

Green Infrastructure as a Component of Sustainable Development

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Abstract

One of the issues today is to ensure the sustainable development of society. Different tools are applied for this purpose. These tools allow for achieving results in a specific area of sustainable development: economic, environmental or social. However, it is more actual to use such tools that will allow for improvements in all of these areas simultaneously. An example of such a tool is green infrastructure. Over the last decade, the practical implementation of its principles in various fields of human activity has made a significant step forward in the realisation of the sustainable development concept. The article considers the main benefits of applying green infrastructure principles in enterprises. Currently, certain principles of green infrastructure are working in enterprises. It has some positive results. However, to increase the effectiveness of principles' implementation is necessary to use a systematic approach. Systematic analysis of existing environmental problems in the enterprise can help identify the causes of their occurrence and find variants of solutions. Ultimately, it will make the ecological policy of the enterprise effective and conscious. Consequently, it appears the understanding of which measures should be taken and what results can be expected. Such an enterprise strategy will provide the implementation of the sustainable development program. Moreover, the experience of applying the principles of green infrastructure at the enterprise level gives the prospect of ensuring the sustainable development of society as a whole.

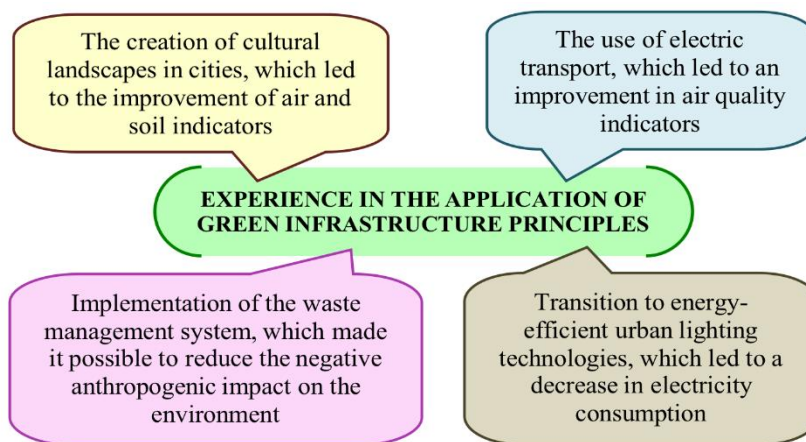
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1. Introduction

In recent years, efficient theories and concepts have appeared in the economic, social and environmental fields. Among such innovations is the green infrastructure, which quickly spread in many countries, for example, Germany, France, the USA, Canada and others [1-4]. The popularity of this concept is the positive experience of its application (Figure 1).

Figure 1: Experience in the application of green infrastructure principles



Unfortunately, green infrastructure principles are hardly applied in Ukraine [5-7] because two reasons. The first is the lack of appropriate funding, and the second is the low level of people's environmental culture. These two factors significantly inhibit the implementation of green infrastructure principles. However, if we recall one of the main ecological slogans: "Think globally, act locally", then today, in Ukraine, the green infrastructure principles can be gradually implemented within local facilities but not entire cities, for example, at enterprises. In the future, this will allow enterprises to:

1. Improve the environmental indicators of their activity;
2. Increase the level of occupational safety;
3. Gain practical experience in the application of these principles.

All these are important for applying green infrastructure principles to larger objects.

Thus, formulate a scientific problem: research and analysis of possible options for implementing green infrastructure principles at enterprises.

2. Literature review

The research and analysis of the ways of implementing green infrastructure principles at enterprises must begin with considering the concept of “green infrastructure”. It is because, as mentioned above, green infrastructure is not common in Ukraine and, therefore, does not have an established interpretation, which, in turn, will complicate finding ways to implement it.

The review and analysis of information on this issue showed that many countries apply the green infrastructure principles, which led to different definitions. Each country, which applies such principles, has its vision of the definition based on existing environmental problems that need to be solved [1-12]. Thus, each definition has certain accents characteristic of this or that city, this or that country. Consider some examples. For instance, in the USA, green infrastructure means applying a new waste-water management system, the feature of which is the use of fundamentally new vegetation, soil and other natural features of the landscape instead of traditional storm-water management measures (storm-water drains and treatment facilities) [1]. In Germany, the emphasis is on the issues of increasing the use of renewable energy (in particular, solar and wind) and waste management (sorting and recycling of waste, the use of zero-waste technologies) [2]. In Poland, the essential issue of green infrastructure is the greening of cities [10]. According to the Japanese, the main goal of applying the principles of green infrastructure is to prevent and mitigate the negative consequences of environmental disasters, reduce the emission of greenhouse gases, and education to people [12]. Canada considers preserving biodiversity, mitigating the consequences of climate change and regulating the water regime as priorities. Thus, the conclusion is green infrastructure combines many different measures that allow solving a wide range of economic and environmental problems of varying degrees of complexity, taking into account the peculiarities of the functioning of a specific city or country.

