The role of greening in the formation of the urban environment on the example of the residential area in Izhevsk

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Abstract. The issue of greening urban areas has become especially acute lately. In many cities, there is a negative trend of infill development in existing residential neighborhoods. At the same time, public spaces with elements of landscaping and park zones are primarily affected. The situation is not always favorable with greening in newly built residential areas. There are miscalculations in the selection of the plants' assortment and the implementation of the project as a whole. The aim of the study was to assess the sanitary and hygienic state of trees, shrubs and lawns. According to the work program, a cameral study of landscaping projects was carried out on the territory of the urban settlement on Bersha Street. The existing landscaping areas were calculated and their compliance with the current landscaping standards was revealed. Recommendations have been developed for the selection of planting material for landscaping in new urban settlements in Izhevsk from the point of view of the oxygen-producing plantings' function.

1. Introduction
The importance of green areas in the formation of the urban environment is of great interest to a wide range of researchers and practitioners, ranging from greensmen to landscape designers and architects. In recent years, the number of publications covering the issues of the species composition of green spaces and their assessment has increased.

In various regions of the country, green spaces of large cities and other settlements are being studied. So, in several works, landscaping of such metropolitan cities as Moscow [1], Yekaterinburg [2] was considered. The geography of works devoted to the greening of large cities includes Tomsk [3], Ulan-Ude [4, 5], Chita and Ulan Bator [5], Khabarovsk [6], Bratsk [7], Yoshkar-Ola [8], Saransk [9, 10], Voronezh [11], Taganrog [12], Vladikavkaz [13], Nizhnaya Salda in Sverdlovsk region [14], Mendeleevsk [15], Perm [16], Izhevsk [17, 18].

Practically in all works, the issues of the ecological significance of green spaces as an environment-forming factor of the urban microclimate are considered. In some works, the question of the rational distribution of landscaping areas and their shortage is raised in accordance with the standards [19, 20, 21, 22, 23, 24].

Over the past decade, there has been a significant increase in the rate of infill development of residential apartment buildings in the territory of Izhevsk. Construction carried out in the courtyards of residential areas is mainly in places where tree plantations grow, thereby leaving the city without trees, and, accordingly, city residents without the most important oxygen-producing role of green spaces.
The purpose of the research was to identify compliance with the landscaping norms of new urban settlements' territories using the example of an urban settlement on Bersha Street, to analyze the quality of landscaping for the growth of the required number of trees per person.

The objectives of the research were: studying the normative literature, conducting a reconnaissance assessment of the area and taxation of existing plantings in a given territory, determining the species composition of plantings, assessing their oxygen-producing function, assessing the sanitary and hygienic state of trees, shrubs and lawns, conducting a camera study of greening projects for the territory of the urban settlement on Bersha Street, calculating the existing landscaping areas and their comparison with the current landscaping standards, developing recommendations based on research data on the selection of planting material for landscaping new urban settlements in Izhevsk in terms of the oxygen-producing function of the plantings.

When these recommendations are implemented, city residents will receive the required amount of oxygen and the air quality will also increase (trees filter dust, emit oxygen and phytoncides, trees reduce wind speed, have a positive effect on the aesthetic and emotional human state)[24].

Every year the building area of residential buildings is increasing and the number of trees in the city is decreasing, which is reflected in Figure 1.

![Figure 1. Commissioning of housing for the period from 2000 to 2017, thousand sq. m.](image)

According to the statistics of the Udmurt Republic for the period from 2000 to 2017, the building area increased more than 3 times, picking up in speed more and more every year.

The tendency of infill urban development was revealed, i.e., the construction of high-rise buildings is becoming denser in the central parts and urban settlements, the density of buildings is increasing. At the same time, the areas of courtyards are shrinking, the infrastructure is developing slowly, and extremely insufficient attention is paid to the landscaping of courtyards, squares and boulevards.

It should be noted that construction does not go beyond the city limits and is carried out in its central parts in the places where existing green spaces grow. Little attention is paid to the greening of new urban settlements.

Big cities have long been choking on air pollution. And the reason is not only the emissions of harmful substances into the atmosphere from industrial enterprises, but also from that the number of vehicles is growing so rapidly that green spaces do not have time to purify the cities' air. Park areas are
unevenly located and cannot efficiently clean the air. Greening of streets, balconies, courtyards of residential buildings, etc. can help in this problem.

