UDC 581.522.6:633.88(477.51)

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ADVENTIVE TREE AND SHRUB PLANT SPECIES WITH MEDICINAL PROPERTIES IN THE CHERNIHIV CITY'S GREEN INFRASTRUCTURE

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АДВЕНТИВНІ ДЕРЕВНІ ТА ЧАГАРНИКОВІ ВИДИ РОСЛИН З ЛІКАРСЬКИМИ ВЛАСТИВОСТЯМИ У ЗЕЛЕНІЙ ІНФРАСТРУКТУРІ МІСТА ЧЕРНІГОВА

DOI: 10.58407/bht.1.24.1

ABSTRACT

Purpose of the work was to identify introduced species of woody and shrubby plants with medicinal properties in the Chernihiv city's green infrastructure and to characterize the medicinal properties of these plants, as well as to determine their role in providing ecosystem services and to assess the potential possibilities of harvesting them as medicinal raw materials.

Methodology. The materials were collected during research of green infrastructure facilities of the Chernihiv city in 2022–2023 using geobotanical methods (Yakubenko et al., 2018). During field research, the degree of invasive activity of introduced trees and shrubs species was recorded. Degrees of invasiveness were measured according to Wagh and Jain (2018) with authors modificationand categorised into 4 different categories namely, recently introduced, possibly invasive, moderately invasive and highly invasive on the basis of their availability. Each category has been given a number (1 to 4) on the basis of the impact of the species in the study area, the higher the number the higher the invasive impact: recently introduced (1), possible invasive (2), moderately invasive (3) and highly invasive (4). In order to characterize the medicinal properties of plants, information sources of the last 20 years were analyzed.

Scientific novelty. The composition of introduced medicinal trees and shrubs of the green infrastructure of the Chernihiv city was determined. Their role in the optimization of the network of natural, semi-natural and man-made areas of the green infrastructure of Chernihiv has been established. Medicinal plants are recommended for harvesting and use.

Conclusions. One of the most compelling motivations to integrate adventive trees and shrubs with medicinal properties into the landscape the green infrastructure of the Chernihiv city is the ecosystem services they provide.

Another advantage of using introduced trees and shrubs in the Chernihiv city's green infrastructure landscapes of is economic. It is that most introduced trees and shrubs are resistant to pests and drought, so less water and fertilizers are needed to grow them.

Adventive tree and shrub medicinal plants play a primary role in the restoration of man-made and semi-natural damaged areas, which are necessary to create a complete network of the urban green infrastructure.

The spectrum of pharmacological properties of adventive trees and shrubs that grow in the Chernihiv city's green infrastructure is quite diverse: from medicinal and cosmetological to antidiabetic and anticancer effects. However, the harvesting of a number of plants is limited by resources and the ecologically unfavorable environment of their habitats. Moderately invasive and highly invasive plants have significant resources and grow in an ecologically safe environment. The procurement of medicinal raw materials from these plants is to regulate their distribution in the natural objects of the Chernihiv city's green infrastructure.

Key words: green infrastructure, ecosystem services, invasive plants, medicinal plants, city

АНОТАЦІЯ

Метою роботи було виявити в зеленій інфраструктурі міста Чернігова інтродуковані види деревних та кущових рослин з лікувальними властивостями та охарактеризувати лікувальні властивості цих рослин, а також визначити їх роль у наданні екосистемних послуг та оцінити потенційні можливості збору їх як лікарської сировини.

Методологія. Матеріали зібрано під час дослідження об'єктів зеленої інфраструктури міста Чернігова у 2022–2023 роках геоботанічними методами (Якубенко та ін., 2018). Під час польових досліджень було зареєстровано ступінь інвазійної активності інтродукованих видів дерев і кущів. Ступінь інвазивності вимірювали відповідно до Wagh and Jain (2018) з модифікацією авторів і класифікували на 4 різні категорії, а саме: нещодавно інтродуковані, можливо інвазійні, помірно інвазійні та високоінвазійні на основі їх доступності. Кожній категорії було присвоєно номер (від 1 до 4) на основі впливу виду на досліджувану територію, чим вищий номер, тим вища інвазійна активність виду, тобто. нещодавно введений (1), можливий інвазійний (2), помірно інвазійний (3) і високоінвазійний (4). Для характеристики лікувальних властивостей рослин проаналізовано джерела інформації за останні 20 років.

