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Sustainable design, modern environmental protection engineering and bioeconomics

Zrównoważone projektowanie a nowoczesna inżynieria ochrony środowiska i biogospodarka

Abstract

New trends in sustainable design contribute to prevention of the deterioration of the natural environment and they are focused on the optimisation of the indoor environment for the improvement of the human life quality. There are complementary goals of sustainable design – the comfort of architecture users,proper spatial planning, and, as a priority, taking into account the needs of both contemporary and future generations. These existential needs are connected with both local and global sozological problems. These are related to the continuing growth of irreversible changes to the environment, such as climate change, the disappearance of biodiversity, and the over-exploitation of nonrenewable sources of energy as result of shortsighted economy. These imply the necessity for the sozological education in all subjects of study and transdisciplinary training focused on the solving of problems associated with sustainable development.

Keywords: new trends, sustainable design, bioeconomics

Streszczenie

Nowe tendencje w zakresie projektowania zrównoważonego przeciwstawiają się degradacji środowiska przyrodniczego i są ukierunkowane na optymalizację środowiska wewnątrz budynków w celu poprawy jakość życia człowieka. Poza dążeniem do komfortu użytkowania architektury i odpowiednim zagospodarowaniem przestrzeni priorytetem projektowania zrównoważonego jest realizacja potrzeb zarówno współczesnego człowieka, jak również przyszłych pokoleń. Z tymi egzystencjalnymi potrzebami wiążą się problemy sozologiczne zarówno o zasięgu lokalnym, jak i globalnym. Dotyczą one nasilających się i nieodwracalnych zmian środowiska, takich jak: ocieplenia klimatu, zanikanie bioróżnorodności, wyczerpywanie się nieodnawialnych źródeł energii, połączone z rabunkową gospodarką. Implikuje to konieczność edukacji sozologicznej na wszystkich kierunkach studiów i szkolenia interdyscyplinarne pod katem rozwiązywania problemów zrównoważonego rozwoju.

Słowa kluczowe: nowe trendy, projektowanie zrównoważone, biogospodarka

A contemporary picture of the living environment of man makes us reflect on the irreversible changes that are occurring and the need to take action to prevent them. On the one hand, we the rapidly progressing degradation of the biosphere, on the other hand, there is an increasing awareness of a society sensitised to issues related to human ecology and understanding the need for the economic management of the natural resources.

Current aspirations in the field of design take into account the need to maintain a balance between the environment transformed by man, the natural environment and the homeostasis of ecosystems. Sustainable design, taking nature into consideration, fits into the existing conditions in which durability is determined by protection ecological balance – an approach also promoted by planning sozology. The importance of greenery in urban structures is widely known due to its ability to purify the air. However, as indicated by many studies, natural elements also have an impact on human health, our social lives and the economy of solutions regarding the management of the urban space [1, 2] (Table 1).

Table 1. The impact of green areas on city life (according to Terrapin Bright Green, 2012) [15]

Social life	**Healthy life**	**Sozological aspect**	**The economy of the solutions**
providing the implementation of various activities in the group	positive effects on the human psyche – the reduction of acts of violence and vandalism	human activity in compliance with nature	activation of trade and commercial services
creating a willingness to identify with the environment	reduction of stress – a positive effect on the mental condition	care for the environment and natural resources	increase of the value of real estate due to the arrangement of green spaces
improving pedestrian safety	increased physical activity/relaxation	reduction of noise and vibration levels	reduction of infrastructure costs
strengthening neighbourly bonds	increase of time spent outdoors	care for pro-health conditions	increased productivity
common spaces with elements of greenery for various functions	reduction of air pollution	reduction of the temperaturę- decreased number of heat islands	business development in green districts
improving the comfort of the housing environment by increasing the green space	creation of an attractive view outside the window – psychological well-being	absorption of air pollutants and carbon dioxide	reimbursement of the cost of each planted tree

Architectural objects which are an inseparable part of the environment adapt to its conditions, such as terrain and climate analysed both on the macro- (region) and micro-scale (urban interior including the nearest neighbourhood). It should be noted that human interference in the environment results in irreversible changes to its structure, leading to an increase in entropy. Anthropopressure also contributes to global warming, which often leads to natural disasters that more and more often impact upon the everyday lives of many people.

Contemporary design trends are not only aimed at helping in the search for measures to prevent these adverse changes but also in minimising the cost of maintaining buildings using alternative energy sources. These activities are facilitated by new technologies, including biotechnology, that are applied in design.

Planning sozology and urban meteorology have a significant application in this field because they allow rational spatial planning and locating architectural objects that remain in symbiosis with the natural environment. Planning sozology is based on the principles of sozology, which were introduced to environmental engineering by prof. W. Goetel. It has its application in the sustainable design of residential areas, which contributes to the rational management of land and natural resources in a way that complies with the requirements of environmental protection and the humanisation of technology [3, 4]. The main assumption of this design trend is to take into account and use the existing environmental conditions while minimising the use of non-renewable energy sources and energy consumption.

