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Editors:
Eduard MOKRIAK, Assoc. Prof, PhD, State University of Economics and Technology (Ukraine)
Nataliia RYTSKO, State University of Economics and Technology (Ukraine)

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ASSESSMENT OF THE PHYTOMELIORATIVE FUNCTIONS OF GREEN SPACES IN THE "EASTERN" DISTRICT OF TERNOPIL CITY

Nataliia Bohun
Ternopil Volodymyr Hnatiuk National Pedagogical University, bohunnataliaed@gmail.com, Ukraine
Supervisor – ***Liubov Yankovska****, PhD, Associate Professor*
Ternopil Volodymyr Hnatiuk National Pedagogical University, lubayank@gmail.com, Ukraine

Abstract. Based on cartographic materials and field research, the article assesses the level of greening in residential areas of the "Eastern" district of Ternopil and analyses the compliance of the level of greening with regulatory indicators. In accordance with the Instructions for Inventory of Green Spaces in Settlements of Ukraine, the condition of the plants is examined. The phytomeliorative functions of green spaces in the city district are analysed, their ecological and recreational potential is assessed, and their role in the ecological network of the city of Ternopil is described. The main problems of the natural framework of the studied area of the city are identified, including a low percentage of evergreen plants; the lack of multi-layered plantings, which are necessary for more effective noise and gas absorption along roads with heavy traffic; a gradual reduction in the area under green plantings due to the development of the territory.

Keywords: phytomelioration, oxygen, carbon dioxide, noise pollution, erosion, flooding, recreational capacity, plant species, ecological network.

Introduction

The relevance of research into urban green spaces is

determined by their important role in improving the ecological situation, promoting sustainable development and enhancing the quality of life of residents. Studies of the current state of greening are essential for urban development planning in order to comply with relevant standards and ensure comfortable and healthy living conditions.

Analysis of recent research and publications. Significant achievements in the development of theoretical and methodological foundations for the study of green spaces in cities, including the analysis of international experience and prospects for the implementation of a green infrastructure strategy in Ukraine, belong to N. Maksymenko and S. Burchenko (Maksymenko N. V. and Burchenko S. V., 2019). V. Kucheriavyi (Kucheriavyi V. P., 2005) made a valuable contribution to the study of complex green areas.

The geo-ecological aspects and peculiarities of the formation of the ecological network of the city of Ternopil, including the justification and characteristics of core areas, connecting and buffer zones, are highlighted in the publications of L.Tsaryk and P.Tsaryk. I. Kuzyk has studied the geoecological parameters and potential of the green and blue infrastructure of the city of Ternopil, as well as the problems of its sustainable functioning. (Tsaryk L., Kuzyk I., Tsaryk P., 2020; Kuzyk I. R., Tsaryk L. P., 2020; Tsaryk L., Kuzyk I., 2022; Kuzyk I. R., 2023).

The spatial structure of the green zone of the city of Lviv, its interconnection with social factors and residential development, the species composition of urban green spaces, as well as the importance of introduced and exotic plants in the creation of the city's green zone are analysed by M. Nazaruk (Nazaruk M., 2022).

A system of measures to improve the greening of the city of Vinnytsia by combining the city's green areas into a single greening system is considered in the works of V. Shvets, V.

Kalinichenko and O. Kudlaienko (Shvets V.V., Kalinichenko V.S., Kudlaienko O.O., 2013).

However, scientific research into green infrastructure in Ukraine is currently in its infancy. Theoretical approaches and methodological concepts are being actively analysed by scientists in the context of landscape planning, the development of ecological networks, innovative approaches to greening, the adaptation of the urban environment to climate change, and within the framework of research into the hydroecological aspects of urban ecosystems and other related issues.

The purpose of this study is to analyse the current state of green spaces in the "Eastern" district of Ternopil, to determine whether the level of greening complies with scientifically based standards, and to assess the ecological, social and other functions of green spaces.

The following methods were used to solve the tasks: cartographic, field research, statistical, and mathematical. Using cartographic sources and the results of our own field research, we assessed the level of greening in residential areas, educational institutions, as well as public and special plantings, and studied the species composition and condition of plants in accordance with the Instructions for Inventory of Green Spaces in Settlements of Ukraine. For convenience, the study area was divided into 19 sections. The use of statistical and mathematical methods made it possible to determine the compliance of the level of greening with regulatory indicators and to assess the ecological and recreational potential of the plantings.

Research results

The "Eastern" district is a residential area in the city of Ternopil, named so because it is located in the eastern part of the city. Its area, together with the National Revival Park, is almost 345 hectares (4.8% of the total area of the city). The aforementioned park is a structural element of the ***macro-level*** green zone of the district, as well as a core area of the local

ecological network of Ternopil. The ***meso-level*** of the natural structure of the district is represented by green spaces in the private sector of low-rise buildings in the western part of the district, where fruit trees, ornamental shrubs and flowerbeds prevail. In addition, there is a public garden on Oleksandro Dovzhenko Street, and a boulevard on Danylo Halytskyi Street (2.5 hectares, 600 m long), which directly serves as a green corridor, connecting the National Revival Park with the local green areas of the "Eastern" district. ***Micro-level*** elements include numerous lawns, flowerbeds, groups of trees and shrubs.

