Foliar dust on leaves of some perennials

Authors: Szabo, Veronika[1], Kohut, Ildiko[1]

[1]Hungarian University of Agriculture and Life Science Institute of Landscape Architecture, Urban Planning and Garden Art, Department of Floriculture and Dendrology

Abstract

Trees can deposit the air-borne dust on their leaves thus they can improve air quality in urban conditions. The degree of deposition is also affected by the species, the shape and the surface of leaves. In addition to the trees, we also find herbaceous plants, perennials, annuals and shrubs in a public places to imitate the forest ecosystems, and on their leaves, the air-borne dust can also deposited.

Next to a busy road (Astoria, VII. district, Budapest), there is a flower bed where we collected leaf-samples of some species to determine the amount of dust on their leaves. We chose the following species from the flowerbed: *Coreopsis grandiflora*, *Gaillardia aristata*, *Tradescantia* × *andersoniana*, *Rosa* sp. and *Verbena bonariensis*.

The samples were prepared according to Margitai and Braun (2005). Beakers were weighed beforehand and the leaf samples were washed into the beakers with 80 ml of distilled water and shaken on a shaker for 2 hours. The leaves were then removed and the distilled water from the suspension containing the powder was evaporated in a drying oven at 115 Celsius-degrees. After that, the beakers were weighed again and the amount of dust deposited by the leaves was calculated by subtracting the starting weight. Individual leaf area was determined by a leaf scanner to count the total leaf area of species.

The leaf surface of each species differs significantly, however, their ability to deposit dust depends on the surface of the leaves (hairiness, roughness, etc.). As in forest ecosystems, it is important for the green surfaces in cities to have three levels (such as perennials, shrubs and trees). These levels can filter more effectively the dust from urban air. If we developed three-level plantings between roads and pathways, the filtering effect can also be increased. This solution not only satisfies our aesthetic needs but is also useful. Further studies are needed to prove this.

Introduction

The important role of trees in the city and in mitigating of environmental impacts is recognized worldwide (Willis and Petrokofsky 2017). But not the trees are the most planted in the city, the urban landscapes are changing also in Hungary. More and more perennials and annuals are planted in cities every year for which contamination is equally dangerous. Concentrations of pollutants in urban air are very high, sometimes exceeding the health limit. The most important are dust, smoke and various gases. The airborne dust consists of two parts based on the constituent particles: a cloud of sedimentary dust, which is the sum of particles of organic and inorganic origin larger than 10 μm (PM 10), and finer particulate matter (PM 2.5) with a finer particle size (Endre et al. 2007).

Background and Literature Review

It is well-known that the trees can deposit the air-borne dust on their leaves thus they can improve air quality in urban conditions (Hrotkó et al. 2021; McDonald et al. 2007). The degree of deposition is also affected by the species, the shape and the surface of leaves (Kovács 1985;

Yunus et al. 1985). Furthermore, the wind velocity, and the location of leaves affect the amount of dust deposited (Han et al. 2020). In addition to the trees, we also find herbaceous plants, perennials, annuals and shrubs in a public places, on the leaves of which some of the air-borne dust can also deposit.

Liu et al. (2012) determined four different types of the urban areas, and the morphological traits of their leaves such as wax, cuticle and stomata what factors can change the amount of deposition. By De Micco et al. (2020) the main aim of this study was to analyze whether the deposition of dust can induce changes in leaf anatomical functional traits and in the efficiency of photosynthetic apparatus in *Centranthus ruber.*

Dust deposited on the leaves can inhibit the stoma conductance, allowing less sunlight to pass through, thus reducing plant growth and photosynthesis, thereby increasing leaf surface temperature, leading to increased water loss by evaporation (Sieghardt et al. 2005). Morphological deformities also occur in plants exposed to environmental damage. The source of pollution and its distance also affect this.

Al faifi and El-Shabasy (2021) investigated the effect of cement dust on the grass species *Cenchrus ciliaris* L., which caused morphological changes. This grass has a high tolerance to drought and salt stress. In their conclusion, *Cenchrus ciliaris* L. is a standard heavy metal tolerant species, which can accumulate and restore areas contaminated by these pollutions.

Reidenbach and Pacalaj (2010) installed a mixed perennial bed on a busy street in Erfurt, Germany. The accumulation of copper in the plants was examined, which was significantly increased, especially for *Geranium macrorrhizum*, measuring a load of 160% compared to the control. It was found that the tested plants (*Carex morrowii*, *Aster divaricatus*, *Helleborus orientalis*, *Deschampsia cespitosa* 'Tardiflora', *Epimedium × perralchium* 'Frohnleiten', *Heuchera villosa* var. *macrorrhiza*, *Anemone sylvestris*, *Geranium macrorrhizum* 'Beavan's Variety', *Waldsteinia geoides*) can deposit the fine dust and control air pollution. The fine dust, particle size below 10 µm is dangerous for cardiovascular disease and respiratory diseases, lung disease.

