Optimization of a spatial organization city protective greening

N N Krupina¹, E N Kipriyanova² and V O Smirnova²

¹St. Petersburg State Agrarian University, St. Petersburg, Russia, 196626 Saint Petersburg-Shushary, Pushkinskaya str., d. 12
²Saint-Petersburg state University of aerospace instrumentation, 67, Bolshaya Morskaya str., Saint Petersburg, 190000, Russia

E-mail: kipr53@yandex.ru

Abstract. The urgency of inclusion in the system of territorial planning and ecological zoning of the procedure of assessment of environmental protection efficiency of green plantations in the context of the task of creating a comfortable and safe urban environment is substantiated. It is determined that the sanitizing efficiency of environmental gardening is an indicator of the ratio of the magnitude of the positive result achieved for a specific period of time (assimilation and neutralization of toxicants) and costs. An analysis of the known methods for assessing the quality of green areas has been carried out, criteria and assessment indicators have been identified, the author’s approach has been identified, which involves calculating the optimal distance of the plantation strip from the object of aerotechnogenic impact, taking into account the value of the dangerous wind speed and the technical characteristics of the emission source. An illustrative example is provided. Provisions are formulated that are advisable to take into account when developing managerial decisions: aimed at improving the quality of urban gardening. The effectiveness of plants is manifested locally, therefore, it is necessary to take into account the nature of priority substances (markers), the effect of the summation of their action, migratory properties, as well as the technical parameters of the emission source.

Numerous studies confirm the environmental, social, cultural, spatial benefits from the development of urban gardening and substantiate the importance of adequately measuring the results of «green» policies (urban greening) in the context of the principles of sustainable development [1]. Today the development of megacities, industrial and large industrial cities occurs due to the reduction of recreational landscaped areas on the background of general degradation of forest belts, as a result of which residents are uncomfortable due to increased levels of noise, vibration, thermal and electromagnetic radiation, dusting and gas contamination. Abroad, in conditions of urban land scarcity, vertical and horizontal facade gardening technologies (roofs and walls) are widely used to reduce negative impacts. It is proved that «green skyscrapers» have the best microclimate characteristics due to the processes of humidity control, energy consumption, noise and heat insulation, sun and wind protection [2]. However, in order to achieve the best sanitary effect, which is expressed in a high degree of dust absorption and assimilation of harmful substances from atmospheric air while maintaining the effects of reducing physical effects, traditional planting of massifs and strips of green spaces is required. According to the current legal norms, along with public gardening in urban areas, special landscaping systems are organized that play the role of a buffer area between an anthropogenic object and a residential area. These are sanitary protection and diverse security zones.
The author’s hypothesis consists in the following statement: the resource of urban space for landscaping is gradually decreasing, therefore engineering decisions are important that take into account the specific conditions for organizing environmentally protective landscaping as much as possible - the distance of the strip from the emission source, its spatial zoning, taking into account the intensity of the input of pollutants, the species composition of trees and shrubs, the nature of development of the adjacent residential area. In each specific urban situation, there is an optimal combination of these factors that ensure the greatest return on green infrastructure.

Despite the significant historical experience of landscaping the urban environment, a unified approach to assessing the environmental protection effectiveness of green spaces has not yet been formed. The relevance of the issue is determined by the fact that the creation and maintenance of green spaces, as fixed assets as part of the depreciable and taxable property of a business entity or municipality, requires significant costs.

The goal of the authors is to justify and illustrate by way of analysis of well-known approaches to assessing the quality of urban green spaces an example of a method for determining the optimal distance from an object to a protective strip of green spaces, as well as to formulate initial theoretical principles for choosing engineering solutions.

A general idea of efficiency, as an economic category, allows us to determine the sanitary effectiveness of environmentally protective landscaping as an indicator of the ratio of the positive result achieved over a specific period of time (assimilation and neutralization of toxicants) and the costs that ensured it. Measurable results are the value of avoided damage, reducing the concentration of impurities in the surface layer of the atmosphere in the space behind the strip plantations (background pollution) and the level of physical impacts, reduction of the size of the impact zone of the facility, improvement of sanitary-hygienic characteristics of climate. If the ratio exceeds one, the efficiency is achieved. However, «long» air protection investments at very low rates of payment and penalties for air pollution allow us to assume that it will at best be close to one.

Analysis of known approaches to assessing the quality of urban green spaces (table 1) allowed us to draw the following conclusions:

1. All scientific points of view are united by an understanding of the importance of the size (area) of the green mass in ensuring environmental protection properties, but at the same time, such important characteristics as the height and diameter of the emission source, flow rate, nature of pollutants and the specific conditions for their dispersion are not considered.

2. Most authors consider urban landscaping as an element of an ecosystem service, which makes it possible to apply not only point scales for expert assessments, but also global methods for assessing the cost of these services.