In light of this, to apply the green infrastructure principles in Ukraine, it is necessary to consider the advantages of implementing green infrastructure and highlight among them the essential elements that will constitute the content of this concept. So, the benefits of applying the green infrastructure principles in various spheres of activity are as follows:

1. In the economic sphere, the application of such innovations as the use of energy-saving technologies and increasing the share of electric transport allows for improving economic indicators and saving money.
2. In the environmental sphere, it is the support of natural parks and landscape zones in cities. These actions help to reduce the content of pollutants in the air, water and soil, etc.
3. In the social sphere, the creation of green zones in cities, which are a place for recreation and cultural events, which improves the level of social interaction among people.
4. In the medical field, reduction of morbidity rates due to improvement of the environment.
5. In the cultural sphere, raising people’s awareness of environmental issues and increasing their ecological culture.

Sum up the above and consider the peculiarities of the environmental needs of Ukrainian society, we formulated the following definition: green infrastructure is a set of measures to minimize the negative impact on the environment and people, which includes technical solutions (building, landscaping and others) and socio-psychological ones (development population ecological culture, formation of ecological needs in people, etc.) [5,13].

Tools and methodology

Specifying the concept of “green infrastructure” makes it possible to move to the next stage of work - finding ways to implement the principles of green infrastructure at the enterprise.

Among the advantages of applying the principles of green infrastructure is the improvement of the population’s health indicators [10,14]. In this case, the result appears due to improving the environment with which a person constantly interacts, not as a result of innovative achievements in medicine.

If we think by analogy, it is also possible to increase the safety of employees during work and improve their occupational health indicators by developing the environmental conditions of activity at the enterprise, that is, by applying the principles of green infrastructure. Of course, the question immediately arises: “How can it be done?”. In fact, it can be realised in different ways. If you carefully examine the existing achievements of enterprises in the field of environmental policy, it becomes evident that several principles of green infrastructure are already widely used today.

One such example is the “Green IT” technologies in enterprises. Let’s consider the content of this concept. Green IT is an environmentally responsible use of IT resources through a decrease in energy consumption and equipment reasonable exploitation [15,16]. In the given definition, “equipment reasonable exploitation” refers to a responsible attitude to IT’s selection, operation and disposal. Green IT began to develop around the mid-90s of the 20th century when the problem of the general spread of computer technologies in all areas of human activity. As a result, a significant increase in electricity consumption, the source of which is mainly non-renewable natural resources, has appeared. This fact has forced scientists and manufacturers of computer equipment to think about the improvement of technical devices to reduce energy consumption. As a result, at the beginning of the 2000s, a new problem appeared. It was related to the need to dispose of outdated models of computer equipment since the pace of updating technology was constantly increasing. Today, computer equipment works for an average of three years. After that, it is replaced. At the same time, used equipment is almost not subject to disposal, which leads to its accumulation and subsequent negative impact on the environment. Thus, the application of Green IT technologies is an example of the implementation of the principles of green infrastructure at the enterprise. However, in Ukraine, in most cases, enterprises apply Green IT partially, as they are limited only to updating equipment. Despite on this, it allows them to obtain positive results,