An important aspect of the usage of urban plants is that we try to imitate diversity, biodiversity and leveling of nature (lawn, perennial, shrub and tree levels) as much as possible with urban vegetation. Thus, in addition to their urban tolerance, it is also a very important aspect to meet these requirements as much as possible (Alvey 2006; Nowak and Dwyer 2007).

Method and Data

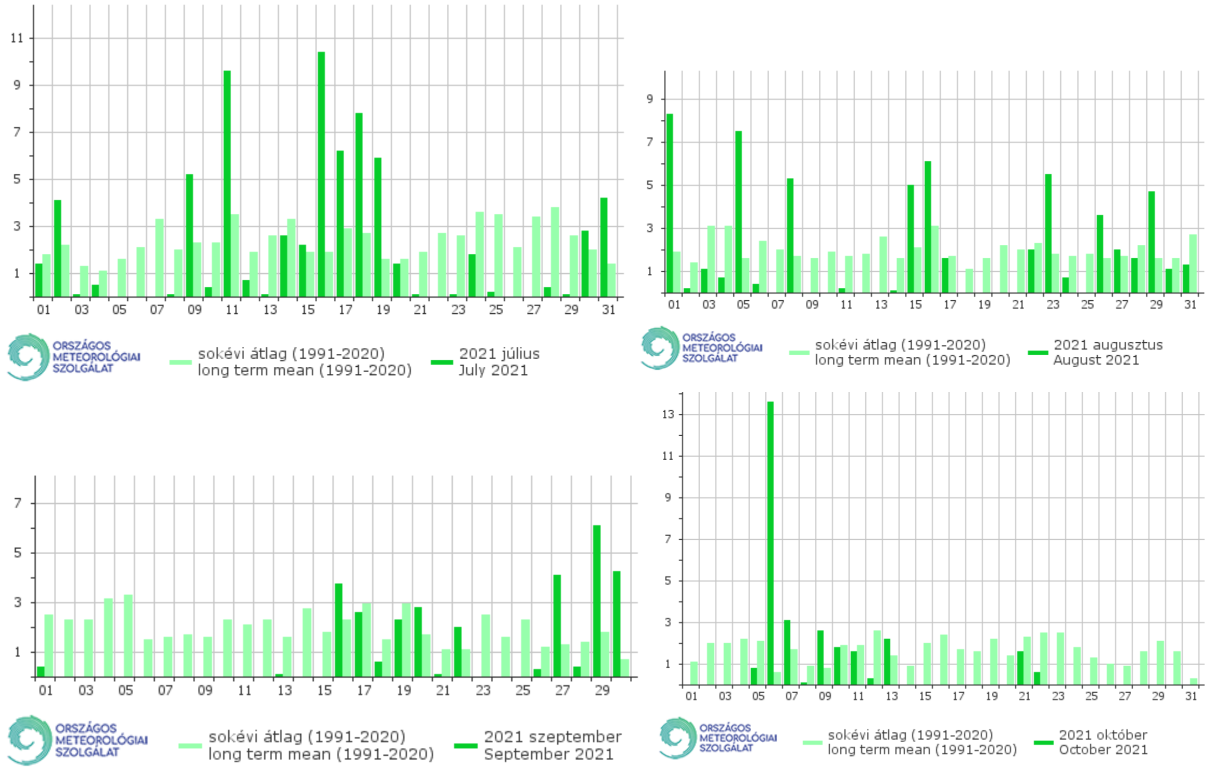
Next to a busy road (Astoria, VII. district, Budapest), there is a flowerbed where we collected leafsamples of some species to determine the amount of dust on their leaves. We chose the following species from the flowerbed: *Coreopsis grandiflora*, *Gaillardia aristata*, *Tradescantia × andersoniana*, *Rosa* sp. and *Verbena bonariensis*. *Coreopsis* is a short-lived plant, the lowest leaf are undivided, becoming split into narrow or lancelike lobs farther un the stem, the upper half of the flower stalk lack leaves. *Gaillardia* has a basal rosette, the leaves are entire, toothed or lobed, lance-shaped (Rice 2006). *Verbena* is an 80-120 cm high annual plant, but its seeds easily overwinter and germinate. Its stem is rectangular and rigid, its leaves are narrow, with serrulated margins and stand opposite. *Tradescantia* is a well-known perennial plant too, these plants have a 48-80 cm high standing up stem, with linear, stalked, drooping, sedge-like, medium green leaves (Szabó et al. 2017).