3. Filtering (assimilation) return of green areas depends not only on their size (area), spatial layout and species composition of plantations, but also on the location of the green band relative to the object of impact.

| Table 1. Quality indicators of urban green spaces. |
|--------------------------------------------------|
| Name of indicator | Formula for calculating | Assessment of analytical potential |
|-------------------|-------------------------|----------------------------------|
| 1. The zone of influence of a large green massif on the air quality of adjacent residential buildings (L) [4]. 2000. | \[ L = \frac{100 \times 0.1 B \times B}{S \times (1 + 8B)} \] | Clarity and accessibility. High air quality is manifested at a distance of 250-1000 m. |
| B - width of the green massif, km (0.25 ≤ B ≤ 10) | S – building density, % |
| 2. Plant quality factor (PQF) [5]. 2011. | \[ PQF = \frac{\sum b}{\sum b_{max}} \] | The ranges of values and quality levels are defined: 0–0.19 very low; 0.20–0.39 low; 0.40–0.59 average; 0.60–0.79 |
| Σb – the total score of the array of stands for a group of indicators |
3. Dust deposition rate ($F_{Li}$) [6]. 2011.

\[ F_{Li} = \frac{V_{di}}{LAI \cdot C_i} \]

$V_{di}$ - dust deposition rate; $LAI$ - index unilateral leaf surface (1-2 m2 leaf per 1 m2 of the array); $C_i$ - dust concentration

The wind regime of the territory (in the conditions of the canyon) – the wind speed over the roofs of houses create «routes of transfer and filtration» of toxicants

4. Area of required technical parks and squares ($S$) [7]. 2013.

\[ S = \frac{N_{cars} \cdot V_{em}}{K} \]

$N_{cars}$ - number of cars; $V_{em}$ - the emission of one car, kg; $K$ - specific absorption of substances, kg / m²

The type of exposure is specified and the wind regime, biological species and the cleaning ability of plants are taken into account

5. An indicator of comfort of green space for general use ($K$) [8]. 2015.

\[ K = 0,32 + 0,008X_1 - 0,0006X_2 - 0,088X_3 \]

$X_1$ - noise level; $X_2$ - green area; $X_3$ - the presence of a protective strip

It is proposed to allocate three zones in the protective band and take into account the amount of oxygen released. Applies only refers to the effects of transport

6. Ecological potential of the plant system of the city (green spaces) ($EP_{GS}$) [9]. 2018.

\[ EP_{GS} = \frac{\sum k_i \cdot S_i}{k_{max} \cdot S} \]

$k_i$ - ecological potential of urban greening element according to V. V. Mazing; $S_i$ - the element area of greenery, ha; $k_{max}$ - maximum ecological potential; $S$ - the total area of greenery, ha.

The application of the category of «ecological potential» of the gardening system and the use of the well-known grading scale makes the assessment complex

7. The quality factor of a gardening system ($K_q$) [9]. 2018.

\[ K_q = \frac{S_{real}}{S_{opt}} \]

Accounting for the area of the green area, the implementation of a set of requirements to ensure their quality and optimal condition

8. Integral indicator of the quality of the green area of common use ($\Pi_{QG}$) [10]. 2018.

\[ \Pi_{QG} = f(F_1, F_2, F_3, F_4, F_5) \]

$F_1$ - sanitary and hygienic; $F_2$ - social; $F_3$ - aesthetic; $F_4$ - legal; $F_5$ - economic factors

A set of criteria is proposed that determine the quality of the corresponding function or the conditions for its implementation

Finding ways of achieving the maximum environmental effect of the shortage of land and high densities of residential areas has allowed to develop a method of creating a protective strip of green plantings in the space of one or a group of sources (Krupina N. N., RF patent № 2649343, 2018).

The author’s approach takes into account the mechanisms generally recognized by the scientific community and the key factors for the dispersion of impurities in the atmospheric surface - layer of populated areas, the fact of the formation of a zone of stable pollution around an industrial object, and the key role of the wind and temperature conditions.

The method is based on determining the optimal distance to the protective strip of green spaces, adjusted for the value of the dangerous wind speed -XM (figure 1). You should first read the general plan of the city in order to take into account the location of large industrial facilities (emission sources), transport routes, residential areas. Then it is necessary to systematize general information...
about the village - the status of the territory, the features of the building and the terrain; prospects for the development of residential development and expansion of industrial enterprises; landscape, level of gardening and the state of woody-shrubby vegetation (age, condition, etc.); population size and density; weather conditions. Separately, it is necessary to analyze data on the wind regime, calm, precipitation, density of landscaping and the nature of development of the city.

**Designations:**
- \( H \) - source height, m; 
- \( D \) - the diameter of the mouth, m; 
- \( \omega_0 \) - the flow velocity, m/ s; 
- \( T \) - the air temperature; 
- \( T_E \) - emission temperature; 
- \( U \) - wind speed, m/s; 
- \( X_M \) - the distance from the object to the point in space where the maximum surface concentration of the substance is observed (the beginning of the strip of green spaces).

