UDC 504.4:502.131.1:628.91+697.1+711.4504.5

Valeriia I. Shepelieva
Alla A. Slobodianiuk

GREEN ROOFS IMPACT ON THE MICROCLIMATE OF URBANIZED AREAS: ENVIRONMENTAL AND ENERGY EFFICIENCY

Vinnytsia National Technical University

Abstract

The article examines the concept of green roofs and their impact on the microclimate of urbanized areas. The design features of green roofs, the principles of their functioning and the advantages of their implementation in the urban environment are described. The main attention is paid to environmental and energy aspects, in particular the ability to reduce the "heat island" effect, improve air quality and reduce the energy consumption of buildings. The prospects and challenges of integrating such systems into modern urban infrastructure are also analyzed.

Keywords*:* green roofs, urbanization, microclimate, energy efficiency, environmental safety, heat island.

Анотація

У статті розглядається концепція зелених дахів та їх вплив на мікроклімат урбанізованих територій. Описано конструктивні особливості зелених дахів, принципи їх функціонування та переваги впровадження в міському середовищі. Основну увагу приділено екологічним та енергетичним аспектам, зокрема здатності зменшувати ефект «теплового острова», покращувати якість повітря та знижувати енергоспоживання будівель. Також проаналізовано перспективи й виклики інтеграції таких систем у сучасну міську інфраструктуру.

Ключові слова: зелені дахи, урбанізація, мікроклімат, енергоефективність, екологічна безпека, тепловий острів.

Introduction

In the modern world of sustainable development, green roofs are becoming one of the key elements of ecological architecture and urban planning. Due to the growing attention to the problems of urbanization, climate change and energy efficiency, it has become possible to integrate multifunctional plant systems on the roofs of buildings, which perform not only a decorative but also a practical role. Although the idea of green roofs originally arose as a landscape solution, today they play an important role in the formation of a comfortable urban microclimate – reducing air temperature, improving thermal insulation and contributing to the purification of the atmosphere. This opens up new prospects for energy saving, environmental safety and sustainable development of urban areas.

Essence and Typology of Green Roofs

Green roofs are innovative architectural structures that combine elements of construction and landscaping. Essentially, they are the roof surfaces of buildings that are partially or completely covered with vegetation planted in a special substrate, supported by systems for drainage, waterproofing, and root protection. The main idea behind green roofs is to create additional natural spaces within densely urbanized areas in order to reduce the negative impact of the urban environment on the ecosystem and microclimate.

Green roofs serve several functions. Firstly, they cool and humidify the air, improving the building's thermal insulation. This means that rooms do not heat up as much during hot weather. Secondly, they purify the air by absorbing carbon dioxide. Thirdly, they retain up to 90% of rainwater, which helps reduce the load on stormwater drainage systems. This water can be filtered and reused. Fourthly, such roofs can absorb up to 40-50 decibels of noise pollution [1].

Based on structural characteristics, green roofs are divided into extensive and intensive types.

Extensive green roofs are lightweight, have a minimal layer of substrate (up to 15 cm), and are usually planted with low-growing, hardy plants such as mosses, sedums, or grasses. They require minimal maintenance and are often used on roofs that are not intended for regular human use.

Intensive green roofs have a thicker layer of soil (more than 20 cm), which allows for the planting of shrubs, flowers, ornamental trees, and even the creation of full garden or park-like areas. These roofs require regular maintenance, but at the same time, they can serve as fully functional recreational spaces for residents.

For effective functioning, a green roof must have a multilayered structure, with each component playing an important role in ensuring reliability, waterproofing, thermal insulation, and drainage. Figure 1 below presents a diagram of a typical structural cross-section of a green roof, clearly showing the sequence of layers and their primary functions.

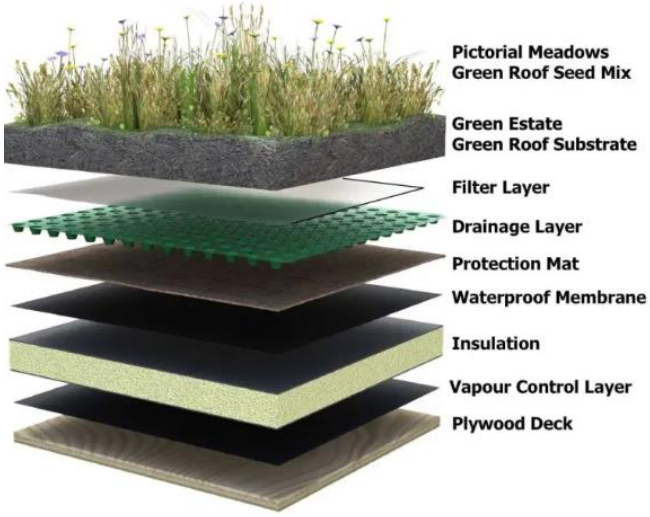

Figure 1 – Structural cross-section diagram of a green roof

Energy Efficiency and Technical Advantages

One of the main reasons for the popularity of green roofs and vertical gardens is their contribution to environmental preservation. In cities where high population density and industrialization lead to air pollution and urban heat islands, greenery on roofs and walls acts as a natural filter. Plants absorb carbon dioxide and other harmful substances, purifying the air and improving its quality for residents.