Sustainable architecture based on the principles of sustainable design uses the above trends, approaching the idea of *Green Architecture (GA)* [5], or bioclimate in architecture. A summary of the factors taken into account by the *GA* concept is presented in Table 2 [6].

Table 2. Table 2. The Basic principles of green architecture; own concept related to S. Lehmann Principles of Green Urbanism [6, p. 45]

Energy and materials	Spatial planning and transportation
the use of local raw materials for the production of building materials with low energy consumption improvement of traditional materials the application of new technologies the recycling of materials energy efficiency the reduction of construction waste	striving to fulfil the assumptions of planning sozology and implementation of the assumptions of sustainable urban design in: ▸ adaptation to biometeorological conditions in the area of housing planning with increased compactness and maximum use of land allocated for many functions ▸ the use of climatic conditions for the rational location of facilities ▸ the application of the BIM control system in the planning and use of architectural objects ▸ the increase of biodiversity ▸ the reduction of water consumption ▸ the improvement of pro-health conditions ▸ economical land management ▸ the reduction of the intensity of car communication for green transport (walking and cycling) and collective transport using vehicles with electric motors ▸ the elimination of the nuisance of communication solutions (vibrations, noise, air pollution)

Many contemporary developments in residential areas prove the effectiveness of the above ideas. It is not a major problem in friendly conditions or those that become "natural". However, it should be noted – as indicated by the study of J. Ramanowska and M. Brzezicki [7] – that as a result of climate change, extreme conditions are increasingly occurring in areas of human residence, which means that people will be forced to adapt to changing conditions. Thus, in the extremely cold zone buildings are located on permafrost. Igloos with rounded

blocks made of cut snow blocks enable the minimisation of loss of heat and the pressure of air mass (–wind). In extremely dry zones, objects are frequently made of straw or clay, covered with a stake. In extremely hot zones, inhabited by Berbers among others, houses are either carved in sandy clay sedimentary rocks or are underground, where appropriate thermal conditions are maintained – they provide some coolness during hot weather. In extremely humid zones, traditional architecture is erected on platforms based on piles, and in the case of stoney terrains, on concrete foundations built under construction poles. In addition, the structure is stiffened with transverse beams, which allows free airflow [7].

It seems that an important role in shaping architecture in such difficult climatic conditions is attributed to the bioclimatic form of objects [8]. It allows architecture to adapt to the prevailing climatic and meteorological conditions in order to achieve parameters responsible for a comfortable living environment.

The modern environment of human life is not only affected by climatic changes, such as the weather. Growing air pollution, excessive waste production and high energy consumption are all serious problems. Other negative phenomena include the growing intensity of communication traffic and shrinking biodiversity. All these circumstances not only lead to a change in the image of cities and the lives of their inhabitants but also directly affect humans with regard to their health and functioning. Therefore, paying due consideration to this subject seems even more justified.

1. Contemporary tendencies in the shaping of the housing environment

Modern architecture and spatial planning must not only keep up with the changing conditions and lifestyle of man and the principles of functioning. New trends in design oppose contemporary problems related to environmental degradation. The impact of unfavourable phenomena on human health is the subject of continuous research. The impact of road noise on the well-being of people began to be analysed relatively recently. It has been found that it causes irritability, and in extreme cases, disorder, impairment or even loss of health (Table 3) [9].

Table 3. The influence of noise on health and human well-being [9, p. 23]

Effect	Measured factor	Acoustic indicator	The threshold value of the health effect	Influence in time
1	2	3	4	5
annoyance nuisance	psychosocial, quality of life	L_{DWN}	42	long-period
sleep disorder based on self diagnosis	quality of life, somatic effects	L_{N}	42	
learning, memory	efficiency	L_{Aeq}	50	
stress hormones	stress indicator	L_{max} $^{3}L_{Aeq}$	lack of data	

1	2	3	4	5
sleep (polysomnographic sleep)	agitation, mobility, sleep quality	$L_{max,\ wewnątrz}$	32	
reported awakening	sleep	SEL_{insde}	53	
self diagnosis of the health condition	well-being, clinical health (clinical symptoms)	L_{DWN}	50	
hypertension	physiology, somatic health	L_{DWN}	50	
coronary heart disease	health (clinical symptoms)	L_{DWN}	60	

Limiting noise by means of acoustic insulation, including green walls, is just one of the important contemporary activities improving the living conditions of modern man [10].

The use of new solutions and new technologies in the design process allows us to increasingly control the life cycle of architectural structures and introduce the ability to adapt buildings to changing climatic conditions. This is provided by intelligent construction implemented with the use of appropriate software that manages the way objects operate. The functioning of the building in its surroundings is influenced by an in-depth analysis of the full life cycle from the first idea (concept), through the planning and design of the building, its construction, exploitation and utilisation. The BIM process is helpful in this respect, as it enables control of all stages of the building's construction and operation. It also allows us to reduce energy consumption and avoid errors occurring during its design. A detailed analysis of the life cycle of objects – LCA – confirms that construction is responsible for the inefficient energy economy as it consumes around 40%. Another problem includes the excessive production of waste related to mistakes made during the design and construction of new buildings, their operation and subsequent utilisation. Therefore, it is important to select the right building materials not only in terms of the optimal time of their use but also the prospects of recycling – the so-called technical death of the object. In the future, the minimisation of waste will be ensured by the use of 3D printing technology.