Наукова новизна. Визначено склад лікарських інтродукованих дерев та чагарників зеленої інфраструктури м. Чернігова. Встановлено їх роль у оптимізації мережі природних, напівприродних та техногенних ділянок зеленої інфраструктури м. Чернігова. Рекомендовано лікарські рослини для заготівлі та використання.

Висновки. Однією з найбільш переконливих мотивацій для інтеграції адвентивних дерев і кущів з лікувальними властивостями в ландшафт зеленої інфраструктури Чернігова є екосистемні послуги, які вони надають.

Ще одна перевага використання інтродуцентних дерев та чагарників у ландшафтах зеленої інфраструктури м. Чернігова – економічна. Вона полягає у тому що більшість інтродукованих дерев та чагарників стійкі до шкідників та посухи, тому для їх вирощування потрібно менше води та добрив.

Адвентивні деревно-чагарникові лікарські рослини відіграють основну роль у відновленні техногенних і напівприродних пошкоджених територій, необхідних для створення цілісної мережі міської зеленої інфраструктури.

Спектр фармакологічних властивостей адвентивних дерев та чагарників, які зростають у зеленій інфраструктури міста Чернігова досить різноманітний: від лікувально-косметологічних ефектів до протидіабетичної та протипухлинної дії. Проте заготівля низки рослин обмежена ресурсами та екологічно несприятливим середовищем їх середовищ існування. Помірно та високоінвазійні рослини мають значні ресурси і зростають у екологічно безпечному середовищі. Заготівля лікарської сировини з цих рослин є регулювати їх поширення у природні об'єкти зеленої інфраструктури м. Чернігова.

Ключові слова: зелена інфраструктура, екосистемні послуги, інвазивні рослини, лікарські рослини, місто

Introduction

Human society depends on the benefits provided by nature such as food, materials, clean water, clean air, climate regulation, flood prevention, pollination and recreation (European Union, 2012). However, many of these benefits, frequently referred to as ecosystem services, are used as if their supply is almost unlimited and treated as free commodities whose true value is not fully appreciated. This can result in public authorities turning to built infrastructure – grey infrastructure – as a substitute for natural solutions to problems such as flood prevention. In Europe we consequently continue to degrade our natural capital, jeopardising our long-term sustainability and undermining our resilience to environmental shocks. Green infrastructure spaces improves the quality of the environment, the condition and connectivity of natural areas, as well as improving citizens' health and quality of life (European Union, n. d.). This green infrastructure function is primarily provided by plants that contain phytoncides and essential oils. In addition to their use for medical purposes, by using medical and aromatic plants in recreation areas, natural views can be provided, which is a difficult design process (Demirkan, 2018).

Landscaping is an essential aspect of any property, be it residential, commercial, or industrial. It involves the art and science of modifying and designing the land to enhance its aesthetic appeal and functionality. Sustainable landscaping is a type of landscaping that aims to maximize the benefits of the land while minimizing its negative impact on the environment. One way to achieve sustainable landscaping is by incorporating medicinal plants into the design. Medicinal plants are plants that are used for their therapeutic properties. They have been used by various cultures for thousands of years for the treatment of various ailments. Medicinal plants offer a unique texture and aesthetic appeal to the landscape (Borealis, 2023).

In this regard not only natural species of plants, but also introducers are used to optimize green plantings of green infrastructure.

The purpose of our study was to identify introduced species of woody and shrubby

plants with medicinal properties in the Chernihiv city's green infrastructure and to characterize the medicinal properties of these plants, as well as to determine their role in providing ecosystem services and to assess the potential possibilities of harvesting them as medicinal raw materials.

Materials and methods

The materials were collected during research of green infrastructure facilities of the Chernihiv city in 2022–2023 using geobotanical methods (Yakubenko et al., 2018). During field research, the degree of invasive activity of introduced trees and shrubs species was recorded.

Degrees of invasiveness were measured according to Wagh and Jain (2018) with authors modificationand categorised into 4 different categories namely, recently introduced, possibly invasive, moderately invasive and highly invasive on the basis of their availability. Each category has been given a number (1 to 4) on the basis of the impact of the species in the study area, the higher the number the higher the invasive impact: recently introduced (1), possible invasive (2), moderately invasive (3) and highly invasive (4).

The names of the taxa are given according to the data of the encyclopedic Internet project World Flora Online (WFO, 2023).

In order to characterize the medicinal properties of plants, information sources of the last 20 years were analyzed.

Results and Discussion

We study the degree of invasiveness of the adventive trees and shrubs plant species in the green infrastructure of the Chernihiv city. Out of the total of 18 species with medicinal properties, 5 species were under the «recently introduced» category. by 6 species possibly invasive, 5 species moderately invasive and 2 species highly invasive.

