several studies have shown that parks have the ability to increase physical and mental health of those who live around and utilize them. This is especially true concerning children and the senior population [3,4]. Some authors argue that people need to restore their psychological resources in environments that are not fully conducive to their activities [5]. These psychological benefits could be explained by the work of Edward Wilson, famous American biologist. He coined the term of Biophilia in the 1980's. His hypothesis suggests that humans cannot be separated

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from nature and that being connected to nature is the quintessence for psychological well-being [6].

A study by Penn State University showed significant correlations to reductions in stress, lowered blood pressure, and perceived physical health to the length of stay in visits to parks.

Neighborhoods thrive where there exists a strong sense of community between residents. It is crucial for organization of public activity aimed at street cleaning, energy conservation and amenities provision and maintenance under the conditions of limited financial support of these work from the state authorities. Studies have shown that parks can cause a significant rise in social connection in communities they are located in [7]. High density development separates residents, resulting in social disengagement. The crowded urban environment makes it difficult to interact with residents and inhibits productive social communications. Parks offer a space for social gatherings on top of increasing a sense of communities.

The role of green infrastructure in the support of environmental balance on the territory of settlements is undeniable. Ecologically urban green spaces supply cities with ecosystems services such as preservation of biodiversity and regulation of the urban climate. They also help with air and noise pollution control: air pollutant particles are trapped by vegetation, while noise pollution can be physically reduced by green spaces depending on their quantity and distance from the noise source. Parks and protected public lands are proven to improve water quality, protect groundwater, prevent flooding, improve the quality of the air we breathe, provide vegetative buffers to development, produce habitat for wildlife, and provide a place for children and families to connect with nature and recreate outdoors together.

From the economic point of view parks play an important role in improving the local tax base and increasing property values by 9 – 11% over the average price. It also helps retain educated and skilled workers in cities offering better living opportunities [8]. Well planned land use, such as parks, is one way to increase the attractiveness of a city not only for residents, but also for visitors and tourists. This way parks and recreation generate money for the local economy. American Forests, a national conservation organization that promotes forestry, estimates that trees in cities save \$400 billion in storm water retention facility costs.

So, accounting the high importance of green infrastructure in sustainability of a city it is necessary to control the condition of these objects and implement maintenance activities as soon as possible to support their efficient functioning for the provision of human needs.

The purpose of the research is to assess the condition of the existing green infrastructure of the Dniprovsky region of Kyiv and its ability to fulfill their environmental functions.

The basic tasks of research are the analysis of green plantations role in the formation of city environment and determination of factors of plant associations' degradation and deterioration of urban environment on

the whole. Consequently, the purpose of this work is the generalization of theoretical bases from organization, maintenance and management greenery at municipal territories, study of foreign countries experience in this field, and development of recommendations for the improvement of the existing practice of urban green plantations management.

Characteristics of structure of dniprovsky district green infrastructure. Dniprovsky district is one of the largest districts in Kiev, with a fairly large density of population, municipal and industrial facilities, which form significant anthropogenic pressure on the environment.

The total area of green infrastructure in the Dniprovsky district is 1.16 thousand ha, which is the highest relative area among all other districts of Kyiv. The structure of green plantations of the district includes 4 parks, namely Dniprovsky (located on Trukhaniv Island of the Dnipro River), "Aurora", "Peremoha (Victory)" and Hydropark complex (located on Venetial and Dolobetsky Islands of the Dnipro River). Here green infrastructure is represented with deciduous, mixed and pine woods, as well as shrubs and bushes, which are predominant on the islands.

Also green plantations of the Dniprovsky district include the following protected areas: group of European beech trees in Victory Park (the Liberators Prospect); giant black poplar as a natural floodplain forest residue, 27 m high; state botanical reserve of local importance "Fish" (total area is 4 ha); landscape reserve of local importance "Plyahova" (total area 100 ha).