In the implementation of such important challenges of the present day, greater inter-university cooperation of specialists from complementary fields of science is necessary, including the adjustment of education to the needs of the labour market. This would allow the broadening of knowledge on, among other things, the application of sozology principles, not only in modern environmental engineering based on biotechnologies and ecological engineering but also in the planning of architectural and urban solutions [11]. The future direction is to use methodological experiences the 50 years of inter-university training for thousands of students interested in sustainable development based on eco-innovation to train the staff and develop the so-called Municipal Agriculture, in particular, the Underground Centers of Environmental Biotechnology (for the in-situ cleaning of sewage and waste treatment). Such centres might be combined with the production of non-contaminated food

products (including mushroom and vegetable cultivation) in underground greenhouses that use bioenergy from waste biomass and new energy-saving lighting systems for plants. This kind of personnel training will contribute to the broad implementation of the principles of sustainable development, the bio-economy, as well as the stabilisation of the labour market [12–15].

2. Conclusions

The main goal of the new tendencies in the field of architectural design is to minimise the effects of the economy that exploit the natural environment. It is also an attempt to reduce energy consumption and waste production. Life cycle analyses (LCA), often supported by the BIM process, are helpful in this respect.

The use of modern tools enables the more accurate design of investments and the operation of buildings, including their renovation and modernisation. New technologies improve traditional building methods, the value of which is increasingly appreciated. Thus, traditional technologies and materials are characterised by new properties that allow adaption of the building to the prevailing climatic conditions. Similarly, the intelligent architecture, quipped with a management system supports the reduction of energy consumption by adapting to the weather conditions.

Regardless of the accepted methods and technological possibilities, urban sozology supporting the principles of sustainable design requires special attention. This can be applied in spatial planning at various scales. The rational planning of facilities and their appropriate localisation with respect to the natural environment that also takes into account climatic factors are perceived as striving for sustainable development promoting pro-health conditions.

The problems presented in this paper require analysis and the search for remedies due to their global scope and the consequences resulting in irreversible changes in the natural environment, which is also not indifferent to human life and health.

References

[1] Terrapin Bright Green, https://www.terrapinbrightgreen.com/report/page/2 (online: 26.06.2019); Regulation No. 9 of the Minister of Local Economy and Environmental Protection of 29 January 1974 on indicators and guidelines for residential areas in cities. Dz. Bud. no 2 of 2 February 1974, position 2., 2002.

[2] Kobylarczyk J., *Environmental conditions in the design of residential areas*, Cracow University of Technology, Krakow, 2018.

[3] Goetel W., *Nature protection and technology*, PWN, Warszawa 1969.

[4] Goetel W., *Rational management of natural resources*, PWN, Warszawa 1971.

[5] Vale B. & R., *Green Architecture. Design for Sustainable Future*, Thames & Hundson, Londo, 1991.

[6] Haupt P., *Natural elements of the composition in shaping the contemporary urban space. Relations of the building with the surroundings*, Cracow University of Technology, Kraków 2015.
[7] Romanowska J., Brzezicki M., *A building in extreme climatic zones*, [in:] Builder 04, April 2010.
[8] Ryńska E.D., *Bioclimatic and architectural form*, Warsaw University of Technology, Warszawa 2001.
[9] Bohatkiewicz J., *Modeling and evaluation of solutions to protect against road noise*, Lublin University of Technology, Lublin 2017.
[10] Bohatkiewicz J., Czarnecka W., Jamrozik K., Biernacki S., Hałucha M., *The impact of traffic reduction on the acoustic climate in the streets*, Building and Architecture 13(1), 2014, 235–252.
[11] Dobrowolski J., Kobylarczyk J., Tursunov O., *Integration of local eco-innovation with global problems of protection of the natural environment and bio-based green economy*, Siew Qi Toh, *CAS 2015 [Dokument elektroniczny]: international conference on Circuits and Systems*, August 9–10, Paris 2015.
[12] Dobrowolski J.W., *For the Future*, Poland, 2, 3–5, 1972.
[13] Dobrowolski J.W., *Modern science for future environmental and social activity of university youth*, [in:] *Environmental Quality and Safety, Global Aspects of Chemistry, Toxicology and Technology as Applied to Environment*, F. Coulston, F. Korte, (eds.), Vol. 5, Georg Theme Publ., Stuttgart, Academic Press, New York–San Francisco–London 1972, 78–88.
[14] Dobrowolski J.W., *The Polish Initiatives*, Naturopa 61, 1989.
[15] Dobrowolski J.W., *Environmental monitoring and human ecology as well as biotechnology as the premises for pro-health development of the environment*, [in:] *Urban housing environment*, G.Schneider-Skalska, E. Kusinska (eds.), Cracow University of Technology, Krakow, 2017, 111–120.
[16] Kobylarczyk J., *Environmental conditioning in the design of living districts*, Cracow University of Technology, Kraków 2018.