The samples were prepared according to Margitai and Braun (2005). We weighed the beakers beforehand and the wash the leaf samples into the beakers with 80 ml of distilled water and shook on a shaker for 2 hours. We removed the leaves from liquid. We took the beakers full of the distilled water and wash-off dust into drying oven to evaporate destilled water at 115 Celsius degrees. After that, we weighed the beakers again and calculated the amount of dust deposited by the leaves. We determined the individual leaf area with a leaf scanner to count the total leaf area of species. We took three samples from each plant, i.e. the amount of deposited dust was determined in the case of three leaves.

We counted leaf numbers on some plants (three times per species) one time in the season (in August). The collected leaves were scanned with a leaf scanner (AM 350 portable leaf area meter, BioScience Ltd, UK) to determine the individual leaf area (cm^2). The leaf number was multiplied by the leaf area to obtain the average total leaf area per plant. The total amount of deposited dust was calculated from the amount of washed dust and leaf area.

The weather was varied in precipitation (fig. 1.). July and August were quite rainy, but in the first half of September was a dry period. The first half of October also was rainy.

Figure 1. The amount of precipitation in the investigated season, from July to October 2021 (Source: internet 1)



We organized the data into an excel sheet to evaluate them. From the data a table and a diagram were made.

Results

The individual leaf size is shown in table 1. *Rosa sp.* has got the smallest leaves at both times (4,545 and 6,628 cm^2). *Verbena* is the following (6,308 and 7,157 cm^2). *Coreopsis* has 7,136 cm^2 individual leaf size on average in July, but is increased to 14,272cm^2. *Gaillardia* leaves are 18,013 cm^2 large in July, but their individual surface became smaller by October (13,953 cm^2).

The amount of deposited dust showed similar rates in both months. *Rosa* deposited the least dust (0,076 and 0,089 mg/cm^2), followed in ascending order: *Gaillardia*, *Coreopsis* and

Tradescantia. *Verbena* deposited dust in varying degrees in the two different months. In July it deposited 1,468 mg/cm^2 dust, but in October only 0,219 mg/cm^2.

The number of leaves per plant is the following: *Verbena* has the fewest leaves (94 pcs), *Gaillardia* and *Coreopsis* have the same leaf number per plant on average. *Rosa* has got 123 pcs of leaves and *Verbena* has got the most leaves (379 pcs) on average (table 1.).

Table 1. Average of individual leaf area (cm^2), deposited dust (mg/cm^2) and total leaf area per plant (cm^2) of investigated plants. Astoria, Budapest, 2021

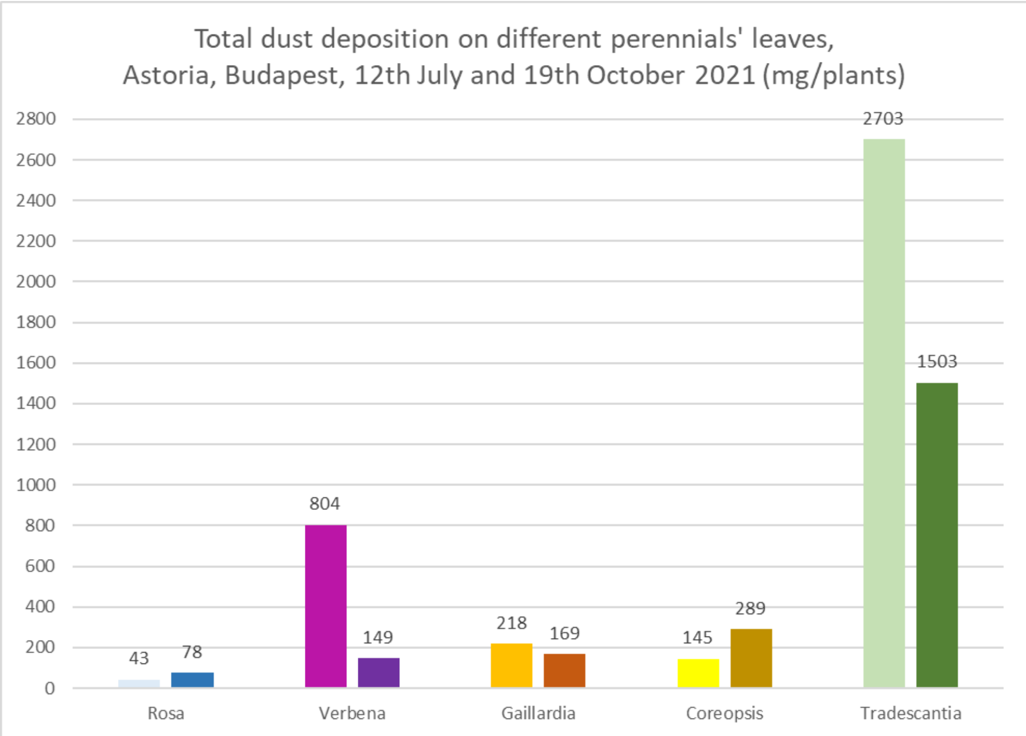
name of species	average of individual leaf area (cm^2)	deposited dust (mg/cm^2)	leaf number per plant (pcs)*	total leaf area per plant (cm^2)
	12th July 2021			
Rosa	4,545	0,076	123	559
Verbena	6,308	1,468	94	593
Gaillardia	18,013	0,110	118	2126
Coreopsis	7,136	0,175	118	842
Tradescantia	17,827	0,417	379	6756
	19th October 2021			
Rosa	6,628	0,089	123	815
Verbena	7,157	0,219	94	673
Gaillardia	13,953	0,103	118	1647
Coreopsis	14,272	0,170	118	1684
Tradescantia	10,660	0,421	379	4040