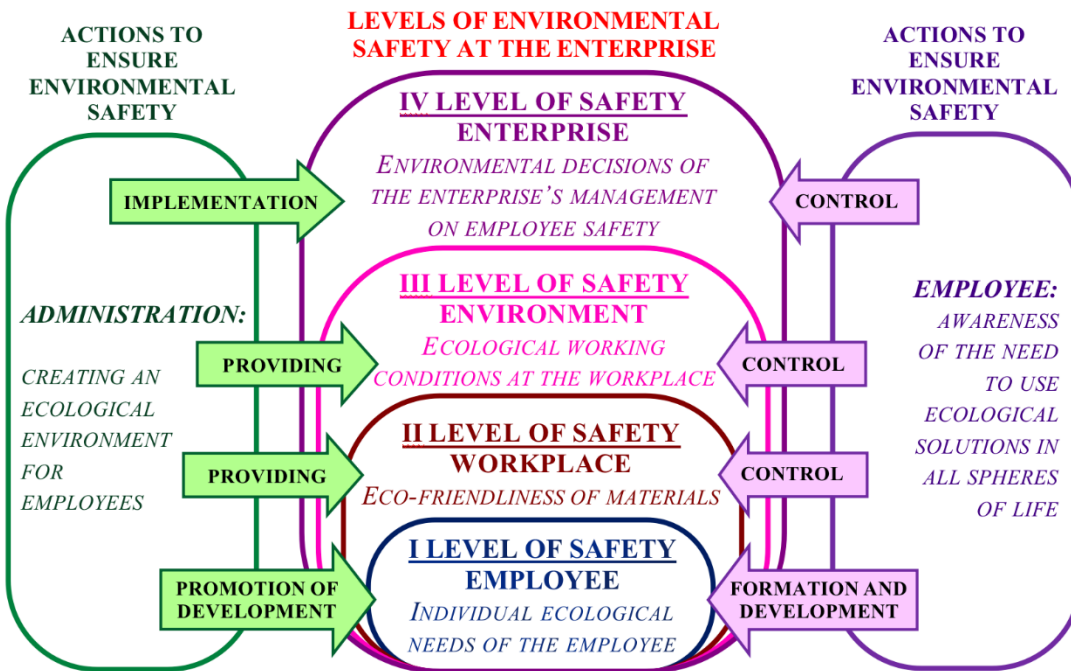
namely: reducing energy consumption, improving working conditions and increasing the safety of workers.

Another example of green infrastructure principles implementation at enterprises is the widespread use of energy-saving lighting inside and outside the premises. It allows enterprises to save money on lighting significantly. Unfortunately, in Ukraine, there are no state legislative mechanisms for the introduction of energy-saving means of lighting in enterprises and everyday life, as is done, for example, in the countries of Western Europe. State regulation of this issue could significantly contribute to increasing the effectiveness of the application of this measure.

To sum up, we have the following conclusion: today, green infrastructure principles are implemented and working partly at enterprises. However, they work not for the reasons of understanding and awareness of the importance of environmental problems. More often, it happens because of economic benefits, which decreases the possible positive results of their application. In order to increase the effectiveness of these principles, a systematic approach is needed, which will make it possible to make a comprehensive analysis of existing environmental problems at the enterprise, to determine the causes of their occurrence and mark the main ways of solving them. Eventually, it will make the ecological policy of the enterprise, above all, conscious. Thus, there will be an understanding of what measures need to be implemented and what results can be expected. To use this approach, we need to research:

1. The level of environmental safety at the enterprise, which will allow for estimating the level of environmental problems.
2. Actions that have to be applied at the enterprise to ensure environmental safety from the side of the enterprise's management and the employee.

The generalized results of the research on the enterprise's environmental safety are in Figure 2.

Figure 2: Environmental safety of the enterprise and actions on its implementation

The first level of environmental safety is the individual ecological needs of the employee. At this level, difficulties in green infrastructure principles application have already arisen since Ukraine has a low level of the population's environmental culture. It is impossible to expect an employee will monitor the eco-friendliness of materials at the workplace or evaluate the quality of the environmental solutions of the enterprise's management if he does not know what environmental standards exist, how they should be applied, etc. Moreover, there are almost no social programs that would contribute to the formation and development of people's environmental consciousness, increase awareness of environmental issues, etc.

The management's environmental policy is at the highest level of the enterprise's environmental safety. At this level, we have the same problems as in the first one – due to ignorance of many environmental issues, the applied measures are often impractical and limited only by economic benefits. Instead, it is possible to improve such indicators, for example, the level of employees' health, a decrease in a negative impact on the environment, etc.

Thus, presented in Figure 2 scheme for ensuring the environmental safety of the enterprise either works partially or does not work at all, which makes it hard to apply the green infrastructure principles. Undoubtedly, this situation needs to change. And in this case, it is possible to propose a generalized system for estimating the eco-friendliness of the enterprise [17-20]. It can be used by the employee and the enterprise's management simultaneously. It can be presented in the form

of a survey regarding the subjective assessment by workers and management of the general environmental situation at the enterprise. It will allow:

To draw the attention of employees to environmental issues and, thereby, increase their awareness.

2. To reveal the actual environmental problems of the enterprise, which will allow rational planning of costs for ensuring environmental safety considering the application of green infrastructure principles.

As a result, we will have:

An assessment of environmental problems from different positions and distribution of them according to the degree of importance.

Determination of appropriate solution options considering modern trends in environmental safety issues.

In developing a survey to assess the eco-friendliness of the working environment, it must be taken into account:

The survey must contain assertions that describe the possibility of applying a specific green infrastructure principle at the enterprise. The respondent must determine to what extent, in his opinion, this principle is implemented.

