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Monitoring the dispersed composition of dust particles on the leaf blades of common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*) in urban agglomeration

Irina Glinyanova, Valery Azarov

Institute of Architecture and Construction, Volgograd State Technical University (VolgSTU), ul. Academic 1, Volgograd, 400074, Russia

E-mail: escue2019@yandex.ru

Abstract. The article presents the study results of dusty particles on the leaves of tree species forms in the residential area of the Srednehtubinsky district of the Volgograd region. The aim of the study was to monitor the dispersed composition of dust particles on various types of urban vegetation. Leaves of common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*) as mass plant species growing in the residential area of the Srednehtubinsky district of the Volgograd region were chosen as objects of study. The novelty of the work is the study dispersed composition of dust particles on the leaves of common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*) from the standpoint of random functions expressed by integral distribution curves of particle mass over their equivalent diameters. The measurement of dust particles, dust processing, and the study of dust dispersed composition of was carried out in accordance with GOST R 56929-2016 using the SPOTEXPLORER computer program. As a result of the studies, it was found that the surface of the laminate leaf of common lilac (*Syringa vulgaris*) and elm have the best adsorption ability small-leaved (*Ulmus parvifolia*). The study's results are of practical importance - they provide information on the urban plants ability of leaves surface to retain fine-dispersed dust, offer a specific range of plant species for urban green areas, which can use the regional public services greening of urban areas in order to reduce PM_{2.5} emissions of PM₁₀ in urban areas.

Fine dust (PM_{2.5}, PM₁₀) in the atmospheric air of the urban environment creates certain risks to human health, as there are numerous evidences from scientists from around the world [1-3].

Al-Thani H., Koc M., Isaifan RJ. also point out that fine dust pollution has “a serious adverse effect on materials, structures and climate, which directly affect the sustainability of urban cities” [4].

Accordingly, dust monitoring and environmental measures for dust control of PM_{2.5}, PM₁₀ are of current importance.

Urban plant communities have the unique ability to protect metropolitan areas from pollutants. L.I. Atkina, M.V. Ignatova in their study indicate the leaves dust-holding ability of apple berry (*Malus Baccatal*), common rowan (*Sorbus Aucuparia L.*), maple (*Acer Negundo L.*), and Siberian hawthorn (*Crataegus Sanguinea L.*) in the urban areas of Ekaterinburg. From the results of their work it can be seen that the amount of settled dust on the leaves is approximately the same for all species of the studied plants. At the same time, the author notes that it is slightly smaller on the berry apple (*Malus baccata*). The author suggests that this is likely due to the smaller size of the leaf blade [5].



Chernyshenko O.V. investigated the ability of urban plant communities to retain pollutants. Studies were conducted in Moscow. The author offers an assortment of tree species forms with increased dust-filtering ability. Chernyshenko O.V. concluded that “in areas of severe pollution, it is recommended to use fluffy ash (*Fraxinus pennsylvānica*), Ginnala maple (*Acer ginnala*), poplar, elm feather (*Ulmus pinnato-ramosa*), and mountain ash (*Sorbus Aucuparia L.*), Ussuri pear (*Pyrus ussuriēnsis*), hanging birch (*Bétula péndula*), small-leaved linden (*Tília cordáta*) as biofilters,. Chernyshenko O.V. also explored the shrubby vegetation of the urban area. According to the author, shrubs also have a high adsorption ability to retain dust. For example, “smooth leaves of golden currant (*Ribes aureum*) had the maximum dust-absorbing ability compared to other shrub species, and it was towards the end of the growing season” [6].

Recently, scientific papers have been published abroad, in which studied the possibility of various urban plants types to retain fine dust on the surface of leaf blades.

Thus Popek R., Lukowski A., Karolewski P. As a result of the studies, it was found that plants such as “common bird cherry (*P. Padus*), black cherry (*P. Serotina*) accumulated fine dust, mainly on the surface of their leaves, and not in the wax layer”. Moreover, the common bird cherry (*P. Padus*), according to the authors, accumulated dust more than black cherry (*P. Serotina*) [7].