Our research proves that the residential area of the "Eastern" district of Ternopil is greened by 32–38%, which exceeds the minimum standard - 25% (ДБН Б.2.2-12:2019). However, some streets have insufficient green spaces (part of Stepan Bandera Avenue, the intersection of Lesya Ukrainka and O. Dovzhenko Streets, and Hlyboka Street). The percentage of greenery in restricted-use areas is also mostly above the norm, especially in preschool educational institutions (60-70%), while in two of the seven schools (secondary schools № 17 and 18) this indicator is slightly below the norm (40%), and particularly low near the Ternopil College of Restaurant Service and Trade (only 26%).

Taking into account public green spaces in the National Revival Park, the total level of greening in the "Eastern" district of Ternopil is 54%.

The species composition of green spaces in the "Eastern" district of Ternopil is diverse, with both native and introduced species found. The most common tree species are *Tilia Cordata*, *Acer Platanoides*, *Acer Negundo*, *Juglans Regia*, *Populus Nigra*, *Betula Pendula*, *Pinus Sylvestris*. The species composition of shrubs is represented by *Rosa Canina*, *Crataegus Rhipidophylla*, *Cornus Mas*, *Hippophae Rhamnoides*, *Corylus Avellana*. Various types of herbs such as *Poa trivialis, Festuca pratensis, Phléum praténse* as well as *Taraxacum Officinale, Béllis*

perénnis, Artemisia Vulgaris, Medicago Sativa, Arctium Nemorosum, Urtica Dioica, Chelidonium Majus, Glechoma Hederacea, Barbarea Verna form lawn cover. Exotic species such as *Prunus Serrulata, Kerria Japonica, Rhus Typhina, Magnolia Kobus, Pieris Japonica* and others can be found in the study area.

The condition of green spaces is mostly satisfactory or good. Cases of unsatisfactory plant condition were observed in areas marked in red (Fig. 1). For example, these included minor damage to the bark of some trees and necrosis on the leaves, sparse crowns and dry branches on bushes, trampled lawns, sparse plantings and dry leaves in flowerbeds. Of particular concern is the condition of *Aesculus hippocastanum*, whose leaves are almost completely damaged by *Cameraria ohridella*.

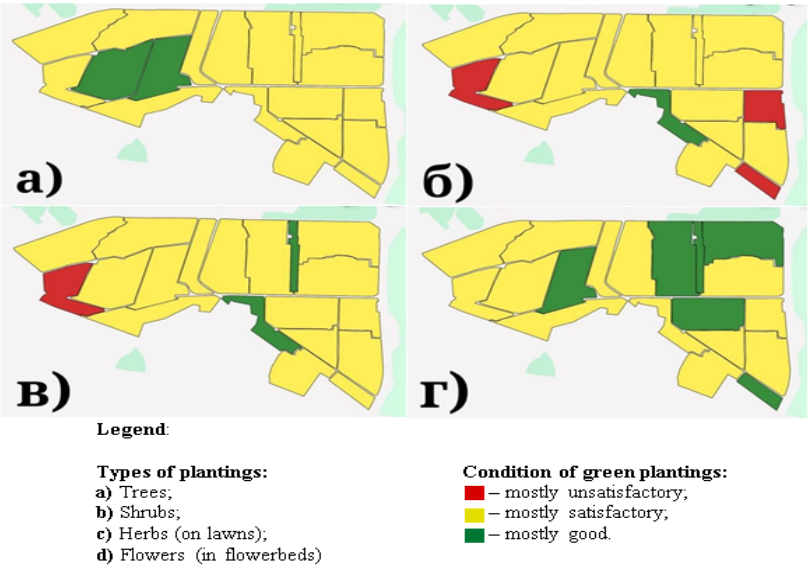

Fig. 1. Condition of green plantings in the "Eastern" district of Ternopil within residential areas (by the author)

Green spaces in urban systems perform important ecological functions, regulating the oxygen-carbon balance,

purifying the atmosphere of pollutants, reducing noise levels, etc.

One of the priority ecological functions of plants is the release of oxygen (O_2) and the absorption of carbon dioxide (CO_2). It has been calculated that 1 hectare of urban green spaces on a fair day absorbs 220-275 kg of CO_2 and releases 180-215 kg of O_2 (V.P. Kucheriavyi, 2005).

Therefore, having performed proportional calculations for the growing season, we can conclude that the plantings in the "Eastern" district of Ternopil can assimilate approximately 6,500 tonnes of CO_2 per year and release 5,300 tonnes of O_2 per year.

According to research by I. Kuzyk, 6,445 tonnes of oxygen per year are needed to oxidise the main pollutants in the atmosphere of Ternopil (Kuzyk I.R., 2023). Thus, the green spaces of the "Eastern" district can fulfil this task by 82%, i.e. they make a significant contribution to the recovery of the city's air basin. It is known that the urban ecosystem of Ternopil produces 21,815 tonnes of oxygen per year (Kuzyk I.R., 2023). Therefore, the vegetation of the studied district provides almost a quarter of the O_2 to the city's atmosphere.

