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BIODIVERSITY IN CITIES AS THE SYNERGY OF ARCHITECTURE AND NATURE

BIORÓŻNORODNOŚĆ W MIASTACH JAKO SYNERGIA ARCHITEKTURY I NATURY

Abstract

The implementation of wild ecosystems into the urban tissue is moving towards a new bio-climatic model of the city, where architecture and nature are complementary components of the eco-structure. The aim of a city shaped in this way is to increase the qualitative porosity of the urban tissue and the biodiversity of local ecosystems, as well as eco-education of residents, related to the practice of *friluftsliv* (Norwegian) – experiencing the joy of identifying with wild nature. Eco-architecture shaped together with green structures creates a new quality of space, forming a new image of the city where the building becomes a kind of art integrated with biology.

Keywords: biodiversity, deep ecology, eco architecture, climate neutrality, ecological education parks

Streszczenie

Implementacja dzikich ekosystemów w tkankę miejską zmierza w kierunku nowego bioklimatycznego modelu miasta, gdzie architektura i natura stanowią wzajemnie dopełniające się komponenty eko struktury. Celem tak kształtowanego miasta jest zwiększenie jakościowej porowatości tkanki miejskiej i bioróżnorodności lokalnych ekosystemów oraz eko edukacja mieszkańców, powiązana z praktyką *friluftsliv* (norw.) – doznawaniem radości z identyfikacji z dziką przyrodą. Kształtowana wraz z zielonymi strukturami eko architektura tworzy nową jakość przestrzeni, nowy wizerunek miasta, gdzie budynek staje się rodzajem sztuki połączonej z biologią.

Słowa kluczowe: bioróżnorodność, ekologia głęboka, eko architektura, neutralność klimatyczna, parki edukacji ekologicznej

1. INTRODUCTION

Cities have become home to half of the human population. By 2050, two-thirds of people will live in urban agglomerations. If we compare this data with progressive climate change, i.e. global warming, increasing water deficit and disappearance of species biodiversity, it will become clear that the built environment constitutes an area of the greatest importance in the process of achieving the climate neutrality of our planet. Especially since the buildings are responsible for 38% of global carbon dioxide emissions. To reduce this emission, it is necessary to develop appropriate design strategies aimed at remodeling urban structures so as to ensure an increase in the so-called qualitative porosity of the urban tissue, which means its permeability to rainwater. This is connected with ensuring the largest biologically active

area in cities in the form of green areas and green roofs, remodeling and protection of local species biodiversity as well as ensuring the retention of rainwater, its collection, storage and treatment. This strategy should be completed by actions such as increasing recycling, namely water, materials and energy, as well as the energy efficiency of buildings, including renewable energy sources. Eco education of city residents should play a key role, which is directly related to the need to implement wild ecosystems into the urban tissue and to create Ecological Education Parks within them. The architecture which remains in constant synergy with nature should create a new image of the city where the building becomes a kind of art integrated with biology.

2. THE BUILDING AS AN INTEGRAL PART OF THE NEW URBAN ECOSYSTEM FORMS A CITY AND CREATES ITS NEW IMAGE

One of the forms of integrating architecture with biology is the use of trees in shaping the image of a building and, consequently, of the city. *Arbotecture* makes it possible to introduce greenery into its structure and give the facades of objects an artistic and spatial character. The whole life strives to absorb as much energy as possible, which in effect generates natural colorful phenomena. Leaves and blossoms of trees form pointillist pictures on the facades of buildings as a result of the fact that when turning to the sun wandering in the sky and surrendering to the gusts of the wind, their lighting angle and thus the intensity of their color are constantly changing. At the same time, the sunbeams permeating through the crowns of trees in the interiors of buildings, give the effect of Nordic light which is similar to the one that occurs in a forest glade surrounded by high trees or in the Norwegian churches called *stavkirke*. This phenomenon was noticed and applied in architecture by Norwegian architect Sverre Fehn when designing Nordic Pavilion (Norwegian: *Nordens Pavilong*, implementation in 1962) at Venice Biennale[1]. Locating trees in the structure of a building, on its roof, terraces, and balconies, might be connected with the philosophy of life, which remains in the trend of deep ecology and emphasizes the importance of absolutely all forms of life, regardless of their usable value for people[2]. Hundertwasser's Viennese implementations, which are full of intense colors and trees on the facades, constitute the best examples. In the case of these objects, the color on the facade emphasized individual apartments, whereas trees leaning out of the loggia – their full-fledged co-inhabitants. Hundertwasser's implementations influenced the perception of the city's image, becoming its new landmarks, stimulating reflection on the meaning of life and the need to protect all its manifestations without any exception. The living facades of *arbotecture* are not only cyclically returning colors as the imitation of the year-round vegetation cycle of trees, but it is also a design strategy aimed at increasing the share of the biologically active tissue in the structure of urban agglomerations. It also combines the reconstruction and protection of local wild ecosystems as a method of increasing species biodiversity and eco education[3].