Liang D., MaC., Wang Y. and others investigated 25 species of urban plants in Beijing and Chongqing. They determined that “broad-leaved species contribute to PM_{2.5} capture due to their rich leaf morphology and have an advantage over conifers in PM_{2.5} capture per leaf area. Nevertheless, conifers had a great ability to capture PM_{2.5} on a tree due to the advantage of a large leaf area” [8].

Zha Y., Shi Y., Tang J. and others found the largest accumulations number of PM, PM₁₀, and PM_{2.5} by the Himalayan cedar (*Cedrus deodara*). They studied the distribution of fine dust by mass and quantity among various tree species in Nanjing, identified dust particles in combination with a scanning electron microscope. As for the particle mass, 48% of the identified particles had a diameter of 10 µm, and only 18,3% of them had a diameter of 2,5 µm. As for the number of particles, their results showed that 73% of them had a diameter of 2,5 µm, and only 5,5% of them had a diameter of 10 µm [9].

ZhangW., Zhang Z., Meng H. And others experimented with leaves of coniferous (*Pinus tabuliformis* Carr., *Pinus Bungeana* Zucc.), broad-leaved (*Acer truncatum* Bunge, *Salix matsudana* Koid., *Populus tomentosa* Carr., *Ginkgo biloba* L.) trees. The researchers came to the interesting conclusion that the structure of leaves significantly affects the ability of plants to capture PM. Their study found that both coniferous and deciduous trees make a huge contribution to PM retention, while the authors proved that there are significant differences in the contact angle of leaves and drops (which indicates the wettability of leaves) and the ability of trees to capture PM ($p < 0, 05$). In their opinion, “the larger the wetting angle, the less the plant’s ability to capture solid particles” [10].

The aim of the study was to monitor the dispersed composition of dust particles on the leaf blades of common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*) as mass plant species growing in the residential zone of the Sredneahhtubinsky district of the Volgograd region. The novelty of the work is the study of dust particles dispersed composition on the leaves of common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*) from the standpoint of random functions expressed by integral distribution curves of particle mass over their equivalent diameters

The collection of material for the study was carried out at the end of June 2018 after the completion of intensive leaf growth. Leaf samples were taken at a height of 1,5-2 m crowns (the height of the layer of air inhaled by humans). The leaves were taken from 10 trees of small-leaved elm (*Ulmus parvifolia*), from 10 trees of common apricot (*Prunus armenica*), from 10 shrubs of common lilac (*Syringa vulgaris*). From 1 plant, 10 leaves were selected. In total, 30 trees and shrubs and 300 leaves were investigated in the residential area. When collecting leaves, attention was paid to the condition of the leaf plate: it should not be subject to changes, for example, traces of insect activity or the presence of bacterial necrosis or any other damage. Dust from the leaves of one sample (10 pieces of leaves) was washed off into a beaker with distilled water. The resulting suspension was filtered through the middle of the AFA-VP filter and dried at a temperature of no more than 30–40 ° C (the natural temperature of

atmospheric air in the summer in Volgograd and the Volgograd Region). The dried filtrate (dust from the leaves) was placed evenly on a glass slide, which was placed on an optical microscope. Each sample contained a flush of dust from 10 leaves of one plant species.

The measurement of dust particles, dust processing, the study of dust dispersed composition was carried out in accordance with paragraphs 11-13 of GOST R 56929-2016 using the computer program "SPOTEXPLORER".

Figure 1 shows the integral distribution curves of particle mass over their equivalent diameters in a probability-logarithmic grid for dust taken from the leaves of small-leaved elm (*Ulmus parvifolia*).

Figure 2 shows the integral distribution curves of particle mass over their equivalent diameters in a probability-logarithmic grid for dust taken from the leaves of common lilac (*Syringa vulgaris*).

Figure 3 shows the integral distribution curves of particle mass over their equivalent diameters in a probability-logarithmic grid for dust taken from the leaves of common apricot (*Prunus armenica*).

The studies of the dust dispersed composition on the leaves of common lilac (*Syringa vulgaris*), apricot trees (*Prunus armenica*), and small-leaved elm (*Ulmus parvifolia*) in the residential zone of the Srednehtubinsky district of the Volgograd region allow to conclude that its truncated log-normal distribution is subordinate.

