Complex Environment-Forming Phytotechnologies of the XXI Century: Successful Ecotechnological Solutions

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Abstract. The risk factors of various diseases for the modern urban dweller are the environmental conditions of the environment, and above all the quality of the air. The aim of this work was to generalize the environmental innovations proposed as technological solutions for air purification using plants. Methods. The modern methods of greening urban space, allowing to solve environmental problems, including air purification of cities are analyzed. Results. Modern solutions of green architecture and different approaches to landscaping elements of urban areas are considered. It is shown how vegetation provides and regulates (within certain limits) the gas composition of the air, the degree of its pollution, improves the microclimatic characteristics of urban areas, reduces the influence of the noise factor and is a source of aesthetic relaxation, increases the comfort of living conditions in the city. Conclusion. The implementation and use of the technologies considered should involve specialists in various fields, conduct educational work and solve environmental problems in practice.

1. Introduction

The risk factors of the disease for the modern urban dweller are the environmental conditions of the environment, and above all the quality of the atmospheric air. According to the results of the annual socio-hygienic monitoring, the increasing pollution of the environment contributes to the growth of chronic respiratory diseases, which are much more often registered among children and adolescents. There is a marked increase in the level of diseases of the nervous system, sensory organs, as well as a high level of mental and allergic diseases among all groups of the population. [1, 2].

The ratings of the dirtiest cities in the world and Russia are compiled annually. According to Rosstat (Federal state statistics service) in 2018, the list of the dirtiest cities in Russia included such cities as Norilsk, Chelyabinsk, Angarsk, Omsk, Magnitogorsk, Novokuznetsk, Cherepovets and Moscow. In the presented cities, the main adverse anthropogenic factors were: road transport (Moscow), non-ferrous and ferrous metallurgy (Norilsk, Lipetsk, Magnitogorsk, Cherepovets, Chelyabinsk), oil production (Omsk) and chemical industry (Angarsk).

As a result of urbanization people got into the local environment, where there is a high level of anthropogenic pollution. Therefore, it is necessary to take measures aimed at restoring the quality of the air environment on the basis of natural mechanisms of ecological metabolism with the participation of plants. Vegetation provides and regulates (within certain limits) the gas composition of the air, the degree of its pollution, climatic characteristics of the territories, reduces the influence of...
the noise factor, is a source of aesthetic rest, provides comfort of living conditions in the city [3].

Today it is necessary to rebuild the creation of cities of the future, taking into account all the elements of environmental safety, health and quality of life.

In this regard it is important to search for various engineering solutions to improve the environmental situation.

In this context, the aim of this work was the synthesis of eco-engineering approaches, proposed as technological solutions to a number of technological problems of urbanized areas, for example in the purification of atmospheric air, control of noise, improving the microclimate parameters (temperature, humidity), improving video ecological and sanitary-hygienic indicators, which can be done using plants [5].

2. Functions of plants and trees in cities
Consider the main functions of vegetation in cities. Generally they can be divided into: sanitary-hygienic, recreational and decorative-artistic [4, 5].

2.1. Sanitary and hygienic functions [4,5]
- **Air purification.** Trees actively absorb carbon dioxide and restore oxygen. One tree in 24 hours restores as much oxygen as three people need to breathe during the same time. One hectare of coniferous trees holds up to 40 tons of dust per year, and deciduous trees - about 100 tons.
- **Air ionization.** Plants enrich the air with light negative ions, which has a beneficial effect on humans. It is established that the number of light ions in 1 cm3 of air above the forests is 2000-3000, in the city Park - 800, in the industrial area - 200-400, in a closed crowded room - 25-100.
- **Isolation of phytoncides,** special volatile organic compounds that kill pathogenic bacteria or delay their development.

In pure pine forests and forests with a predominance of pine (up to 60%) bacterial air pollution is 2 times less than in birch.

- **Noise protection.** Different species of plants are characterized by different ability to protect against noise. According to Hungarian researchers, conifers (spruce and pine) in comparison with deciduous (wood and shrub), better regulate the noise regime. As the distance from the highway to 50 meters deciduous tree plantations (acacia, poplar, oak) reduce the sound level by 4.2 dB, deciduous shrub - 6 dB, spruce - 7 dB and pine - 9 dB. Studies have shown that hardwood is able to absorb up to 25% of sound energy, and 74% - to reflect and dissipate it

- **The influence of green spaces on the formation of microclimate,** the formation of winds or decrease their speed. On the one hand, green spaces contribute to the formation of air flow. This happens as follows. On hot days, the heated air of urban development rises, and in its place comes the colder air from the territory of green spaces. Such air currents are formed at a temperature difference of not less than 50C and a pressure difference of not less than 93.3254 Pa most often they occur on the outskirts of the city. On cool days, air currents are not created. On the other hand, windproof properties have green spaces, even a relatively small height and density of planting. The wind protection effect of a narrow green strip consisting of eight rows of trees 15-17 m high is observed at a distance of 300-600 m. In this zone, the wind speed is 25-30% of the original.

It is established that to reduce wind speeds, the presence of green strips 20-30 m wide placed at certain distances from each other is sufficient. In the depth of the forest at a distance of 120-240 m, a complete calm comes.

