ROOFTOP AND VERTICAL GREENERY - THE IMPROVEMENT CONCEPT OF COMMUNITY HYGIENE CONDITIONS IN THE CITIES OF SERBIA

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Abstract

In conditions of overpopulated urban centers, one of the main issues is to ensure new green spaces. Vertical and rooftop greenery in urban centers is often the only possibility to increase the green areas, as well as the factor of creating better living conditions, which is the subject of this paper analysis. The greening concept of vertical surfaces and rooftops has also been proved as the factor for creating better community hygiene conditions (landscaping of neglected buildings' rooftops and solving communal problems, as well as landscaping of slopes, repairing of bridge structures, retaining walls, concrete riverbanks and canals). In addition, it has been the significant environmental protection factor (increase of green areas, decrease of climate extremes and mitigation of city "heat island", energy efficiency of buildings, increase of biodiversity, etc.). This research includes the analysis of relevant literature, scientific papers, monographs and planning documents, as well as the specific examples of various cities around the world. The aim of this paper is to determine the possibilities for implementation of the rooftop and vertical greenery concept, as the improvement factor of community hygiene conditions in the cities of Serbia.

Keywords: rooftop and vertical greenery, community hygiene, environmental protection, landscaping

Methodology

Since the subject of the research are rooftop and vertical greenery, the methodology of scientific-research work includes the analysis of the planning documentation of the City of Belgrade, which directly treats this area. In that manner, it has been concluded how much this area is represented in the planning documentation of the largest city in Serbia, which should be the leader in this area. The results obtained from this research paper are the starting point for a case study for the City of Belgrade, which would be used as a model for other cities in Serbia, but also the starting point for an initiative to change certain laws. The paper also uses the method of classification and synthesis, as well as the geographical-ecological method.

Significance and role of rooftop and vertical greenery in creating better community hygiene conditions in urban areas

The importance and role of rooftop and vertical greenery in creating better community hygiene conditions in urban areas is significant. Due to the growing problem of lack of greenery in central city parts (as a result are the worst housing and living conditions), many cities in the world are opting for the so-called rooftop greenery - green roofs (Milanović M, Samardžić I, Milinčić M, Momčilović P, 2011).

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The advantages of green seedlings on building roofs are multiple: reduction of the impact of the "city heat island", aesthetics, heating-isolation-ventilation and material recycling, atmospheric water governance, reduction of air pollution, new gardens and green seedlings, energy efficiency, longer roof life, etc. (Samardzic I, 2017). The modern age and way of life have led to specific health problems of city residents such as stress, depression, tension. Rooftop and vertical greenery can have a positive impact on the mental state of residents. Green seedlings on residential buildings have a different visual effect compared to old buildings, which are often in gloomy colors.

People live in conditions of a certain microclimate that affects human health and life, and the microclimate can be changed by planning and implementing sanitary-technical measures (Kocijančić R. et al, 2009). Rooftop greenery has an active role in retaining a certain amount of atmospheric sediment, while a roof with a substrate of 12 cm reduces noise by 40 dB, and with a layer of substrate of 20 cm by 45-50 dB (Afforestation Strategy of the Belgrade Area, 2011). Greenery absorbs rainwater, but also reduces the load on a sewer system during precipitation. Green roofs last two times longer than ordinary roofs, while a single storey house with a green roof of 10 cm of substrate and a grass cover, consumes 25% less electricity to cool rooms in summer months (Afforestation Strategy of the Belgrade Area, 2011). Some green seedlings can also be indicators of pollution. Bioindicators of air pollution are plant organisms that are sensitive to unfavorable environmental effects, most often lichens and some wooden forms (Maričić T, 2007). The health role is also reflected in the fact that green seedlings are air ionizers and have a role of phytoncides. They also increase the humidity of the air and represent places for birds to settle.

The design of such roofs is extremely important for construction to be appropriate and safe. Green roofs reduce the costs of maintaining roofs, although the initial investment is higher, but also increases the market value of apartments. Factors that must be taken into account are wind strength, temperature fluctuations, insolation. The roof construction must be waterproof, long-lasting and protected from damage, as well as appropriate for the depth of a plant root system. So, the question of the profession is how to build a suitable facility and maintain it (construction and maintenance automation), but also how to equip it and with which seedlings, taking into account the quality and type of seedlings and aesthetic fit into the ambient unit. It is necessary to avoid environmental problems related to invasive species, habitat of certain species, drought-resistant plants (botany, landscape architecture, environmental protection).

Rooftop greenery is specific for urban areas where there is no free space for the formation of parks or any green seedlings. Such roofs are used as rest areas for residents, if they are larger, they are also used as classic parks. Most often, these are green areas of closed type only for the residents of these residential buildings. There are many examples in Singapore, Monte Carlo, but also in cities that are trying to increase the area under greenery in the function of fighting air pollution, such as Milan.