Figure 4 (a, b) shows diagrams of the mass and quantity distribution of PM 2.5 over equivalent diameters, (%) on the leaf blades of common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*)

Figure 5 (a, b) shows diagrams of the mass and quantity distribution of PM 10 by equivalent diameters, (%) on the leaf blades of common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*).

Diagram analysis allows to diagnose the following:

- the largest distribution of the fine particles mass / (PM2.5) by equivalent diameters ($D(dh)$ (%) occurs on the leaves of small-leaved elm (*Ulmus parvifolia*) and apricot ordinary (*Prunus armenica*), and the largest distribution of the particles number (PM2.5) by equivalent diameters ($N(dch)$, %) is found only in common apricot (*Prunus armenica*);

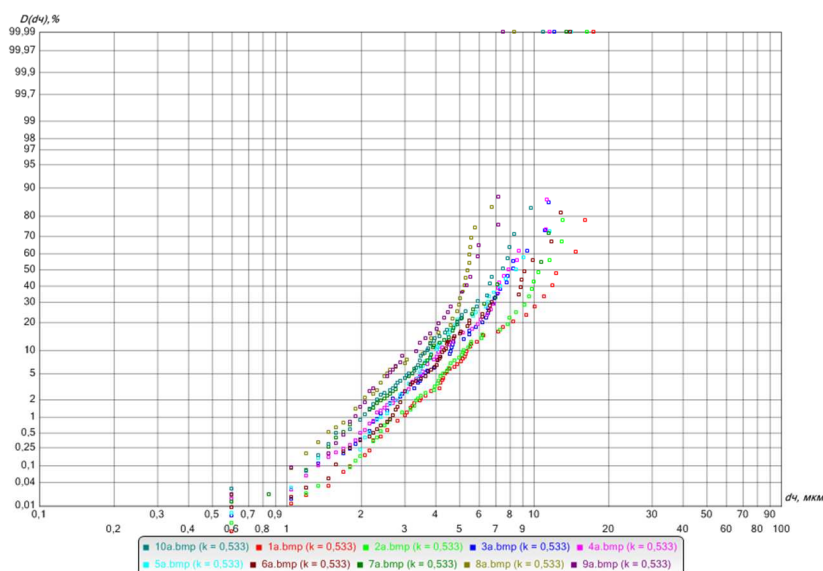


Figure 1. Integral distribution curves of particle mass over their equivalent diameters in a probability-logarithmic grid for dust taken from the leaves of small-leaved elm (*Ulmus parvifolia*).