The group of recently introduced species includes *Ptelea trifoliata* L., *Cotinus coggygria* Scop., *Physocarpus opulifolius* (L.) Maxim., *Rhus typhina* L., *Robinia viscosa* Michx. ex Vent. We did not detect invasive activity of these species: they are localized in places of planting in semi-natural areas of green infrastructure. The volume of resources of these plants does not allow to collect them for obtaining medicinal raw materials. However, it is worth examining their medicinal properties.

Ptelea trifoliata and *Cotinus coggygria* occur on slopes and play an anti-erosion role. Root periderm and inner stem periderm *Ptelea trifoliata* have been used as part of Spring tonics, as a tonic for malaria, and medicinally to aid in digestion and relief of asthma (Coder, 2016).

Cotinus coggygria Scop. is an important source of essential oils and extract with a wide range of biological activities such as antibacterial, antifungal, antiviral, anticancer, antigenotoxic, hepatoprotective and anti-inflammatory. In traditional and folklore medicine, it has been used for its many pharmacological and biological activities, which make it an effective remedy for various kinds of illnesses. Total phenols, flavonoids and tannins are the main group of biologically active constituents in ethyl-acetate and methanol extracts of various parts of *C. coggygria* According to HPLC profiles, gallic acid and its derivatives were the dominant in flowers and leaves of the *C. coggygria* extracts. The major components, i.e. limonene (47.0 % and 39.2 %), (Z)-β-ocimene (16.4 % and 26.3 %), α-pinene (8.2 % and 8.4 %), (E)-β-ocimene (4.6 % and 9.0 %) and terpinolene (6.8 % and 5.3 %) were the same in both oils (Matić et al., 2016).

Physocarpus opulifolius is located on the edges of forests. Americans used a decoction with *P. opulifolius* (extract resulting from boiling tissues down to concentrate desired compounds) made from the inner bark as pain relievers, analgesics, emetics, laxatives, and cathartics. However, excessive doses of the bark decoctions can be toxic (White & Scaroni, 2016).

Rhus typhina L. and *Robinia viscosa* were planted in forest parks of urban green infrastructure as solitary or group plants.

Rhus typhina L. stem contains a considerable amount of phenolic compounds with significant antioxidant activity (Liu et al., 2019). *R. typhina* is used to make a beverage termed «sumac-ade» or «rhus juice» prepared from its fruits and serves also as a traditional medicine having pharmacological functions such as antihaemorrhoidal, antiseptic, diuretic, stomachic and tonic (Kossah et al., 2011).

Robinia viscosa used as an antispasmodic, febrifuge, antioxidant, diuretic, emollient, laxative, antitumor, and antimicrobial. Dried leaves are helpful in treatment of wounds caused by wounds. It acts as pain reliever. Used internally, it calms stomach burns, and is usually recommended to individuals who suffer from hyperacid gastritis and distensions. It is helpful in easing digestion. It has a sedating and calming effect and could be very useful in cases of headaches and stress. Infusion added to baths can

help young children who suffer from insomnia. Flower powder is used in cases of gastritis, duodenal and gastric ulcer (Kaloo et al., 2018).

Given the insignificant distribution of *Ptelea trifoliata*, *Cotinus coggygria*, *Physocarpus opulifolius*, *Rhus typhina* and *Robinia viscosa*, the use of these plants as medicinal raw materials is impossible. They withstand moisture deficit well. However, their primary importance in the green infrastructure of Chernihiv is determined by ecosystem services (consolidation of erosive areas), as well as the creation of a healthy environment.

Acer saccharinum L., *Caragana arborescens* Lam., *Fraxinus pennsylvanica* Marshall., *Gleditsia triacanthos* L., *Juglans mandshurica* Maxim. and *Spiraea sorbifolia* L. belong to the second category – possible invasive. They show little invasive activity, spreading by seeds or root shoots to small areas near their location. They occur in urban forest parks and do not displace natural shrub and tree natural species.

Acer L. species can be used to treat rheumatism, hepatic disorders, eye disease, pain, etc. effectively. Some indications from ethnomedicine have been validated by pharmacological activities, such as the anti-inflammatory and hepatoprotective activities of the species. The available literature showed that most of the activities of these species can be attributed to flavonoids and tannins (Bi et al., 2016). *Acer saccharinum* phytoncides are the part of its natural defense system. *A. saccharinum* used as a bark infusion as a pain relief for cramps, for the treatment of diarrhea due to dysentery, and for treating menstruation-related issues, for treating intestinal ailments but also as a diuretic, to clean sores (Van Wyk & Wink, 2004).