In addition to rooftop greenery, there are examples in the world where outdoor spaces are also used for

Figure 1. Hotel Royal-Singapore (photo: Banjanin N, 2018)

Figure 2. CapitaLand Malls-Singapore (photo: Banjanin N, 2018)

gardening. The *Wabe23* buildings complex in Vienna offers to its tenants the opportunity to supply fruit and vegetables from their own sources, i.e., the concept of sharing outdoor space for urban gardening. Each of the five residential buildings offers the possibility of gardening on elevated or normal plant beds located around the building or on a roof of a building. There is a possibility of growing herbs on the building loggias, as well as a possibility of fruit trees planting. This complex is the largest of its kind in Europe. Similar projects of "self-sustaining settlements" have been established in Sweden.

Vertical greenery represents an aesthetic landscaping of vertical surfaces (facades, retaining walls) and contributes to energy efficiency, more rational use of air conditioning systems in the summer months, air purification and dust absorption, but also represents a space for plant species (Samardzic I, 2017). It reduces climate extremes, accelerates aeration of settlements, reduces insolation, protects from strong winds

Figure 3. Building Bosco Verticale in Milan, Italy (stories.rbge.org.uk)

Figure 4. Vertical greenery of a residential building in Sirmione, Italy (photo: Samardžić I, 2016)

Figure 5. Rooftop greenery of residential buildings in Monte Carlo, Monaco (photo: Samardžić I, 2016)

and noise, regulates humidity, protects from high and low temperatures (it can lower air temperature by 3-4 ˚C), purifies the air by removing dust, binding harmful gases (Savićević M. et al., 1997).

Vertical greenery also dampens vibrations, and like rooftop greenery contributes to the reduction of "city heat island", air ionization, retains atmospheric precipitation, and is used as the air pollution bioindicator. It also affects the real estate market value. Recycled materials can be used for the construction of vertical greenery. Vertical greenery also contributes to the lifespan of the facades.

Vertical greenery in urban areas implies green facades, green walls and gardens. Green facades are extremely useful in forming the isolation of buildings, which contributes to energy efficiency. "The role of protecting the walls of buildings from overheating is very important, whose temperature due to direct sunlight, can be significantly higher than the air temperature by 12.2 ˚C" (Savićević M. et al., 1997). It is necessary to provide water supply to green gardens as well as soil maintenance.

Maintenance of the vertical greenery system is largely automated, especially when it comes to adding substrates or irrigation. The maintenance service is necessary for arranging the greenery and replacing the soil where needed. For such jobs, housing communities hire professional companies whose activity is the maintenance of such seedlings, while there is a possibility that the housing community performs these jobs only by hiring its own tenants.

Green facades are similar to rooftop greenery and are important places for preservation of the biodiversity, because they represent a shelter or habitat for a large number of insects and birds. It is necessary to perform expert analysis to conclude which plant species are suitable for vertical landscaping (creepers, vines, shrubs, ornamental grasses), while a larger number of species can be found in small gardens (even low trees with shallow roots).

Cassette vertical gardens belong to the green walls, but they are more technologically demanding. Such gardens are interconnected and thus provide food and water better. Each pot can be replaced individually, if necessary, which is a great advantage of such gardens. A special advantage is a large number of species that can be used.

There are many examples of vertical gardens in the world, where one of the largest vertical gardens is the

Figure 6. Building Santalaia in Bogota, Colombia (inhabitat.com)

Figure 7. Vertical greenery of bridge structures in Mexico City, Mexico (en.reset.org)

building *Santalaia* ("Green heart of Bogota") in Bogota, Colombia, built in 2015 with over 3100 m² covered with 115,000 plants.

Other vertical areas in cities are also considered as vertical greenery. Lundholm T.J. et al. (2011) state that the term *walls* generally refers to old rocks (old walls that are an opportunity for the settlement of a large number of species). "Walls as ecosystems and as habitat can have multiple species, which are suitable for school teaching of several generations and usually have botanical value" (Francis A.R., Chadwick A.M., 2013). Many sources of literature and studies speak in favor of which species inhabit such areas and to what extent. Therefore, Jim C.Y. & Chen W.Y. (2010) state that they have found 134 plant species on "built" walls in Hong Kong. Hoggart S.P.G. et al. (2012) list 90 plant species and 37 invertebrate species that inhabit flood protection walls on the River Thames through the center of London.

In Serbia, such vertical surfaces are most often neglected. Particularly endangered are the vertical sections that are under vegetation and often represent places of waste disposal (landfills) and unarranged green areas (Samardžić I, 2017). Areas that can be enriched with green forms are bridge constructions pillars in the zones of uneven roads (Samardžić I, 2017). The pillars of uneven roads and overpasses in Mexico City (Fig. 7) have been planted with seedlings on recycled plastic panels, which have been attached to the bridge structures. Also, the forms of greenery were carefully selected because of resistance, while the entire system has been built with an automated watering method.