To increase effectiveness, it is necessary that the maximum number of employees engaged in various types of activities pass the survey. Therefore, the survey should contain universal characteristics of the work environment typical for most types of activities.

The counting and interpreting of the survey results should be as simple as possible and not require special knowledge, since the employee should be able to assess the environmental conditions by himself. Therefore it is suggested to use a point system.

A fragment of the survey on the estimation of the working environment eco-friendliness is in the Table 1.

Table 1: Coefficients of workplace environment eco-friendliness

№	Working environment characteristics	Coefficients of eco-friendliness, points
1	Eco-friendliness of enterprise infrastructure:	
	presence of special parking areas	5
	chaotic parking of cars	1

2	Building eco-friendliness:	
	concrete construction	5
	brick construction	4
	breezeblock building	3
3	Trash-cans and their service:	
	enough number of trash-cans and their timely servicing	5
	not enough number of trash-cans, but their timely servicing	3
	not enough number of trash-cans and their timely servicing	1
4	Rooms cleanliness:	
	indoor cleaning is done daily	5
	indoor cleaning is done one time in 2-3 days	4
	indoor cleaning is done once a week	2
	indoor cleaning is done one time in 2-3 weeks	1
:	:	:

Total points:

Overall, the survey contains sixteen working environment characteristics. Each characteristic has points in the range of 1 to 5 points. 1 point corresponds to an unsatisfactory level of eco-friendliness of the working environment characteristic, and 5 points – a satisfactory level of eco-friendliness of the working environment. In the survey, the ecological coefficient for each characteristic was determined based on the results of a statistical analysis of the impact on human health. At the end of the survey, it is necessary to sum the total number of points and determine to which of the three ranges of the working environment eco-friendliness it corresponds. The ranges of the working environment eco-friendliness are as follows: unsatisfactory, average and satisfactory levels.

Approbation of the survey at the enterprise producing flexo-printed products showed the following results:

1. 47 employees completed the survey. Processing the survey results making it possible to identify two characteristics of the working environment that need improvement. These are the eco-

friendliness of the enterprise's transport infrastructure and the eco-friendliness of the furniture on the premises.

2. 92% of respondents, including employees and management representatives, rated these characteristics with the lowest points.

3. The employees assessed the general level of the working environment eco-friendliness as satisfactory.

4. Among the green infrastructure principles for increasing the enterprise's environmental safety, the employees chose rational planning of parking zones, which will allow reducing emissions of combustion products and noise load. In addition, it will make it possible to use the territorial areas of the enterprise more rationally.

Thus, the identification of existing environmental problems at the enterprise, even through the use of a general survey of employees on their vision of the ecological safety of the working environment, allows us to determine which green infrastructure principles can be applied to improve it. At the same time, improvements can be achieved not only in environmental issues but also in the field of occupational safety at the enterprise and the occupational health of employees.

Conclusions

To sum up the above, we have the following conclusions:

The concept of "green infrastructure" is an attempt by modern society to implement a comprehensive approach to solving the problem of minimizing any negative impact on people and the environment. The implementation of green infrastructure principles is carried out through the application of various practical measures of technical, social, economic and cultural direction at the level of cities or even entire regions.

The concept of green infrastructure is rapidly spreading in the world. Unfortunately, in Ukraine, these principles are implemented slowly. The main reasons for this are the lack of funding for ecological projects and the low level of ecological culture of the population.

Of course, the implementation of the principles of green infrastructure requires significant capital investments. However, it is possible to start applying them from smaller-level objects, for example, enterprises. It will improve the quality of the company's activities in the field of its environmental policy, increase the level of occupational safety and improve the occupational health indicators of workers, and gain practical experience in applying the principles of green infrastructure.

Research on possible options for implementing the green infrastructure principles in Ukrainian enterprises showed that some measures are implemented at enterprises already. For example, using energy-saving lighting technologies, Green IT technologies, etc. However, these are separate and non-systematic actions, which, eventually, give a smaller result than can be expected.

To optimize the application of green infrastructure principles at enterprises, it is necessary to apply a systematic approach. It will make it possible to analyse current environmental problems at the enterprise, determine the causes of their occurrence and indicate the principles of green infrastructure that can be applied to their solution. At the same time, it will also contribute to the formation and development of ecological awareness among employees.

A systematic approach to green infrastructure principles at the enterprise is proposed to be realized as the survey, which contains questions about the environmental aspects of the working environment organization. The survey is unified to cover as many employees as possible.

The approbation of the survey at the enterprise of flexo-printing products made it possible to identify environmental issues that, according to the employees, are of primary importance and the green infrastructure principles that can be applied to solve them.

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