MATERIALS AND METHODS OF RESEARCH. The research has included the analysis of city planning structure, its functional zoning system, landscaping, urban green infrastructure structure and condition, including their range and overall health status. The green infrastructure has been studied based on city cartographic materials and data of field surveys with standard technique.

The main stages of work organization and monitoring in specific areas, such as parks Aurora, Victory, the Dniprovsky and Hydropark are:

1. Definition of the areas, under the most intensive technogenic impact, and choice of scientifically substantiated permanent observation points.
2. Choice of methods and equipment for the conduction of the research.
3. Conduction of the research, formation of database with results and development of cartographic material.
4. Development and implementation of recommendations for the reduction of technogenic pressure and improvement of support of stability and decoration of green infrastructure in the city.

An important point of this work is that the study was conducted during early autumn, when all the leaves damage is clearly seen. This gave us information about arboreal plants at the end of the growing season under different environmental conditions.

Indicators were collected on the following parameters: direction of the street (south-east-north-west), correlation with the wind rose; street side (sunny or shadow); width of street; traffic intensity (slow,

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medium, high, extremely high); presence of high buildings and air circulation efficiency (increased air circulation – draught, normal air circulation, standing air); presence of public transport stations, traffic-lights and crossings. All these parameters are particularly important, since they have impact on distribution of environment pollution, thus causing increased damage at certain plantations.

All major elements of green infrastructure were evaluated with objective parameters: density of plantation (number of rows and distance in between); type of plantation (road green belt, public garden, park, yard); predominant arboreal breeds of the plantation; phenophase of plants.

Evaluation of trees condition is conducted by two methods, complementing each other. First, trees are divided into three quality groups according to city planting regulations: 1 – good, 2 – satisfactory and 3 – unsatisfactory conditions. Secondly, on the basis of the operating «Sanitary rules in the forests of Ukraine» there are 6 categories of trees living potential: 1 – trees without the signs of weakening, 2 – weak, 3 – extremely weak, 4 – drying, 5 – dead trees of current year (dried in current year), 6 – dead trees of past years.

Analysis of the assessment results. The observations of the Dniprovsky district green infrastructure show that the arboreal plantations condition can be classified as satisfactory. Trees are relatively healthy with unevenly developed crown. Insufficiently foliated, disease and damaged (insignificant mechanical damages, not threatening life of plants) trees are present in limited quantity and decay signs are on the initial stage, so the situation can be improved.

More detailed research has shown that roughly 60% arboreal plantations are weakened. Thus, leaves on the trees are often lighter than ordinary; crown is poorly foliated; growth is weak as compared to normal, crown contains less than 25% dry escapes; the signs of local damage are possible. Another 20% represent trees with healthy, normally developed, thickly leaves, without mechanical damages and diseases. The rest 20% are trees and bushes with smaller or lighter than ordinary, grayish, mat leaves; crown is sparse, dry sprouts over 25%, sprouts and leaves are often marked with illnesses and damages.

As for the separate green areas analyzed through the research, the cleanest territory is the Hydropark: 70% trees are without the signs of weakening, 25% are weak. The arboreal group of "The Peremoha (Victory) Park" has similar characteristics, but more than 30% are weak, 10% are extremely weak and also 60% are without the signs of weakening.

The smallest park of this list is "Aurora" and only 35% plants are without the signs of weakening, 55% - extremely weak and 10% - dead trees. The Truhaniv island area is one of the most weakened of the Dniprovsky district. There are approximately 73% healthy trees, without signs of weakening, 17% is accounted for weak and extremely weak, essential share of all plants are attenuated, the leaves have light-green color, 10% plants are drying and dead. The summarized research results are presented at Fig. 1.

So, green plantations of the Dniprovsky district could be considered relatively normal, but growing anthropogenic pressure will eventually lead to deterioration of their quality. The potential negative influence is caused by pollution of air, soils, water, which depresses growth and complicates the existence of trees and bushes, as well as constructional and recreational activity of people. But taking into account the obtained research results and literature data we can state that the environmental condition of green plantations at the territory of Dniprovky district has improved since 2005.