Caragana arborescens as being used medicinally for breast and uterine cancer and other female anatomy problemsтhas describes the USDA. *C. arborescens* also been used to treat menoxia, fatigue, rheumatoid arth-ritis, asthenia and uterine, cervical and breast cancer. The two main chemical classes thought to contribute to the medicinal properties of *C. arborescens* are flavonoids and lectins (Shortt & Vamosi, 2012).

Fraxinus pennsylvanica to other *Fraxinus* species, coumarins, flavonoids, phenolic acids, secoiridoids are generally found in *F. pennsylvanica*. Esculin, esculetin and fraxin are mainly present in bark. Antimicrobial activity of *F. pennsylvanica* leaf extracts and bark extracts has been reported so far (Tahirović et al., 2017).

In recent decades, phytochemical studies were carried out on *Gleditsia triacanthos*, and that found the existence of triterpenes, sterols, flavonoids, alkaloid, phenolics and their derivatives Pharmacological studies revealed that the crude extracts and purified molecules possess a wide spectrum of biological activities, involving in anti-tumor, anti-inflammatory, anti-allergic, anti-hyperlipidemic, analgesic, antimutagenic, anti-HIV, antioxidant, antibacterial and antifungal activities, confirmed by various in vivo animal, and in vitro studies (Zhang et al., 2016).

Juglans mandshurica has been traditionally used to treat cancer, gastric ulcers, diarrhea, dysentery, dermatosis, uterine prolapse, and leukopenia. To date, more than 400 constituents including quinones (e.g. naphthoquinones, anthraquinones, naphthalenones, tetralones), phenolics, flavonoids, triterpenoids, coumarins, lignans, phenylpropanoids, diarylheptanoids, and steroids, were isolated and structurally identified from different plant parts of *J. mandshurica*. Among them, quinones, phenolics, triterpenoids, and diarylheptanoids, as the major bioactive substances, have been extensively studied and displayed significant bioactivity (Luan et al., 2021).

In traditional Chinese medicine, *Spiraea sorbifolia* has been used for the treatment of bone fracture, bruise, and rheumatic arthritis based on its functions of invigorating blood circulation and eliminating stasis, decreasing swelling, and alleviating pain. *S. sorbifolia*, a series of cyanoglucosides, flavonoids, and two cucurbitacin-type triperpenoids were isolated, including six new leucine-derived cyanoglucosides with moderate anti-inflammatory activity (Wu et al., 2019).

Most representatives of medicinal plants of the second category, in particular *Acer saccharinum*, *Caragana arborescens*, *Juglans mandshurica* and *Spiraea sorbifolia*, have moderate reserves and grow in ecologically safe conditions. Their medicinal parts can be harvested in regulated volumes.

Representatives of group 3 show moderate invasive activity. They spread beyond the boundaries of cultivation in semi-natural (disturbed) urban forests and forest parks (*Quercus rubra* L., *Prunus serotina* Ehrh., *Prunus virginiana* Du Roi.), along railway tracks (*Ulmus pumila* L.), as well as on the Liskovitsa sandy alluvium in the floodplain of the Desna River (*Hippophae rhamnoides* L.). The volumes of their resources are significant. But medicinal raw materials can be harvested in ecologically safe, local growth.

Seeds of *Quercus rubra* species are characterized by the high content of natural antioxidants such as phenolic compounds and tocopherols (Oracz et al., 2023). *Q. rubra* is a promising medicinal plant material, which is used in traditional medicine for colds and viral diseases to increase immunity and as an astringent (Konovalova et al., 2023).

Prunus serotina fruit has a good antioxidant capacity, which could be accounted for its polyphenol content. Additionally, this fruit contains compounds such as hyperoside and chlorogenic acid that elicit antioxidant, vasodilator and antihypertensive effects. Equally important are the results from proximate and mineral analyses, which showed that *P. serotina* fruit has high protein and mineral contents. For these reasons, *P. serotina* fruit may be used as a functional food, which could be potentially useful in the prevention and treatment of hypertension (Luna-Vázquez et al., 2013). Olso, twelve phenolic compounds were found in the fruit peel of *P. serotina* which contribute to their strong antioxidant properties. The HPLC-MS analysis showed that cyanidin-3-O-rutinoside, chlorogenic acid, hyperoside and quercetin pentoside are present in the greatest amount in the *P. serotina* peel. However, the main phenolic compounds in the fruit flesh are cyanidin-3-O-rutinoside, chlorogenic acid, procyanidin B, hyperoside and quercetin malonilglucoside. Other studies demonstrate that water and dichloromethane extracts from the fruit of *P. serotina* contain polar and non-polar vasodilating metabolites. It was also noted that *P. serotina* fruits have a high content of phenolic compounds such as chlorogenic acid, gallic acid, coffee acid, catechin, epicatechin and quercetin and kaempferol glycosides, which are directly related to the high antioxidant activity and the resulting vasodilating effect (Telichowska et al., 2020).