Psychologists have long been talking about the beneficial effects of flowers and plants on the emotional state of people. Only one calm contemplation of a flower bed or flowers in a pot helps to improve the mood and calm down to any resident of the metropolis.

Green spaces in the city perform the following functions: sanitary and hygienic (wind and gas protection functions, phytoncidal effect, influence on thermal and radiation conditions, air humidity, wind formation) and decorative and organizational (landscape forming, planning, recreation organization of the urban population).

To a greater extent, trees in cities are negatively affected by air pollution, unfavorable thermal conditions of the soil, as well as a lack of moisture.

To neutralize carbon dioxide released during breathing by one person, at least 3 medium-sized trees are required. The design norm of the green area per person is 3.5m², whereas 10 years ago this figure was close to European cities and was 9m² per person. Oxygen-producing function in trees begins at the age of 40 to 60 years. Studies have found that 1 medium-sized tree releases about 2 liters of oxygen per day. This amount is enough to provide a person's breathing for 3 days[24, 25].

In a modern city, a person is constantly faced with oxygen starvation. Bad ecological situation leads to that the amount of harmful substances in the environment is increasing.

2. Materials and methods
The research was carried out in a new urban settlement on Bersha Street. The assessment of the sanitary and hygienic state of trees, shrubs and lawns was carried out according to generally accepted methods. A cameral study of landscaping projects was carried out on the territory of the urban settlement on Bersha Street. The existing landscaping areas and their compliance with the current landscaping standards were determined by calculation.

3. Results
According to the methodology, the number of residents of this urban settlement was calculated, the data are presented in Table 1.

| No. Lt. | Mail address | Construction address | Number of entrances in the house, pcs | Number of floors | Estimated number of citizens, people |
|---------|--------------|----------------------|--------------------------------------|-----------------|-------------------------------------|
| 1       | Arkhitektora Bersha 14 | 7-2D | 2 | 1 entrance-16 2 entrance-14 | 450 |
| 2       | Arkhitektora Bersha 16 | 7-2C | 3 | 1 entrance-17 2 entrance-18 3 entrance-15 | 750 |
| 3       | Under construction | 7-2E | 2 | 1 entrance-16 2 entrance-14 | 450 |
| 4       | Arkhitektora Bersha 2 | 7-2A | 3 | 1 entrance-17 2 entrance-18 3 entrance-15 | 750 |
| 5       | Arkhitektora Bersha 4 | 7-2B | 2 | 1 entrance-16 2 entrance-14 | 450 |
| 6       | Arkhitektora Bersha 5b1 | 8-2A | 2 | 10 | 300 |
| 7       | Arkhitektora Bersha 5b2 | 8-2B | 2 | 6 | 180 |
It was revealed that about 15 residents live on one floor. This assumption is based on the average statistical data that there are 4 apartments per floor - one-room, two-room, three-room and four-room. Accordingly, on average, 1 person lives in a one-room apartment, 2 people live in a two-room apartment, etc. According to the calculated data, it turned out that an average of 450 people live in one house. In the area of the conducted research in the new urban settlement on Bersha Street, the estimated number of residents was 4,755 people.

Based on the total number of residents, the estimated and actual area of landscaping required for a residential area is determined. The actual area of greening is taken from the acts of work performed. The calculation is presented in Table 2.

| Postal address | Construction address | Number of residents | Estimated landscaping area, m² | Actual landscaping area, m² |
|----------------|----------------------|---------------------|-------------------------------|----------------------------|
| 1              | Arkhitekta Bersha 43 | 8-5D                | 630                           | 630                        |
| 2              | Arkhitekta Bersha 43 | 8-5C                | 270                           | 270                        |
| 3              | Under construction  | 8-5E                | 270                           | 270                        |
| 4              | Arkhitekta Bersha 41 | 8-5C                | 255                           | 255                        |
| 5              | Total                |                     |                               | 4755                       |

The actual landscaping area exceeds the calculated one by 1550.6 m². A significant excess of the area is noted at the 7-2E facility under construction (1031 m²). For the rest of the objects, the deviations are not significant.
In urban conditions, the required number of trees recommended per person is 3 pcs. According to urban planning standards, 70% of the plantings should be in the park of a residential area. Such an object in the urban settlement on Bersha Street is "Tishino" park, the remaining 30% of trees should grow in the actual courtyard areas.