[1] K. Frampton, *The Tectonic Form of Sverre Fehn*, „Area", 2014, no. 116, pp. 12–15.
[2] A. Næss., *Livsfilosofi. Et personling bidrag om følelser og fornuft*, Universitetsforlaget, Oslo 1998.
[3] B. Devall, G. Sessions, *Ekologia głęboka. Żyć w przekonaniu, że natura coś znaczy*, Pusty Obłok, Warszawa 1994.

The building as an integral part of the ecosystem can be a supporting structure for it. These solutions, which are implemented on various scales, are often defined as new forms of art being a coupling of architecture with biology. Apart from undoubted aesthetic values, such solutions are, above all, beneficial for nature itself by providing a biologically active surface on roofs, terraces, and balconies of objects. Such construction of a stable ecosystem, which consists of species of fauna and flora characteristic of a given location, often precedes and determines formal and functional solutions of a building. Contemporary attempts at this type of actions seem to follow the criteria of deep ecology, namely they aim at increasing biological biodiversity in cities.

A perfect example of this includes buildings referred to as *Vertical Forest* by Stefano Boeri. Representative projects were implemented in Italy (Milan, 2014), Switzerland (Lausanne, 2017) and in Belgium (Antwerp, 2018).



Ill. 1. Bosco Verticale (left). The designed ecosystem in the structure of two buildings consists of about 900 trees and 15,000 shrubs, constituting a home for many species of insects and birds in Milan, Italy, architect Stefano Boeri, implementation in 2014, photo by A. van Herck.

Ill. 2. Palazzo Verde (right). Its integral part includes complex numerous roof gardens which form a common space for residents and green, individual, private terraces adjacent to residential units in Antwerp, Belgium, architect Stefano Boeri, implementation in 2018, photo by E. Cisek.

The project of *Bosco Verticale* in Milan, which consists of two residential tower buildings, constitutes a pilot implementation that gave the impulse to create subsequent objects of this type not only in Europe, but also all over the world. The ecosystem which was designed in the structure of both buildings consists of about 900 trees and 15,000 shrubs (Ill. 1). However, *Vertical Forest* in Lausanne, which is 120 meters high, is the highest building in the city, which makes it its showcase. The object is a new landmark of the city

which is easy to see from the surrounding communication arteries. The greenery of trees which are part of green gardens occupies about 3,000 square meters of the surface and is intended to emphasize cycles taking place in nature as well as affect the bio-climatic condition of the building. Palazzo Verde in the District of Nieuw Zuid in Antwerp is a complex of 66 apartments, whose integral part consists of numerous roof gardens which form a common space for residents as well as green, individual, private terraces, adjacent to residential units (Ill. 2). 86 trees, 1,000 shrubs and 1,200 plants create this local ecosystem organized on the roof. As the author of the project emphasizes, in every place where *Vertical Forest* is created, climatic conditions are first checked and on this basis the species of plants which form the ecosystem are selected. The concept of their selection must also be maintained in the future, which means that the owners of apartments cannot interfere in the designed plant compositions and on no account can they remove them. For this purpose, the owners sign appropriate clauses in the purchase or rental apartment agreement. The building is designed at the end of this process. Trees are not a building decoration, i.e., on the one hand, they are a necessity to improve the quality of life and happiness of residents, and on the other they contribute to the increase in species biodiversity in cities. The proximity of nature is becoming more and more necessary, which is what city residents found out during the Coronavirus pandemic. Palazzo Verde is a real symphony of greenery and colors. It is the twentieth building out of 38 included in the General Plan of Nieuw Zuid. In the future, implementations of remarkable architects such as Shigeru Ban and Peter Zumthor are planned. The next *Vertical Forest* objects are supposed to be constructed in Utrecht, Eindhoven, Cairo, Tirana, Nanjing, Huanggang and in Sint-Lambrechts-Woluwe in Brussels, as an adaptation of the office building for housing purposes[4]. These implementations constitute a sort of green acupuncture of the city. Where they appear, they act as a form of changes setting a new direction by means of introducing nature into the structure of the built environment. Instead of taking its space, they lend it that space. These solutions are also effective in reducing the peak flow of rainwater. They slow down this flow and thus contribute to the reduction of the flood risk. Their effectiveness can range from 5 to 95% reduction of water flows, depending on the type and depth of the ground, the season, as well as the intensity of rainfalls. The colors which the images of eco-objects obtain are, just like in nature, unique, which is why they are becoming a harmonious part of a larger image of the organic city.

