Dust-holding capacity of tree plantation in the industrial area of Cherepovets, Russia

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Abstract. An important property of green spaces is the ability to capture dust particles from the atmosphere, thereby reducing its pollution. The main organs adsorbing dust are leaves, therefore, in this work, the dust-retaining capacity of woody plants was determined by leaves. These studies are relevant for the selection of an assortment of woody plants with increased dust-holding capacity for urban areas. The research work presents data on the dust-holding ability of the leaves of the following plant species of the industrial area of Cherepovets: Betula pendula, Crataegus sp., Quercus robur, Acer platanoides, Acer negundo, Tilia platyphyllos, Sorbus aucuparia, Malus sp., Cornus alba. To determine the amount of dust deposited by plant leaves, in the summer of 2022, leaf plates similar in morphology and age were collected in the industrial area of Cherepovets. According to the results of the study, the leaf surface has the highest dust-holding capacity of Betula pendula – 6.16 g/m2, the leaf surface of Sorbus aucuparia has the lowest dust-holding capacity is 0.87 g/m2.

1 Introduction

Green spaces are an obligatory component of urbanized areas. Along with the architectural, planning and aesthetic role of green spaces, sanitary and hygienic components are also important [1]. Therefore, a large number of scientific papers have recently appeared on the assessment of dust adsorption by different types of woody plants [2-7]. The use of such plants as a "green filter" is necessary not only for local improvement of the urban environment, but can also affect the greenhouse effect [2].

Cherepovets is a large industrial city with a developed transport system. There is a strong enough technogenic load. Gross emissions of solid substances into the atmosphere from stationary sources for 2021 amounted to approximately 28 thousand tons, half of which are emissions from metallurgical production (54%). [8]

Trees are considered the most important component in the process of capturing and settling dust pollution because they are larger and have a greate leaf area and biomass. Therefore, the study focused on the wood component. The main organs adsorbing dust are leaves, although dust partially settles on the branches and bark of woody plants [1].

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2 Methodology

The material was collected in the industrial area of Cherepovets. The city is located in the southwest of the Vologda Oblast (59°08′ N 37°55′ E) in the temperate continental climate zone, which is characterized by excessive moisture, warm short summers and long cold winters [9].

To determine the amount of dust deposited by plant leaves, in the summer of 2022, leaf plates similar in morphology and age were collected in the industrial area of Cherepovets. Samples of *Betula pendula* Roth, *Crataegus* sp., *Quercus robur* L., *Acer platanoides* L., *Acer negundo* L., *Tilia platyphyllos* Scop., *Sorbus aucuparia* L., *Malus* sp. and *Cornus alba* L. leaves were selected for analysis.

For woody plants, leaves were selected from a height of one and two meters, from different sides of the crown. The leaves were cut from the shoots (3-5 pieces for large-leaved, 7-10 for small-leaved species). Under laboratory conditions, dust particles were washed off with distilled water, followed by filtration through paper filters and their weighing on an electronic analytical scale. To determine the specific dust capacity, the area of the leaf blade was also calculated using the contour method. Both the upper and lower surfaces of the leaf were taken into account as the dust holding surface.

The specific dust-holding capacity of plant leaves was estimated by the formula (1):

$$C = m/S \quad (1)$$

where: C – specific dust-holding, g/m^2; m – mass of dust held by one sheet, mg; S – average area of one sheet, m^2.

The study was carried out on the basis of the Regional Shared Services Center of Cherepovets State University.

3 Results

As a result of the study, it is considered that the leaf surface of *Betula pendula* has the highest dust-holding capacity – 6.16 g/m², which is consistent with other research works [5]. The leaf surface of *Sorbus aucuparia* has the lowest dust-holding capacity – 0.87 g/m² (table 1), which is consistent with scientific research on the territory of Yoshkar-Ola [4].

When comparing the dust-holding capacity of leaves collected at different levels and from different sides of tree crowns no statistically significant differences were found.