Research work results

The possibilities for the development of the rooftop and vertical greenery concept as a factor in improving the community hygiene conditions in the cities of Serbia are enormous and havea great potential, but also limitations. This concept has health, social and economic effects, it improves air quality and housing conditions. Limitations exist in the complete absence of realization of such a concept and failure to recognize its significance, but also in the legal basis that requires amendments (Law on Planning and Construction, Law on Energy Efficiency and others) and adoption of completely new bylaws.

Planning is necessary for every newly built settlement and city, and it should be on a long-term basis (Kocijančić R. et al., 2009). Obstacles to the introduction of rooftop and vertical greenery system may be the size of the investments in old buildings or the impossibility of realizing such a reconstruction. A novelty would be the introduction of the obligation that all newly built facilities in commercial zones must be partially covered with plants (Samardžić I, 2017).

This especially refers to the facilities of shopping centers, hotels and hostels, but to a possible extent also when designing superstructure facilities. Problems exist in the realization of green areas. Since the needs for green areas are rarely based on economic reasons, the demands for increasing the areas under greenery in cities generally do not have the support of politicians (Maričić T, 2007).

In France, the law stipulates, that new facilities built in commercial zones must be partially covered with plants or solar panels. This is important from the aspect of energy efficiency, because rooftop greenery help in reducing the amount of energy needed to

heat buildings during the winter and cool them during the summer. They also retain the rain and are home to birds. This is especially popular in Australia, Germany and Canada (in Toronto in 2009, a bylaw was adopted which determines that all new residential and industrial buildings must have green roofs) (Samardžić I, 2017).

Belgrade should also be in the center of attention for the development of the vertical and rooftop greenery concept, because the air pollution is at an extremely high level, especially in winter when there is no Košava wind. Increasing the area under greenery would contribute to the absorption of pollution. Another problem that occurs in Belgrade is so-called "Belgrade Heat Island". According to Andjelković G, (2005), "the so-called "Belgrade Heat Island" has a big impact on climate elements, which is a consequence of the construction of the territory, heating of facilities, traffic, industry, etc."

The Belgrade City Development Strategy, strategic goals, priorities and measures of sustainable development until 2021, defines the implementation of projects related to increasing green areas through its action plan, but also related to energy efficiency (Belgrade City Development Strategy, 2017). Also, the current Master Plan of Belgrade envisages an increase in the area under greenery (Master Plan of Belgrade 2021, 2016), while the Afforestation Strategy of the Belgrade Area defines vertical greenery and the importance of rooftop greenery (Afforestation Strategy of the Belgrade Area, 2011). Green Regulation of Belgrade and General Regulation Plan of Belgrade Green Areas - Draft plan, define green areas, type and purpose, as well as reservation of areas for green purposes (Green Regulation of Belgrade, 2002; General Regulation Plan of Belgrade Green Areas - Draft plan, 2016).

On the example of Belgrade, it is clear that the lack of green areas and the need to improve such a situation has been recognized as the problem. However, following a similar model, other local self-governments in Serbia can define problems and deficiencies, but also the goals and projections of the green area systems development.

In cities throughout Serbia, a large number of residential buildings are about half or in the second half of the projected lifespan, and due to age and lack of investment, urgent repair of roofs and facades is necessary. Where possible, the renovation of roofs and facades could include the introduction of the concept of rooftop and vertical greenery. It depends on the statics of buildings, load-bearing capacity of building and financial investment possibilities. This would be especially important for places that have registered high levels of air pollution and lack of green areas (Belgrade, Užice, Bor, Smederevo). Rooftop and vertical greenery can be realized by adequate planning of future facilities and adaptation of existing ones, and implement them in the function of urban centers development.

Terminologically speaking, *Smart City* is directly related to the environmental protection and investment in green areas. Research shows a link between planning, investment and green spaces (Hajduk S, 2016). Also, the term *Sustainable Urban Park Management* can be found in international articles, and according to Hermy M. et al. (2010) it is the reason for the development of parks since as far back as 1900, as well as the need to protect ecosystems in this way. In the conditions of densely populated urban areas in many cities, the only possibility of forming *urban parks* is on the roofs of residential and other buildings.

The concept of rooftop and vertical greenery has ecological, social, but also economic justification. If there are problems of economic justification in the development of green areas in urban environments, there is a clear financial calculation regarding savings through isolation and consumption of heat and electrical energy (energy efficiency) for rooftop and vertical greenery - e.g., to calculate the slowdown of precipitation runoff, calculate savings by recycling materials and costs of maintaining roofs and facades. On the other hand, the health effects (reduction of air pollution, noise, vibration), as well as the prevention of stress and depression are immeasurable. Researches in the world have shown that such spaces have also influenced the increase of biodiversity in urban areas.

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