Among Polish implementations, the green roof of the Warsaw University Library deserves special attention (landscape architect Irena Bajerska, implementation in 2002).

This building is considered one of the best examples of combining architecture with biology. The roof of the object is a biologically active plane representing species of fauna and flora which form the local ecosystem. In particular, the world of plants is diverse and divides its impressive area of 0.5 hectares into four-colored compositions, i.e., golden-yellow, silver-blue, as well as carmine and green. In each of them, there are colorfully selected plant species growing, so that the color assigned in a given location is kept in a year-round cycle. This implementation is a perfect example of a structural connection of the building with the local ecosystem, which constitutes its integral part (Ill. 3).

[4] A.M. Tavares Martins, I.D. Campos, *From the Horizontal Garden to the Vertical Garden: An Architectural and Environmental Perspective of the "Green" Element*, "IOP Conference Series: Materials and Science and Engineering", 2019, vol. 471, no. 7, art. no. 072022.



Ill. 3. A four-colored ecosystem on the green roof of the Warsaw University Library in Poland, landscape architect Irena Bajerska, implementation in 2002, photo by R. Czajka.

3. BUILDING THAT LOST ITS FORMER CHARAKTER AND FUNCTION BUT MAINTAINED ITS SYMBOLIC IMPORTANCE FOR THE CITY AND CREATED A NEW URBAN ECOSYSTEM

Revitalizations of former post-industrial areas in connection with a pro-climate policy, aimed at recreating old ecosystems and incorporating them into the urban tissue, is a trend which is dynamically developed by many European countries, including Norway. Since the dawn of time, the city-forming element was a river. Trade and industry, which constituted city-forming elements, usually concentrated in the vicinity of a river. In the capital of Norway, Oslo, this role was performed by the Akerselva River which was called the "mother of the Norwegian industry". In this country, one of the most successful projects of recent years includes the reconstruction of the local Akerselva ecosystem and the transformation of the river once contaminated with industrial sewage into a home for various fauna and flora. The eight-kilometer-long ecological park running along the river consists of twenty waterfalls, extensive forest and park terrains ensuring species biodiversity as well as numerous historic buildings from the time of the Norwegian industrial revolution. The latter include factory buildings powered by waterfalls from the mid-19th century. They have now been adapted to new functions: residential, educational, exhibition and service. The second group consists of the former housing districts for factory employees, which were revitalized and intended for



Ill. 4. Studenthus, a former grain silo adapted to a residence hall in Akerselva river Ecopark in Grünerløkka district in Oslo, Norway, architect HRTB Arkitekter, photo by E. Cisek.