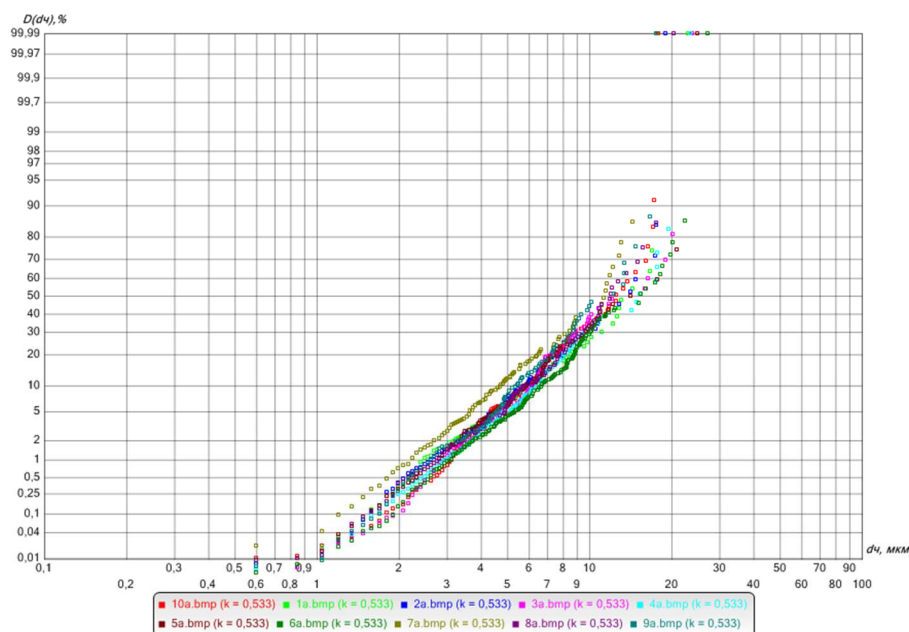


Figure 2. Integral distribution curves of particle mass over their equivalent diameters in a probability-logarithmic grid for dust taken from the leaves of common lilac (*Syringa vulgaris*).

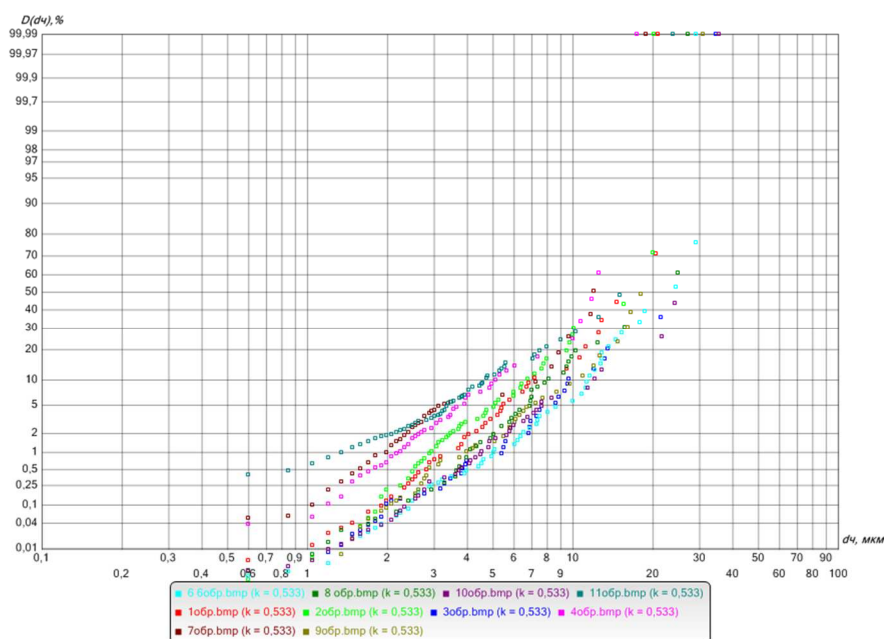


Figure 3. Integral distribution curves of particle mass over their equivalent diameters in a probability-logarithmic grid for dust taken from the leaves of an ordinary apricot (*Prunus armenica*).

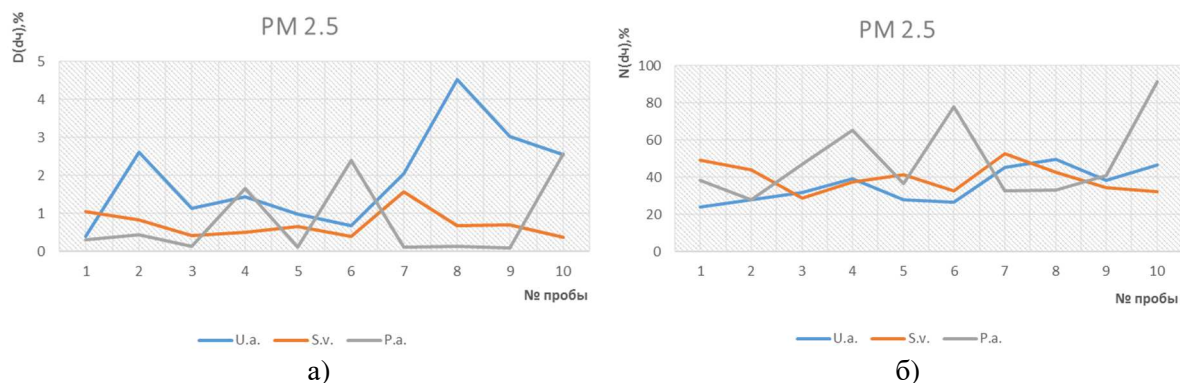


Figure 4. Mass and quantity distribution of PM 2.5 by equivalent diameters, (%) on the leaf blades of common lilac (*Syringa vulgaris*) (Sv), small-leaved elm (*Ulmus parvifolia*) (Ua), common apricot (*Prunus armenica*) (Pa): a) diagram of the particle mass distribution by diameter ($D(dh),\%$); b) a diagram of the distribution of the particles number by diameter ($N(dh),\%$).