Recommendations for the improving dniprovsky district green areas condition. Unfavorable conditions of urban environment lead to plantations premature aging and reduce their viability. This also prevents normal provision of environmental functions by green infrastructure. In order to make valid prognosis of environment condition at the study area it is necessary to account the viability of arboreal plant associations in terms of their ability to provide environmental functions, which make an essential contribution into formation of the environmental situation, by reducing air pollution, mitigating physical pollution and provision of recreational facilities.

The maintenance of green infrastructure include: looking after plants, decorative associations, small architectural forms; protection of green plantations from pests and diseases; restoration, renovation, expansion and sanitary clearing of green infrastructure, facility improvement.

The elements of maintenance activities for green plantations include watering, fertilizing, covering, spraying crowns, soil fertility maintenance, weed control, treatment of mechanical damage, formation of crowns of trees and shrubs (for normal growth and proper development of trees). This complex of actions must be balanced in favor of environmental function provision, instead of aesthetic, organizational or economic. It is especially important for in case of circumcission planning: dust retention, oxygen and humidity provision, carbon dioxide assimilation and other environmental functions performance depends directly on the volume of tree crown and area of leaves.

Also one of the main conditions of normal growth and development of plants at urban territories is watering, which should provide ongoing optimal moisture of soil root layer to the depth of 60-70 cm. The municipal area of Kyiv is characterized with lowered humidity, reduced quantity and duration of precipitation as compared to adjoining non-urban areas.

The best growing conditions are provided at soil moisture of 60-80% full capacity. Sandy and loamy soils (typical for Dniprovsky district of Kyiv area) one-time watering rate for trees must be 30-50 l/m², which is lower than for heavy clay and loamy soils (50-80 l/m²); and in the period of summer drought single rate per watering tree is 100 l/m². Most trees should be watered in the first half of the growing season (May-June), which is the period of their intensive growth. This additional watering is also crucial for the provision ecological functions of green islands: after long periods

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without rain, the leaves of the trees are covered with fairly thick layer of dust, which leads to closing their stomata, photosynthesis deterioration, slowing metabolism. In order to wash out the dust settled on the leaves should be removed with spraying watering. They is especially necessary in summer (July, August).

The results of this study has showed the insufficient level of protecting measures against pests and diseases of plants. From the environmental point the most important element of this protective system is sanitation. Its task is to eliminate sources of infection and prevent the emergence and propagation of such problems.

In order to control the state of urban green plantations special course of full monitoring must be conducted twice a year - spring and autumn, - when all elements of green infrastructure are examined. Partial monitoring could be conducted more often to check the course of improvement in relation to previously identified problem areas.

The main factor having influence on green infrastructure well being is the condition of soil, water and air at the territory of the Dniprovsky district. Therefore the results of these environment components monitoring must be used to predict and prevent the negative changes of green infrastructure at the area of the Dniprovsky district.

Based on the experience of monitoring studies of municipal green areas and specific environmental conditions of Kyiv urban ecosystem, we defined a set of interrelated issues that must be addressed in the monitoring process, namely the state of green infrastructure and their decorative quality, entomologic and phytopathological condition of arboreal plantations, air quality with determination of basic phytotoxic substances quantity and total volume of industrial and transport emissions, soil condition analysis and phytotoxicity of precipitations.

In order to improve the condition of the green areas of the Dniprovsky district of Kyiv city a set of research, social-economic and planning activities is necessary. Research efforts must be aimed at finding the ways to:

- 1) state the principles and develop scientific and practical background for the regulation of green infrastructure maintenance;
- 2) substantiate and standardize the value environmental functionality of green areas in terms of their composition and structure;
- 3) develop special complex monitoring practices, which would combine instruments for plant associations condition control with the assessment of target environments conditions;
- 4) choose or develop methods of assessment and prediction of vegetation condition;
- 4) develop recommendations for effective management of green infrastructure.