social apartments. Together with the river ecosystem, they form green districts that are part of the modern city[5]. Their unique character is created by narrow quaint streets of the historic building development and fifty bridges connecting former small factories situated on the left bank of the river along with residential units located on the right bank of the river. The river with an accompanying ecosystem facilitates the perception of even these imperfect buildings. Massive factories, which were built from red brick over a hundred years ago, can be included in the architecture constructed for itself. These impressive buildings with a Gothic character have now changed their function but have not lost anything of their symbolic size for the city. They stand on steep river cliffs along waterfalls like fortified castles and remain in an expressive contrast to the development of workers' housing estates. This symbolic meaning of factories' building developments for the city is clear until today. Especially since many of them were adapted to important central and creative functions for the city. The most interesting adaptations include Vulkan – a former ironworks from 1908 in Grünerløkka district, which in 2010 was adapted to Mathallen – a gastronomic hall and Dansens Hus – a concert hall (architect LPO Architekter). In 2011, the quarter was supplemented with a new hotel development (architect Niels Torp) and a residential development with apartments for artists on the green roof, which ensured a view of the river (architect Snøhetta). The former grain silo, which was located in the vicinity, also changed its function. At present, there is a Residence Hall there – Studenthus (architect HRTB Arkitekter, Ill. 4). From one of the windows on the ground floor of the building, we can see a replica of the former grain tramcar which in the past transported grain up the river to the mills located there. The 19th-century workers' housing estates in Grünerløkka and Lilleborg were adapted to social apartments, and the accompanying allotment gardens located in a historic complex are still used as the oldest social gardens in Norway. Maintenance and protection of these gardens are also included in the pro-climate policy of the city, which is aimed at successive extension of the biologically active plane of the capital of Norway[6].

4. THE CONTEXT IS A LOCAL ECOSYSTEM. A BUILDING WITH A FORM WHICH FOLLOWS THE LANDSCAPE CHARACTER SUPPORTS BIODIVERSITY IN THE CITY

The environmental context is necessary in order to support biodiversity in the city. The preferred forms of spatial organization of housing architecture in cities, which are conducive to climate neutrality, include eco housing architecture integrated with Ecological Education Parks. These new urban ecosystems constitute closed local ecosystems and were created on the basis of the existing forest and park greenery often concentrated around watercourses and water reservoirs[7]. The environmental context seems to be crucial for organizing this type of eco-structures, whereas the architectural context – not necessarily. This design strategy is part of the deep ecology trend which was established in the 2nd half of the 20th century in Norway as an expression of disappointment with the mainstream of Western European

[5] M. Hopfer-Gilles*, Oslo. Miasto, które oddycha*, Wielka Litera, Warszawa 2022, pp. 203–235.

[6] *Oslo BiodiverCity – Maintaining ecosystem services in a rapidly developing but biodiversity rich city* [in:] Oppla, https://oppla.eu/casestudy/19231 (access: 16.03.2023).

[7] K. Jakubowski, *„Piękno nieoczywiste". Rola miejskich nieużytków w kształtowaniu nowej kategorii parków miejskich*, „Przestrzeń i Forma", 2015, no. 24(2), pp. 145–162.

culture soaked in the spirit of consumerism and the progressive degradation of the natural environment. Its founder was the eco-philosopher Arne Næss (1912–2009)[8]. Deep ecology as a long-term attitude fosters values such as an increase in species biodiversity and eco-education of the city's inhabitants[9]. *Friluftsliv* (Norwegian) – the joy of identification with wildlife, i.e. going out to nature which ensures necessary balance and empathy – belongs to the fundamental assumptions of deep ecology[10]. In the urban context, this role is performed by new city ecosystems, namely Ecological Education Parks and the functions connected with them, such as residential – including houses for seniors, educational – forest kindergartens and schools, service – small gastronomy focused on local products and community spaces. The purpose of designing these urban eco-structures comprises rebuilding local ecosystems by increasing the biodiversity by means of modeling the processes of ecological succession and the mosaic character of plant communities; eco education – residents gain knowledge about the processes and natural cycles occurring in ecosystems and integrate around protective actions; proper development of children, maintaining their physical and mental balance; spatial conditions for participatory initiatives, e.g. joint cultivation; eco solutions in the friendly architecture of local wild ecosystems; increasing the qualitative porosity of the urban tissue, its permeability for rainwater and its retention; reducing the effect of the urban heat island[11].