Table 3. Estimated and actual number of trees in the urban settlement.

| Mail address | Construction address | Number of inhabitant s | Estimated number of trees, pcs. | Actual number of trees, pcs. |
|--------------|----------------------|------------------------|---------------------------------|-----------------------------|
|              |                      |                        | total for given urban settlement | 30% trees, for a residential yard |
| 1            | 2                    | 3                      | 4                               | 5                           | 6                             |
| Arkhitektora Bersha 14 | 7-2D               | 450                    | 1350                            | 405                         | 19                            |
| Arkhitektora Bersha 16 | 7-2C               | 750                    | 2250                            | 675                         | 3                             |
| Under construction | 7-2E               | 450                    | 1350                            | 405                         | None                          |
| Arkhitektora Bersha 2 | 7-2A               | 750                    | 2250                            | 675                         | 3                             |
| Arkhitektora Bersha 4 | 7-2B               | 450                    | 1350                            | 405                         | None                          |
| Arkhitektora Bersha 5b1 | 8-2A              | 300                    | 900                             | 270                         | None                          |
| Arkhitektora Bersha 5b2 | 8-2B              | 180                    | 540                             | 162                         | None                          |
| Arkhitektora Bersha 5b3 | 8-2C              | 270                    | 810                             | 243                         | None                          |
| Arkhitektora Bersha 43 | 8-5D              | 630                    | 1890                            | 567                         |                               |
| Under construction | 8-5E              | 270                    | 810                             | 243                         | 50                            |
| Arkhitektora Bersha 41 | 8-5C              | 255                    | 765                             | 229,5                       |                               |
| Total         |                      |                        | 14265                           | 4279,5                      | 75                            |

There are only 75 trees on the actual greening area of the urban settlement amounting to 18193.1 m². In recent decades, there has been a tendency to increase the number of storeys in buildings under construction, so the number of residents is increasing significantly, while the greening area remains the same. Trees are planted at a young age, and they are unable to perform sanitary-protective and oxygen-producing functions. It is also noted that the landscaping areas do not allow for the placement of the necessary shrubs.

The calculation of the number of shrubs is presented in table 4.

Table 4. Estimated and actual number of shrubs.

| Postal address | Construction address | Number of Estimated number of Actual number of |
|----------------|----------------------|------------------------|---------------------------------|-----------------|
|                |                      |                        | shrubs, pcs.                   | shrubs, pcs.    |
|                |                      |                        | total for given urban settlement | 30% trees, for a residential yard |


There are only 458 shrubs on the actual greening area of the urban settlement amounting to 18193.1 m². According to the study, a shortage of shrubs was established in the amount of 13807 pieces. In October 2019, a reconnaissance survey of plantings was carried out in this area, the assortment of trees and shrubs was studied in the design documents. The results are presented in the table of table 5.

**Table 5. Assortment of plantings on Bersha Street.**

| No. bld. | Name                          | Quantity, pcs | Height, cm |
|----------|-------------------------------|---------------|------------|
| 7-2D; 7-2E | Rocky Mountain juniper       | 5             | 125-150    |
|          | Virginian juniper             | 6             | 60-90      |
|          | Savin juniper                 | 6             | 60-90      |
|          | Pfitzeriana Aurea             | 6             | 60-90      |
| 800-5E; 8-5D; 8-5C | Ornamental apple tree | 8             | 125-150    |
|           | Silver berry                  | 22            | 40-60      |
|           | Blue spruce                   | 4             | 150-175    |
|           | Black poplar                  | 21            | 150-175    |
|           | Canadian maple                | 15            | 125-150    |
| 7-2A; 7-2C; 7-2B | Green spruce                   | 10            | up to 1000 |
|           | Boxelder maple                | 2             | up to 700  |
| 7-2D; 7-2E | Norway maple                  | 1             | 150-175    |
|           | Amur maple                    | 8             | 100-125    |
|           | John Downey Crabapple tree    | 3             | 125-150    |
|           | Ornamental apple tree         | 3             | 125-150    |
| 7-2D; 7-2E | Spiraea × vanhouttei          | 28            | 40-60      |
| 8-5E; 8-5D | English dogwood               | 26            | 60-80      |
|           | Savin juniper                 | 10            | 60-80      |
According to the research results, the average age of trees at the time of planting is 6-8 years with an average height of 125-150 cm. To perform sanitary-protective and oxygen-producing functions, the required age of the plantings is 10-12 years. The total number of trees for the entire urban settlement was 75, of which 61 are deciduous and 14 are conifers, which is very small for such a densely populated area.