Planning measures include: rational territory zoning, tracing highways, construction organization, maintenance and plantation of greenery. Maximum possible cover of urban territories with green plantations belongs to the most important planning activities. Important pre-condition of this is the creation of scientifically substantiated system of internal green

plantations and organization of suburban green zones. Thus, green infrastructure must be maximally close to the place of people residence to provide maximum positive environmental effect.

Social-economic activities are also important for the complex solution of the above mentioned problems of urban green infrastructure. In particular it is necessary to:

- develop and introduce ecological policy at municipal level to form ecological awareness of citizens;
- change principles and procedures of greenery construction and maintenance, providing scientific organization of relevant authorities work and high executive discipline;
- develop and implement the concept of maintenance and expansion of urban greenery;
- organize participation of citizens of various age groups in the works on green plantations maintenance, and budget money saved this way could be used for conduction of other works related to green infrastructure;
- provide Kyiv park authorities with skilled managers;
- strengthen the responsibility for violation of legislation and crimes in relation to green plantations of Kyiv city;
- develop and implement the state monitoring system of urban green plantations.

CONCLUSIONS. In the course of the research the role of green plantations for urban territories and in particular for Kyiv was established. To give green plantations the possibility to fulfil their useful functions, it is necessary to implement city-planning rules and principles of green economy management.

Green plantations development is time-consuming and technologically difficult process. Plantation of trees and bushes is usually carried out, when plants are young and as a result are very vulnerable. At the same time green plantations in cities undergo serious influence, caused by humans: pollution of air, soils, water, which depresses growth and complicates the existence of trees and bushes; sometimes it even leads to their deaths. From the other side, humans often consciously destroy green plantations in the process of constructional and recreational activities.

The maximum possible cover of city territories with green plantations belongs to the major ecological targets of city development. One of the most important tasks of city environment improvement is optimization of management and care after green zones of cities based on geoecological approach, which enables complex assessment of geosystems condition and definition of methods of their improvement, not limiting the use of these areas for recreational and other needs.

The analysis of the green plantations management system in Kyiv has showed the basic problems in this field and defined main parameters of green plantations quality. It has been suggested to develop the inventory digital map of Kyiv based on the available and additional information to be acquired specially for this purpose. The presence of such map will give the

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possibility to optimize work of authorities, which coordinate the work on maintenance and development of urban green plantations.

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ОЦЕНКА СОСТОЯНИЯ И ЭКОЛОГИЧЕСКОЙ ФУНКЦИОНАЛЬНОСТИ ЗЕЛЁНЫХ НАСАЖДЕНИЙ ДНЕПРОВСКОГО РАЙОНА ГОРОДА КИЕВА

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Рассмотрена роль зелёных насаждений в городских экосистемах. Критический анализ имеющихся результатов исследований показывает, что городские зеленые насаждения делают решающий вклад в здоровье экосистем и человека, а также формирование устойчивых городских сообществ. Определено, что оптимизация эксплуатации зелёных зон является важной составляющей повышения качества жизни городских жителей. Днепровский район является одним из крупнейших районов в Киеве, густонаселенный и загруженный коммунальными и промышленными объектами, что приводит к повышенной антропогенной нагрузке на окружающую среду. Было проведено исследование состояния зелёных насаждений Днепровского района города Киева для оценки способности фитоценозов выполнять свои экологические функции. Общее состояние и функциональность районных зеленых насаждений являются удовлетворительными, но они нуждаются в дополнительной поддержке и обслуживании, которые должны быть сбалансированы в сторону обеспечения экологических функций, а не эстетических, организационных или экономических требований.

Ключевые слова: зелёные насаждения, экологические функции, городская экосистема, состояние окружающей среды.