A great example of such actions is the following implementation from Norway – Nansen Park (architect Bjørbekk & Lindheim Landskapsarkitekter, implemented in 2008). The idea of this layout was to reconstruct the original ecosystem of Fornebu Peninsula after the liquidation of the international airport operating in the years 1939–1989. Local species biodiversity was restored, a thoughtful retention system of rainwater was provided within the designed green areas, and thanks to the recycling of building materials and soil from the former airport the park tectonics were modeled. The local ecosystem was reproduced on an area of 130 hectares. The remaining 200 hectares were allocated to four educational and service centers which consisted of a school, a kindergarten, apartments for seniors and a community house, as well as residential units, i.e. Storøya, Rolfsbukta, Hundsund, Oksenøya, Koksebukta, Piloten, Hagebyen, Nansenløkka and Storøykilen. Housing complexes on the outskirts of the Ecological Education Park were shaped in a way that made it possible to mutually penetrate greenery with architecture. These are usually two up to five-storey group layouts with openwork forms with internal greenery courtyards and simple cul-de-sac layouts. Low multi-family building development blends harmoniously with the single-family one[12].

The Eva Lanxmeer project in Culekborg in the Netherlands (architect Joachim Eble, implementation in the years 1999–2021), which was created as a cooperation of residents, is an example of combining the local ecosystem in the Old Rhine river bed with residential buildings and formation of spatial conditions for participatory initiatives, including urban agriculture.

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[8] A. Næss, *Life's Philosophy, Reason and Feeling in a Deeper World*, University of Georgia Press, Athens 2002.

[9] D. Abram, *Ekologia głębi*, „Dzikie Życie", 2011, no. 7-8(205-206), http://pracownia.org.pl/dzikie-zycie-numery-archiwalne,2306,article,5348 (access: 16.03.2023).

[10] E. Cisek, *Norweska architektura i rzeźba wobec natury*, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2017, pp. 65–66.

[11] T. Molenda, *Problematyka ochrony środowisk antropogenicznych w Polsce*, „Journal of Ecology and Health" 2013, no. 1, pp. 76–80.

[12] E. Cisek, *op. cit.*, pp. 268–269.



Ill. 5. Polderstad, a retention reservoir with a community house designed within the estate as an integral part of the Hobokense Polder, an ecological education park in Antwerp, Belgium, photo by A. van Herck.



Ill. 6. Groen Zuid. Combination of multi-family and single-family housing developments with a local ecosystem as the synergy of architecture and nature in Antwerp, Belgium, architect Binst Architects, implementation in 2020, photo by E. Cisek.

Hobokense Polder, an ecological education park in Antwerp, Belgium and the two housing complexes connected with it, i.e., Polderstad and Groen Zuid (architect Binst Architects, implementation in 2020) are an example of restoring the local wild ecosystem in the former polder of the Scheldt River and its synergy with housing architecture, where 30% are social apartments (Ill. 5) and co-creating a new urban ecosystem (Ill. 6).

5. CONCLUSIONS

Implementation of biologically active planes into the urban tissue, which perform the role of wild ecosystems in the form of buildings' crowning – green roofs and terraces or forest and park terrains with the character of ecological education parks, is part of actions aimed at increasing the qualitative porosity of the urban tissue and species biodiversity of local ecosystems. The building as an integral part of the ecosystem creates a city and by making its new image contributes to the achievement of climate neutrality.

Architecture, which was formerly built for itself, is acquiring a new value. Objects that have lost their former character retain their symbolic significance for the city. Former factories and their accompanying infrastructure, which have been destroying the natural environment, are now becoming its ally by co-creating new urban ecosystems which shape the empathetic attitude towards nature in the youngest. These multi-functional architectural structures penetrating with forest and park areas are supposed to educate people from an early age through living, playing, learning and working in direct contact with wild nature. Whenever these structures are developed on the basis of a given place, which is the existing ecosystem and the local audio-sphere, they create a sensual, complementary environment in which images, sounds and smells stimulate the harmonious development of all forms of life.

The environmental context seems to be crucial for organizing this type of eco-structures, whereas the architectural context – not necessarily. Biological diversity often goes hand in hand with the variety of architectural forms and their aesthetics. The idea of an organic city and the introduction of nature into cities in various forms of eco-architecture are part of the long-term trend of deep ecology, which was initiated in Norway by Arne Næss and has become a means to fight the ecological crisis.

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