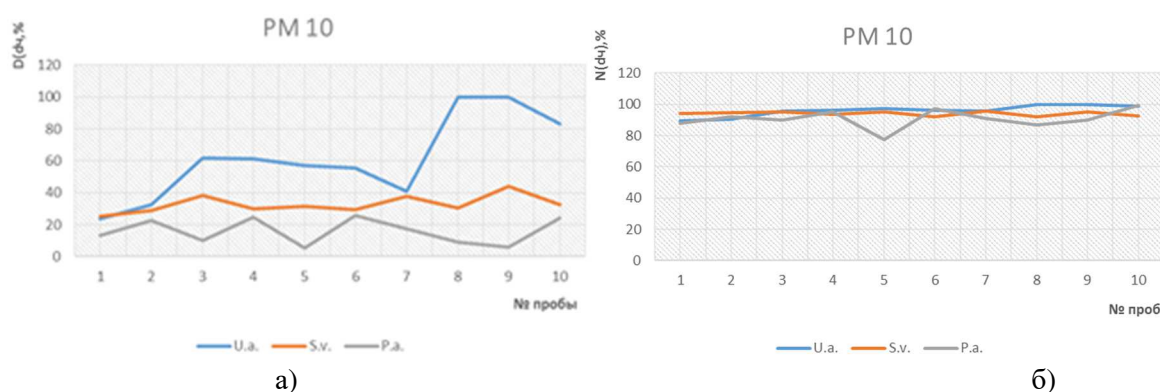


Figure 5. Mass and quantity distribution of PM 10 by equivalent diameters, (%) on the leaf blades of common lilac (*Syringa vulgaris*) (Sv), small-leaved elm (*Ulmus parvifolia*) (Ua), common apricot (*Prunus armenica*) (Pa): a) a diagram of the particle mass distribution by diameter ($D(dh),\%$); b) a diagram of the distribution of the particles number by diameter ($N(dh),\%$).

- the largest distribution of the fine particles mass / (PM10) by equivalent diameters ($D(dh),\%$) occurs only on the leaves of small-leaved elm (*Ulmus parvifolia*), and the distribution of the particles number (PM10) by equivalent diameters ($N(dh),\%$) is the same in all three species of the studied plants: common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*).

Conclusions: based on the monitoring of dust particles on the leaves of common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*), common apricot (*Prunus armenica*), the following significant results were obtained:

- the random distribution function of the mass fraction (%) of PM2.5, PM10 by equivalent diameters is determined, which describes the fractional dust composition;
- plants of the forest-steppe zone were identified in which the distribution of the particles number (PM2.5) by equivalent diameters or the surface retention of leaf blades occurs most of all - an ordinary apricot (*Prunus armenica*);
- plants of the forest-steppe zone were identified, on the leaves of which the particle mass distribution (PM2.5) most equivalently takes place over equivalent diameters, these are: ordinary apricot (*Prunus armenica*) and small-leaved elm (*Ulmus parvifolia*);

- the distribution of the particles number (PM10) over equivalent diameters or the surface retention of leaf blades of plants occurs identically in the three studied plants of the forest-steppe zone, these are common lilac (*Syringa vulgaris*), small-leaved elm (*Ulmus parvifolia*) and common apricot (*Prunus armenica*);

- the distribution of the particles number (PM10) over equivalent diameters or the retention by the surface of leaf blades occurs most of all among the elm (*Ulmus parvifolia*).

It should be noted, that obtained results are of practical importance and can be recommended to the city's landscaping services for planting certain types of plants in order to purify urban agglomerations from PM2.5, PM10.

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