Prunus virginiana in medicine it is used with anorexia, biliousness, bleeding, burn, cholera, cough, conjunctivosis, cramp, diarrhea, dysentery, dyspepsia, enterosis, fever, flu, gallstone, gastrosis, hemoptysis, hoarseness, insomnia, jaundice, measles, ophthalmia, pain, pulmonosis, scrofula, sore, sore throat, stomachache, tuberculosis, ulcer (Duke, 2002).

Owing to its antibacterial and anti-inflammatory reaction, *Ulmus pumila* has been traditionally used for abscess, infection, edema, rhinitis, empyema, and otitis media. It has also been used for gastric and duodenal ulcers as well as gastric cancer (You et al., 2013). *U. pumila* extract possessed remarkably high amounts of phenols (175.9 ± 5.2mg) gallic acid equivalent/gram extract and total flavonoid content of 68.7 ± 1.2 mg rutin equivalent/g extract (Hussein et al., 2020).

On the Liskovitsa sandy alluvium (south-eastern outskirts of the Chernihiv city) *Hippophae rhamnoides* has become naturalized and actively spreads and bears fruit abundantly (Fig. 1).

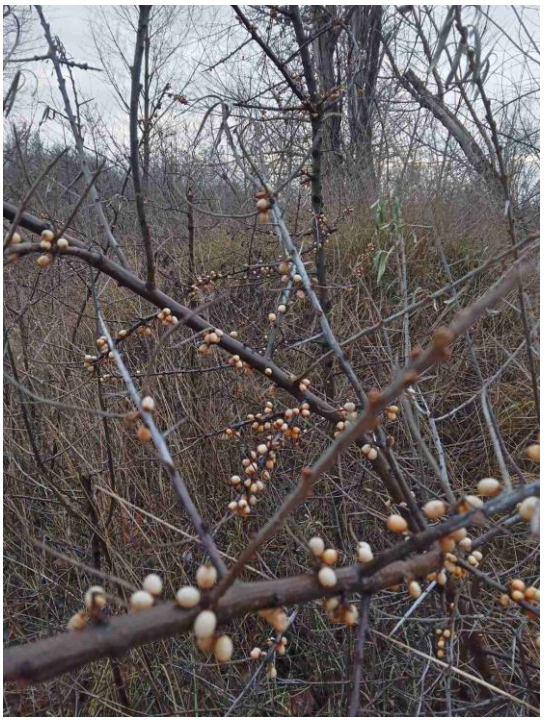

Fig. 1. *Hippophae rhamnoides* L. on artificial sandy alluvium in the Chernihiv city

Oil from *Hippophae rhamnoides* has shown effectiveness in skin therapy for sunburns, chemical burns, radiation burns, and eczema. Furthermore, *H. rhamnoides* oil has shown positive results in treating health problems related to damaged mucous membranes of the gastrointestinal tract including mouth ulcers, gastric ulcers, and stress ulcers. Of particular interest, the berries, the oil, and the seeds of *H. rhamnoides* have been shown to possess antiatherogenic, hypocholesteromic, hypotensive, and anti-inflammatory properties and could therefore be successfully exploited to prevent or treat cardiovascular disease (Wani et al., 2016). *H. rhamnoides* berries contain larger amounts of ethyl 3-methylbutanoate, butyl pentanoate, 2-methylpropyl 3-methylbutanoate, and pentyl 3-methylbutanoate than the Finnish species, which are rich in ethyl 2-methylbutanoate, ethyl 3-methylbutanoate, and ethyl hexanoate. *H. rhamnoides* extract contains β-sitosterol, which have also been reported to exert antitumor activity (Jaśniewska & Diowksz, 2021).