Green roofs provide a natural thermal insulation layer that significantly impacts the energy consumption of buildings. Tall buildings covered with concrete and asphalt absorb and retain heat, creating favorable conditions for overheating the surrounding environment. Green roofs serve as natural coolers: plants absorb some of the heat and reduce the temperature around the building [2].

Additionally, the vegetation on the roof acts as extra insulation, allowing for substantial reductions in cooling costs during summer and heating costs during winter. This, in turn, saves energy resources and reduces CO_2 emissions, which is crucial for the sustainable development of cities.

Traditionally, a building's roof has been perceived as a relatively unutilized part, primarily serving to protect against weather elements. However, with the use of green roofs, this space gains new life. Instead of leaving the roof empty and unused, we can create green areas for recreation, gardening, parks, or even vegetable gardens.

Green roofs open new possibilities for space utilization, enabling residents to grow their own vegetables or flowers. They can be part of the overall landscape design or serve as places for gatherings, meditation, or picnics.

Challenges of Implementation and Development Prospects

The main disadvantage of green roofs is the very high weight of the supporting structure. One square meter of such a roof can weigh up to 500 kilograms, which is significantly more than traditional roofs. This leads to a considerable increase in the cost not only of the roof itself but also of other structural elements of the building.

Additionally, an important drawback is the need to provide proper conditions for the plants growing there. This results in a substantial amount of maintenance work, including drainage cleaning, irrigation, and specific plant care. Costs for materials, installation, as well as design and engineering solutions, can be significant and often become a barrier for developers and building owners. Not all buildings are structurally suitable for installing a green roof without major reinforcements, which further complicates the adoption of this technology [3].

Despite these challenges, the prospects for the development of green roofs are quite optimistic. Growing environmental awareness and tightening regulations on sustainable urban development stimulate the implementation of green infrastructure in urban environments. Government support programs and subsidies aimed at promoting environmentally friendly building technologies help offset initial costs. The development of new lightweight materials and improved engineering solutions make green roofs more accessible for a wider range of buildings. Furthermore, the concept of "smart cities" encourages the integration of green roofs as part of climate adaptation strategies, promoting biodiversity conservation, effective stormwater management, and improving residents' quality of life. Innovations in automated irrigation systems and the use of low-maintenance plant species reduce maintenance costs, making green roofs more practical and sustainable in the long term.

Conclusion

Green roofs are a promising solution for greening urban spaces, combining functionality, aesthetics and sustainability. Due to their ability to improve the thermal insulation of buildings, reduce air temperature in the urban environment and purify the atmosphere, they provide a significant improvement in the quality of life in densely built-up areas. Green roofs also help reduce the load on drainage systems and form new ecosystems within the city.

However, the implementation of such solutions requires careful planning, engineering precision and adaptation to local climatic conditions. Among the main challenges are the initial financial costs, the need for maintenance and training of specialists. However, with a comprehensive approach, green roofs can become an important element of the strategy for sustainable development of urban areas.

In the long term, they have the potential to become a standard practice of modern construction, contributing to the creation of an environmentally balanced and energy-efficient urban environment.

REFERENCES

1. Екодія. Не тільки «зелені фасади». Ось іще 11 екорішень для Києва. 2022. URL: https://ecoaction.org.ua/11-ekorishen-dlia-kyiva.html (date of access: 26.05.2025).

2. TIME DEVELOPMENT. Чому майбутнє будівництва – це зелені дахи та вертикальні сади? URL: https://time-development.com.ua/novyny-ta-propozytsiyi/chomu-majbutnye-budivnictva-ce-zeleni-dahi-ta-vertikalni-sady (date of access: 26.05.2025).

3. Добрий господар. Зелені дахи: переваги та недоліки установки. URL: https://isu.org.ua/zeleni-dahy-perevagy-ta-nedoliky-ustanovky (date of access: 26.05.2025).

Shepelieva Valeriia Igorevna – student, Faculty of Construction, Civil and Environmental Engineering, Vinnytsia National Technical University, Vinnytsia, e-mail: sepelevalera43@gmail.com

Scientific Supervisor: ***Slobodianiuk Alla Anatoliivna*** – Senior Lecturer of the Foreign Languages Department, Vinnytsia National Technical University, Vinnytsia, e-mail: a.allavin@gmail.com

Шепелєва Валерія Ігорівна – студентка групи ТЗД-23б, факультету будівництва, цивільної та екологічної інженерії Вінницького національного технічного університету, м. Вінниця, e-mail: sepelevalera43@gmail.com

Науковий керівник: ***Слободянюк Алла Анатоліївн***а – старший викладач кафедри іноземних мов, Вінницький національний технічний університет, м. Вінниця, e-mail: a.allavin@gmail.com