* Leaf number per plant was counted only once during season (in August) thus we counted with the same leaf number per plant.

The data on the total deposition of investigated perennial species are shown in figure 2. The least dust was deposited by *Rosa sp*. in both months. *Gaillardia* and *Coreopsis* deposited dust in almost the same proportion (between 145 and 289 mg per plant). *Tradescantia* provided outstanding performance in dust deposition in both months (2703 and 1503 mg per plant). *Verbena* has a unique situation. In July it deposited 804 mg of dust, but in October only 149 mg of dust.

We examine the differences between the two months; we can say that *Rosa* and *Coreopsis* show on increasing trend in dust deposition (fig. 2.). *Verbena*, *Gaillardia* and *Tradescantia* show a decreasing trend in it.

Figure 2. Total dust deposition on different perennials' leaves, Astoria, Budapest,12th July (left column) and 19th October (right column) 2021



Discussion and Conclusions

As for the characteristics of the species, we have worked with very different species in this research. The leaf surface of each species differs significantly, however, their ability to deposit dust depends on the surface of the leaves (hairiness, roughness, etc.).

Rosa has got small leaves, but it has a large number of leaves. Its leaves are shiny and smooth, therefore, it is weak in dust deposition. Despite the low rainfall *Rosa* can improve the amount of deposited dust on their leaves by October. This may be due to the fact, that the rose's small leaves were less likely to be hit by raindrops, so there was less washing from the surface.

The values of *Verbena* have changed significantly as far as the dust is concerned. Despite the lack of numerous leaves, it can deposit a lot of dust on its rough leaf surface, which can be easily washed away by rainwater later. Thus, there is less risk of physiological deformation due to dust deposition according to Sieghardt et al. 2005.

Although the leaves of *Gaillardia* are hairier (Rice 2006), the individual leaf size has decreased until October, so its deposition capacity decreases over time. The size of the individual leaf area may have changed because the withered leaves have been removed and the newly formed leaves have a smaller individual leaf area.

On the contrary, *Coreopsis* doubled its individual leaf area by the end of the investigated period, so the amount of dust that could be deposited on the leaves could increase. Thus, with almost the same dust-depositing capacity, it is important how the leaf sizes and a number of leaves of used species change.

Tradescantia has got the largest individual leaf area and leaf number, so it has an outstanding performance of dust deposition. However, the surface of the leaf is smooth, so dust is easily washed away by rain, so like *Gaillardia*, it is more resistant to negative effects.

In order to maintain biodiversity in an urban green surface, it is important that the plants are diverse. In addition to their beauty and the ecological services they provide, it is important that they tolerate severe urban conditions (Alvey, 2006; Nowak and Dwyer, 2007).

The ecological service of the investigated perennial plants is as good as that of the trees. At the lower level of the atmosphere, they are able to deposit the air-borne dust well, although to varying degrees, of course. In the future, we plan to continue and expand the research with additional perennial flowerbeds and the examination of leaf surfaces.

In Hungary, researchers have only studied dust deposition in the case of trees, and few researchers usually deal with perennial plants.

The species that tolerate polluted air, trampling and salting are the ones that are mainly suitable for urban green surface. Some perennial books (Rice, 2006; Szabó et al. 2017) also indicate what perennials are, and the biodiversity is also very important today.

The degree of dust deposition is affected by the distance of the plant from the source of contamination, i.e. more dust is deposited on it in the flower bed along the busy road than e.g. in a pedestrian street; the extent and intensity of the pollution; leaf morphology and water content of leaves.

In our present research, we examined plants at a specific location (Astoria square) in only two different months (July and October). In the future, we plan to examine several sites by measuring several times during the growing season. We also plan to include additional perennial species in the experiment.

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