**Figure 1.** Key factors for choosing the location of the strip of green space between the industrial facility and the city’s residential areas.

Prior to the planting of tree and shrubby green spaces, according to long-term weather observations, the prevailing wind direction and speed are established for the terrain on which the protective strip will be created. The effect of the summation of the action of impurities is also taken into account and the priority pollutant is selected taking into account the geometric and technical parameters of a stationary organized source of emissions. As a result, the distance from the source to the point in space where its maximum concentration is observed is calculated. This is the best part of the urban space to place a protective strip of plants.

Typical situation is considered: in a multi-storey building, a domestic services complex and a city television center are located, a deflector (emission source) and three antennas (electromagnetic radiation sources) are installed on the roof of the building.

The building is surrounded by residential buildings at a distance of 500 m. Toxicants are suspended solids and colorful aerosol, the physical effect is electromagnetic radiation (EMR) from three antennas (rhombic horizontal double type and two in-phase horizontal band with adjustable reflector).

The total field strength at the source varies from 16.2 to 22.6 V / m, and in the surrounding space from 39.2 to 4.50 V / m. Hygiene standards (30 V / m) are exceeded at a distance of up to 200 m. Deflector height (N) - 3 m, diameter (D) - 1.5 m; emission temperature (T) - 28 °C and flow velocity (w0) - 2.8 m3 / s. The degree of mechanical purification of the flow is 80-85%. The maximum air temperature during the year is +25 0C (TW max), dangerous wind speed (um) - 0.35 and prevailing
(u) - 2.1 m/s. The coefficient of gravitational sedimentation of solid particles in the atmosphere on the underlying surface is 2.5.

These data were used in the calculations, according to the current method [3], and it was found that the best distance from the building to the protective strip of stands is 138 m, where there is a complete deposition of suspended solids and aerosol and neutralization of EMR at a shorter distance. It is preferable to create the strip along a closed perimeter with straight-line multi-tiered sections of medium-thick gas-resistant green spaces (a combination of trees and shrubs).

Typical situations are possible, such as the presence of several priority substances in an emission or the presence of a group of stationary sources of emissions nearby. Then the distance from the source to the protective strip of green spaces is determined as the arithmetic average of all the calculated values of individual values (Xm).

In the context of environmental engineering tasks, we formulate the provisions that should be taken into account when developing managerial decisions: aimed at improving the sanitizing effectiveness of the environmentally protective array:

1. Technogenic object has a complex negative aerotechnogenic impact, including dust, chemical pollution with harmful substances (toxicants), physical impact in the form of excessive heat, noise, vibration, electromagnetic or radiation. Around it is formed shifted towards the wind stable «cloud of pollution» circular shape, in which the maximum concentration of the toxicant is fixed at a distance directly proportional to the power of the flow and inversely proportional to the square of the height of the source. In the transition to the best available technologies, the assessment of the level of negative impact is carried out only on priority substances (markers), taking into account the effect of summation of action, migration properties, the ability to accumulate in water and soil and transformation into more dangerous chemical forms. These include substances that pose the greatest danger to the population and biota objects in a particular region, which is established on the basis of monitoring data, statistical reporting on emissions.

2. Lightproof strip as engineering-biological object of the urban green infrastructure, primarily neutralizes and reduces a certain kind of negative aerial technogenic impact (dust removal, noise protection, gas cleaning). A positive result can be quantified by the amount of environmental damage prevented or directly measured by the amount of the assimilated pollutant. The maximum efficiency is observed when placing a strip of plantings at a distance corresponding to the maximum concentration of impurities in the surface layer of the atmosphere, and is determined by calculation.

3. Abatement (sanitary) function priority for landscaping a special purpose unlike recreational and ornamental functions spaces. It forms the basis of a comfortable urban environment. The most effective action is manifested locally, so it is important to choose correctly gas-resistant species of trees and shrubs, adequately determine the location and spatial design of the strip of plantings, to assess the full range of determining factors. It is the simultaneous consideration of the technical characteristics of the emission source, the nature of pollutants and the conditions of their dispersion that allows for dense construction or urban land shortage to obtain the desired result with the smallest area of the planting strip.

So, in the system of green infrastructure, environmentally-protective arrays and planting strips occupy a special place as a passive special air-protection engineering measure provided for by environmental, land urban planning legislation. The solution to the problem of creating a comfortable and safe urban environment aims at maximizing the conservation of limited land, material and financial resources through the optimization of the spatial organization of environmental protection landscaping. Evaluation of the quality and effectiveness of green spaces should also be included in the system of territorial planning and environmental zoning in accordance with the established procedure for civil circulation and regional regulations for the protection of green spaces.

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