As in many other large residential areas, the number of private vehicles in the "Eastern" district of Ternopil is growing, leading to an increase in overall traffic congestion. The problem of air pollution becomes particularly acute in winter, when emissions from boiler rooms, individual heating systems and private homes increase, while natural neutralisers such as green spaces are ineffective. Therefore, the next problem to address is the small number of evergreen plants. It should be noted that coniferous trees reduce noise levels by 6-7 dB more effectively than deciduous trees. Mixed plantings, including trees and shrubs, have the best screening properties, especially when there is good vertical closure.

Plants significantly reduce the impact of dust and harmful

gases on human body. Studies show that under tree canopies, the level of dust in the air is lower than in open areas, and this difference varies depending on the season: in May it is 20%, in June – 21.8%, in July – 34.1%, in August – 27.7%, and in September – 38.7%. Tree plantations are capable of absorbing an average of about 50% of dust in summer and up to 37% in winter. During the entire growing season, the average concentration of dust in the air of urban areas in open spaces was 0.9 mg/m^3, while under trees this figure fell to 0.52 mg/m^3, which is 42.2% less (Kuzyk I.R., 2023).

Another important phytomeliorative function of green spaces is to counteract lateral geophysical flows (wind-dust, wind-snow, water, water-soil).

The eastern part of Ternopil lies within the hilly terrain typical of the Podillia Upland. The highest point of the city is located in the “Eastern” district (Stepan Bandera Avenue) — its height is 374 m, so there is a possibility of water erosion in the studied area.

During heavy rainfall, flooding is common, mainly due to the high proportion of artificial impervious surfaces and the poor technical condition of the drainage system. The city's most problematic flooding areas remain Hlyboka Street, the intersection of Stadnykova Street and Mykulynetska Street, and the intersection of Stepan Bandera Avenue and Tatarska and Chopin Streets, which are located within the study area. Important measures to prevent dangerous processes of this type include expanding green areas and increasing the area covered by vegetation within the city, as the runoff coefficient is significantly lower on natural surfaces than on artificial ones, while the level of transpiration and infiltration is higher.

Green spaces in the district perform a number of important social functions, including recreational, aesthetic, environmental education, creating psychological comfort, providing conditions for sports, cultural and artistic activities, etc.

Residents of the “Eastern” district prefer to relax in the National Revival Park. It offers comfortable conditions for walking, with convenient alleys and paths, as well as benches for pleasant leisure time. In addition to green spaces, the park has attractions, playgrounds, areas for sports, and a stage for cultural events. Races and sports tourism competitions are organised here, as well as festivals, music concerts and exhibitions, which diversify the leisure activities of the citizens. Along the cozy alleys on D. Halytskyi Boulevard, you can often see elderly people and mothers with children. Another wonderful place for walks is the square on Oleksandr Dovzhenko Street. It has footpaths, a health and sports complex, an entrance stele, and both typical and decorative plants.

The recreational capacity, i.e. the maximum number of visitors allowed in the park areas of Ternopil at any one time, is 13,037 people. For the National Revival Park, this figure is 4,500 people (Kuzyk I.R., 2023). Thus, the recreational capacity of the park reaches 34.5% of all park areas of the city, which emphasises the significant recreational potential of the studied territory of the city.

Conclusions

Thus, one of the strengths of the “Eastern” district of Ternopil is its high level of greening, which in most cases complies with state building standards and even exceeds the minimum regulatory requirements. This area contains sites that play a significant role in the city's ecological network and are important for its sustainable development. These include the National Revival Park (45 hectares), which is a core area of the local ecological network, and Danylo Halytsky Boulevard (2.5 hectares, 600 m long), which directly serves as a green corridor, connecting the National Revival Park with the local green areas of the “Eastern” district.

The vegetation of the “Eastern” district performs

important functions: protective, sanitary and hygienic, and recreational. It makes a significant contribution to improving the city's air quality, as it can assimilate approximately 6,500 tonnes of CO_2 per year and release 5,300 tonnes of O_2 per year, and is a powerful tool in combating water erosion and flooding in the studied area. In addition, it has significant recreational potential; in particular, the recreational capacity of the National Revival Park is 4,500 people (34.5% of the total park area of the city).

The main problems of the natural framework of the "Eastern" district in Ternopil are:

- insufficient greening of some educational institutions;
- low percentage of evergreen plants in the structure of plantings that could effectively perform sanitary and hygienic functions during the cold season, absorbing carbon dioxide, releasing oxygen and purifying the air of pathogenic bacteria with the help of phytoncides, as well as being excellent elements for landscape design;
- lack of tiered planting, which is necessary for more effective noise and gas absorption along some roads with heavy traffic;
- unsatisfactory condition of chestnut trees *Aesculus hippocastanum* affected by leaf miner moths *Cameraria ohridella* (need for reconstruction of plantings);
- lack of vertical and container greening;
- gradual reduction of green space due to development of the territory.

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