Table 1. Dust-holding capacity of various types of tree plantations.

Type of plant	Sampling		Dust-holding capacity for sample, g/m^2	Dust-holding capacity for sample the species, g/m^2
	Crown Orientation	Height, m		
Betula pendula	South	1	3.97	6.16
	South	2	2.28	
	Northwest	1	12.22	
Crataegus sp.	South	1	3.31	3.81
	South	2	3.21	
	Northwest	1	1.91	
	Northwest	2	6.82	
Populus balsamifera	South	1	3.57	3.39
	South	2	3.93	
	North	1	3.06	
	North	2	2.98	

Type of plant	Sampling		Dust-holding capacity for sample, g/m^2	Dust-holding capacity for sample the species, g/m^2
	Crown Orientation	Height, m		
Cornus alba	South	1	1.10	1.02
	Northwest	1	0.93	
Quercus robur	South	2	2.45	2.85
	Northwest	1	3.43	
	Northwest	2	2.66	
Acer platanoides	South	2	2.84	2.84
	Northwest	2	2.83	
Acer negundo	South	1	11.86	5.36
	South	2	5.67	
	Northwest	1	1.91	
	Northwest	2	1.98	
Tilia platyphyllos	South	1	0.74	1.14
	South	2	1.30	
	Northwest	1	1.95	
	Northwest	2	0.57	
Sorbus aucuparia	South	1	0.71	0.87
	South	2	0.76	
	Northwest	1	1.08	
	Northwest	2	0.94	
Malus sp.	South	1	2.20	2.70
	South	2	2.54	
	Northwest	1	3.68	
	Northwest	2	2.36	

The studied tree species can be arranged in order of decreasing dust-holding properties in the next row: *Betula pendula*> *Acer negundo*> *Crataegus* sp.> *Populus balsamifera*> *Quercus robur*> *Acer platanoides*> *Malus* sp.> *Tilia platyphyllos*> *Cornus alba*> *Sorbus aucuparia*.

The dust-holding capacity of the studied species of tree plantations was assessed in points using the scale [10] (table 2). Species with the highest score were not identified, only separate leaf samples taken from *Betula pendula* and *Acer negundo* correspond to it.

Table 2. Dust-holding capacity assessment scale and distribution of the studied tree species by groups

Retained dust mass, g/m^2	Dust-holding capacity rating		Type of plant
	Degree	Score	
< 1	extremely low	1	*Cornus alba, Sorbus aucuparia*
1.1 – 3.0	moderate	2	*Quercus robur, Acer platanoides, Tilia platyphyllos,* Malus sp.
3.1 – 5.0	average	3	Crataegus sp., Populus sp.
5.1 – 7.0	high	4	*Betula pendula, Acer negundo*
> 7.0	highest	5	-

The dust-holding capacity of the same species can differ significantly, sometimes by 3 to 6 times. Most likely, this is due to the peculiarities of the location of plants in plantings: growth in linear plantings, solitary, in small groups, shielding by shrubs or crowns of large trees, remoteness from the highway.

The species specificity of dust-holding capacity is indicated by the works of other researchers [5, 6]. This is usually associated with the presence / absence of pubescence and glands on the leaves, the abundance of veins, which are irregularities on the surface of the leaf blade, electrostatic effects and crown features.

4 Conclusion

As a result of this study, the dust-holding capacity of leaves of such species as *Betula pendula*, Crataegus sp., *Quercus robur*, *Acer platanoides*, *Acer negundo*, *Tilia platyphyllos*, *Sorbus aucuparia*, Malus sp., *Cornus alba*. The leaf surface of *Betula pendula*, *Acer negundo*, Crataegus sp., has the highest dust-holding capacity. The leaf surface of *Sorbus aucuparia*, *Cornus alba*, *Tilia platyphyllos* has the lowest dust-holding capacity. Plants that form a leaf surface of a larger area are promising for dust collection.

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