Plants of the third category have significant resources and grow in ecologically safe conditions, with the exception of *Ulmus pumila*. Their medicinal parts can be harvested in the necessary volumes. The main *Ulmus pumila* distribution in the Chernihiv city is localized along the railway (Fig. 2). A potential direction of the use of this species from the known localities in Chernihiv is the study of changes in its medicinal properties under conditions of anthropogenic pollution.

Fig. 2. The main localization the *Ulmus pumila* L. young plants (left) and trees (right) in the Chernihiv city's green infrastructure is along the railway track

Highly invasive species (category 4) are *Amorpha fruticosa* L. and *Robinia pseudoacacia* L. These species actively occupy not only semi-natural habitats, but also displace species in natural phytocenoses. Their resources are considerable. For the most part, these plants are common in ecologically safe places. Therefore, they can be used as medicinal raw materials and be prepared in unlimited quantities.

Amorpha fruticosa is actively spreading in Chernihiv city's green infrastructure of the floodplain phytocenoses. One of the quite promising medical applications of *A. fruticosa* is against diabetic complications. Used infusion

from leaves and stems as a general tonic and also against rheumatism and chronic sickness together with other plants (Kozuharova et al., 2017). The EO extracted from *A. fruticosa* fruits contains antimicrobial active compounds (such as linalool, citronellol, β-caryophyllene, caryophyllene oxide, α- and γ-muurolene, germacrene D, δ-cadinene, τ-cadinol) with moderate microbicidal activity on Gram-positive bacterial strains (Marinas et al., 2021).

Robinia pseudoacacia is the most aggressive invasive plant that takes root in various types of green infrastructure forest phytocenoses in the of the of the city of Chernihiv. *R. pseudoacacia.* The flowers, bark, and leaves of *R. pseudoacacia* have been used in traditional medicine for antitussive, laxative, and cholagogue purposes. These effects may be attributed to the bioactive molecules present in *R. pseudoacacia*, including alkaloids, flavonoids, tannins, phenols, and steroids. Robinia pseudoacacia leaf extract (RP) has been reported to contain flavonoids, including acacetin, apigenin, diosmetin, luteolin, and quercetin (Kim et al., 2019). The black locust flower (BLF), which has been used as a food additive and traditional medicine, is considered very important as the main raw material for honey harvesting. The BLF has been known to have diuretic, sedative and anti-inflammatory effects. The BLF contains a lot of ascorbic acid and phenolics, which have excellent antioxidant effects, and also has a relatively high content of free sugars and minerals (Bhalla & Bajpai, 2017).

Plants of the fourth category, due to their high invasiveness, have unlimited reserves. Environmentally safe conditions exist in most areas within the Chernihiv city's green infrastructure. Therefore, medicinal raw materials from these plants can be harvested in large quantities and thereby regulate their number. Of course, the plants of the fourth category, like the previous groups, provide the environment of their existence with health-improving properties.

Conclusion

One of the most compelling motivations to integrate adventive trees and shrubs with medicinal properties into the landscape the green infrastructure of the Chernihiv city is the ecosystem services they provide.

Another advantage of using introduced trees and shrubs in the Chernihiv city's green infrastructure landscapes of is economic. It is that most introduced trees and shrubs are resistant to pests and drought, so less water and fertilizers are needed to grow them.

Adventive tree and shrub medicinal plants play a primary role in the restoration of man-made and semi-natural damaged areas, which are necessary to create a complete network of the urban green infrastructure.

The spectrum of pharmacological properties of adventive trees and shrubs that grow in the Chernihiv city's green infrastructure is quite diverse: from medicinal and cosmetological to antidiabetic and anticancer effects. However, the harvesting of a number of plants is limited by resources and the ecologically unfavorable environment of their habitats. Moderately invasive and highly invasive plants have significant resources and grow in an ecologically safe environment. The procurement of medicinal raw materials from these plants is to regulate their distribution in the natural objects of the Chernihiv city's green infrastructure.

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Received: 02.04.2024. **Accepted**: 12.04.2024. **Published**: 20.05.2024.

Ви можете цитувати цю статтю так:

Lukash O., Stupak Yu., Morskyi V., Aravin M. Adventive tree and shrub plant species with medicinal properties in the Chernihiv city`s green infrastructure. *Biota. Human. Technology*. 2024. №1. С. 9-18.

Cite this article in APA style as:

Lukash, O., Stupak, Yu., Morskyi, V., & Aravin, M. (2024). Adventive tree and shrub plant species with medicinal properties in the Chernihiv city`s green infrastructure. *Biota. Human. Technology,* 1, 9-18.

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