According to the species composition, predominating plants are those that correspond to the growing conditions in the Udmurt Republic, but there are plants that winter poorly in our climatic conditions, such as: Rocky Mountain juniper (*Juniperus scopulorum*); Virginian juniper (*Juniperus virginiana*); Norway maple (*Acer platanoides L*). On the territory adjacent to the houses located at Bershina Street 41, 43, 222 plantings of European boxwood (*Buxus sempervirens*) were identified, which is non-compliance with winter hardiness zones, because this shrub is exposed to frosting without appropriate shelter in the cold season.

The results of the sanitary and hygienic assessment of trees are shown in Table 6.

### Table 6. Sanitary and hygienic assessment of trees in 2019.

| Name                        | Quantity, pcs | Height, cm | Sanitary and hygienic condition |
|-----------------------------|---------------|------------|---------------------------------|
| **Coniferous trees**        |               |            |                                 |
| Blue spruce                 | 4             | 150-175    | 2                               |
| Green spruce                | 10            | 300-3500   | 2                               |
| Scots pine **               | 12            | 175-200    | 1                               |
| **Deciduous trees**         |               |            |                                 |
| Downy birch*               | 17            | 100-125    | 1                               |
| Ornamental apple tree       | 8             | 125-150    | 1                               |
| Rowan**                     | 6             | 125-150    | 2                               |
| Black poplar               | 21            | 150-175    | 2                               |
| Canadian maple             | 15            | 125-150    | 2                               |
| Boxelder maple             | 2             | Up to 700  | 1                               |
| Norway maple               | 1             | 150-175    | 1                               |
| Amur maple                 | 8             | 100-125    | 1                               |
| John Downey Crabapple tree | 3             | 125-150    | 1                               |
| Ornamental apple tree       | 3             | 125-150    | 1                               |

Note: * - trees planted by residents; ** - replanted trees.

### 4. Discussion

Comparing the design data and the existing plantings, it was revealed that about 80% of the trees corresponding to the declared projects grow on the territory, 5% of the trees did not take root (mortality) and 15% were planted by the residents of the houses. Of the newly planted trees, the following types of trees and shrubs were noted: Scots pine (*Pinus sylvestris L*), Rowan (*Sorbus aucuparia*). All trees were assessed on a categories' scale of the sanitary state of trees in accordance
with the "Rules for sanitary safety in forests" (approved by the Decree of the Government of the Russian Federation dated 09.12.2020 No. 2047).

The trees are estimated to be in good condition with an average hygiene score of 1.5. At the same time, 67% of trees have no signs of weakening and 33% of trees are classified as weakened.

Also, it was noted that the residents and the management company made and installed protective structures for external soil conservation in the zone of tree roots.

5. Conclusion

For the period from 2000 to 2017, the building area of new housing complexes has more than tripled. There is also an increase in the building density in the existing urban settlements of the city. Therefore, greening and landscaping of adjacent territories suffers.

Reconnaissance studies of landscaping and plantings areas in the urban settlement on Bersha Street revealed:

- the actual area of landscaping exceeds the calculated 1.1 times for one facility under construction (7-2E). No deviations were found for the rest of the objects;
- an insignificant number of trees and shrubs grows on the actual greening area of the urban settlement, which does not correspond to urban planning standards;
- the assortment of woody and shrubby plants is represented by three types of conifers, seven types of deciduous trees and seven types of shrubs;
- in general, the assortment of plants corresponds to the climatic conditions of the Udmurt Republic, but the existing plantings of European boxwood are not acclimatized to our conditions;
- 67% of trees belong to the category of sanitary condition of trees without signs of weakening.

According to the research carried out, the following can be recommended:
- to increase the number of trees and shrubs' planting in urban settlement of Izhevsk city;
- increase the age of the planted plants;
- select plants in strict accordance with the growing conditions, consider the winter hardiness zone, comply with other environmental requirements;
- when planting, observe the compositional concept to acquire the aesthetic appearance of plants;
- after the gardening work carried out, follow the care of the plantings: watering, additional nutrition, grass mowing in a timely manner;
- if possible, it is advisable to preserve the existing adult plantings during construction.

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