3. Recreational functions of plants
Manifest in meeting the needs of people in the rest, getting psychological relief. Green plants have a beneficial effect on the emotional sphere, have a great aesthetic value, contribute to the preservation of harmony of the environment and human even in conditions of such anthropogenically altered ecosystems as cities [6].

Decorative and artistic function of plants is the possibility of creating landscapes, space planning
and recreation of the urban population. Being an organic part of the planning structure of the city, green spaces are actively involved in the creation of landscapes of residential areas. Large green areas, located between separate areas of development, unite them, give the city integrity. Bright colors of plants at different times of the year enliven the urban landscape.

The role of greening in modern cities is becoming increasingly important, especially in terms of sanitary and hygienic functions. Experts of different profiles work in this direction: ecologists, botanists, chemists, physicians, landscape designers, agronomists and many others, offering innovative solutions on technologies, both cultivation of plants, and rational use of space. Taking into account the growing population density, the increase in the number of vehicles, constantly searching for innovative solutions in the organization of greening of the urban environment [6].

Gardens. Modern methods of greening urban space can solve environmental problems, including air purification of cities. One of such technologies is vertical gardening of facades and interiors. Vertical gardening not only acts as an ornament, but also purifies the air, provides psychological comfort, returning elements of nature to the urban environment [8-10]. Green architecture and Vertical gardening in the last decade are experiencing a boom, although they appeared quite a long time.

In the history of Russia, one of the first examples of such landscape arrangement was the "riding garden" of the Moscow Kremlin. Garden lay in 1623 gardener Nazar Ivanov. According to the famous historian I. Zabelin, the Upper Garden was surrounded by a stone fence with frequent openings and had an area of about 2600 m2 [7] (Fig.1).

![Figure 1. Riding gardens of the Moscow Kremlin.](image)

Over time, as the industry of building materials and structures and their improvements, roof gardens began to appear all over the world - USA, Canada, Japan and other countries [8]. At present, a lot of experience has been accumulated, a wide range of plants has been created and agrotechnology of their cultivation has been developed, the necessary methods of gardening specific for cities have been found, the methods of keeping green spaces have been determined. Toronto became the first city in North America where roof landscaping is regulated at the legislative level [8]. On may 26, 2009, Toronto issued a decree on mandatory greening of roofs of residential and industrial buildings (Fig.2).
The leading place in the creation of roof gardens, according to experts, currently belongs to Germany, where one of the prerequisites for the design of new buildings - landscaping of the roof. In Switzerland, about 23% of flat roofs of city houses are covered with lawns. In Japan, there is an order to divide gardens on all flat roofs, the area of which exceeds 100 m² [9] (Fig.3).

Designed by landscape architects of France created gardens on the roofs of buildings located at different levels of the hill of St. cloud in Paris. In Copenhagen, the 7000 m² garden is located on the roof of one of the hospitals. Various parts of the roof of one of the buildings are planted in the Centre of Hanover. In Bern, gardens are laid on the roof of the Small city government, on the terraces of the Large city government; landscaping and well-arranged terraces of two parliamentary buildings of the Swiss Confederation, the roof of the casino [10].

4. The creation of green roofs

Currently, there are several types of green roofs [10]:
- *extensive green roof* - the easiest option of green coating, with a small (6-12 cm) layer of substrate and plants that require minimal care and grow in extreme conditions;
- *semi-intensive green roof* - garden with ground cover plants, different varieties of herbs, perennials and small bushes. This type of green roof makes it possible to plan a variety of planting and expands the range of operation of the territory;
- *intensive green roof* - a type of green roof, which, depending on the power of the overlap of the building can have a layer of substrate up to two meters, which allows you to plant not only bushes, but also stunted trees.

On figure 4 shows the technology of creating a green roof, recommended by Greenlife (a) and the practical application of this technology in the modern city (b) [10].
The advantages of the proposed and currently implemented green roof technology are:
- increases the area of green spaces, and, consequently, the cleaning potential of vegetation; reduced chemical load;
- atmospheric precipitation is collected, and the load on the sewage system is reduced, precipitation is returned to the circuit;
- increases sound and thermal insulation of buildings.

The list of plants recommended for planting roofs, has about 50 species. These include different varieties of Sedum, a groundcover, and herbaceous plants. There are usually planted on the lawn of their composite. Of woody plants are preferable to deciduous shrubs (Fig. 5)

![Green roofs with different plants.](image)

**Figure 5.** Green roofs with different plants.

Russia also pays great attention to green architecture. In 2000, the Moscow government issued "Recommendations for the design of landscaping and improvement of roofs of residential and public buildings and other artificial foundations." Since 2007, work began on the creation of gardens on the roofs of high-rise buildings located on Novy Arbat (Fig.6). In 2018, the creation of gardens on the roofs of high-rise buildings is carried out in many large cities of Russia.

![The roof garden of the New Arbat (Moscow).](image)

**Figure 6.** The roof garden of the New Arbat (Moscow).

5. **Conclusion**
The use of sanitary-hygienic and decorative-artistic function of plants to improve air quality in cities is finding more and more supporters. In a short period of time from theoretical studies to clarify the role of plants in the process of air purification from toxicants, there was a transition to the creation and implementation of green architecture technologies that constructively solve man-made problems
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