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A Relative Analysis of Carbon and Dust Uptake by Important Tree Species in Tehran, Iran

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Abstract**—**Air pollution, particularly with dust, is one of the biggest issues Tehran is dealing with, and the city's green space which consists of trees has a critical role in absorption of it. The question this study aimed to investigate was which tree species the highest uptake capacity of the dust and carbon have suspended in the air. On this basis, 30 samples of trees from two different districts in Tehran were collected, and after washing and centrifuging, the samples were oven dried. The results of the study revealed that Ulmus minor had the highest amount of deposited dust in both districts. In addition, it was found that in Chamran district Ailanthus altissima and in Gandi district Ulmus minor has had the highest absorption of deposited carbon. Therefore, it could be argued that decision making on the selection of species for urban green spaces should take the above-mentioned parameters into account.

Keywords**—**Dust, leaves, uptake total carbon, tehran, tree species.

I. Introduction

AIR quality has become a major concern in developing countries such as Iran. The economic burden of diseases from air pollution in Iranian mega-cities exceeds 8 billion dollars annually [18]. The World Health Organization states that 2.4 million people die annually and the causes are directly attributable to air pollution [19]. Tehran, (population: 8.5 million), has suffered from rapid and unplanned urbanization in recent years resulting in substantial environmental impacts, perhaps the most notable of which is undesirable air quality. Tehran air pollution is a major problem which causes a growth in respiratory and cardiovascular illnesses and mortality for the past three decades [3].

Many different studies were emphasized on the importance of green space and its effects on human health, especially in the megacities. Trees with a huge amount of biomass may filter air and remove pollution [4]. The green space has received increasing attention for dust or other pollutants removal, in recent years [22], [23], [25]. The green space plants can effectively improve air quality by blocking dust through interception and fixation [24]-[27]. The dust removal ability of plants depends on different factors such as leaf structures (veins, trachoma, etc.), structural complexity of foliage and branches between species [12] and ambient dust concentration in different functional zones in cities (industrial zone > commercial traffic zone > residential zone > clean zone) [24].

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The deposited dust on the street could be resuspended by traffic, and it has the remarkable role in urban air quality. In contrast, tree leaves capture and hold deposited dust. For these reasons, trees (plants) have an important role to prevent dust resuspension. Green spaces near the roadways could help to reduce traffic-related air pollutants especially dust [31]. For example, tree leaves can act as biologic accumulator of dust and remove air pollution by intercepting particulate matter on plant surfaces and absorbing gaseous pollutants through the leaf stomata [23], [28] and *Platanusorientalis*, *Ulmus minor* and *Robinia pseudoacacia* leaves with varying blade structure were collected from the street sides of Tehran, and these trees are the most abundant species in urban green spaces [30]. On this basis, it could be concluded that trees can do the process of pollutants absorption in different ways. So, taking this fact into consideration can put useful implications for planting and management of appropriate species in urban areas forward [12], [22].

In Tehran, air quality is affected by dust with a variety of stationary or mobile emission sources and anthropogenic and natural sources. Dust is generally made of solid and liquid particles in the air that could be directly released in the air which is called primary particle matter or generated through gaseous precursors such as sulfur dioxide, oxides of nitrogen, ammonia and non-methane volatile organic compounds known as secondary particles. The list of health care problems caused by dust is long and has been introduced for ages [9], [17]. In terms of size, the dust could be categorized into three groups: coarse, fine, and ultrafine particles. Fine particles, mostly due to combustion activities, could have direct emission into the air. It could also be produced as a result of chemical reactions in gases like sulfur dioxide, nitrogen dioxide, and some organic gases. Coarse particles mainly experience a dichotomy of rural particles such as dust and urban particles as road dust, construction and demolition, industries, and biological sources [15].

Sources giving rise to emission of dust are soil, dust lifted by weather, volcanic eruptions, and pollution. Atmospheric or wind-borne dust, also known as aeolian dust, comes from arid and dry regions where high-velocity winds are able to remove mostly silt-sized materials, deflating susceptible surfaces. This includes areas where grazing, vehicle use, and other human activities have further destabilized the land, though not all source areas have been largely affected by anthropogenic impacts [13].

In recent decades, there have been numerous studies on the characteristic identification of deposited dust and their relationship with health problems [32]. The deposited dust comprises a mixture of several toxic and carcinogenic elements, compounds such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), etc. [22].

The carbonaceous aerosol is a major component of urban dust. The quantity of Total Carbon present in the atmosphere is composed of Elemental Carbon (EC) and Organic Carbon (OC) although a minor fraction of carbonate carbon could be also present. Carbonaceous particles have great importance at both local and global scale. In fact, at the local scale, they account for a large part of dust concentration, and there is evidence for a relationship between the presence of carbonaceous dust and cardiovascular disease and mortality. The carbonaceous fraction can be of primary or secondary origin and they can have either natural or anthropogenic origin. Primary carbonaceous particles of natural origin are plant debris, spores, bacteria and wild fires in general, while primary anthropogenic carbonaceous particles are mainly originated by incomplete combustion processes. Secondary particles of natural origin are formed by biogenic VOCs-to-particle conversion, while secondary anthropogenic carbonaceous particles are mainly originated from oxidation due to hydroxyl radical, ozone and nitrate radical [2].

II. Material and Method

Tehran, as the capital city of Iran, according to statistics released in 2011, hosts 8.5 of residents. The average temperature of Tehran is equal to 17 °C, while there is averagely 230 mm of rainfall in this city annually. Tehran has been announced as the 19th largest city in terms of population and one of the largest cities in western Asia. The city covers an area over 700 km^2 and is situated between 35 34'and 35 50'. The capital of Iran is crucially struggling with air pollution that is owing to various reasons such as population increase, a huge rise personal car use, and insufficient as well as inadequate public transportation has been intensified. The geographical features have also had a role in creating the current situation. Surrounding Alborz mountain range to the north and northeast has had a detrimental impact on winds in the east that could result in pollutants' dissipation. Daily air pollution in Tehran alone kills about 30 people [1], [7], [8], [10], [14].

To select sampling sites, first a long-term dust concentration data from air quality monitoring stations were analyzed and then roadway types near each station were investigated on the map. Finally, by site visiting, two out of the most polluted areas and suitable sampling sites for DS on tree leaves were selected. These sites were located in Gandy Street (as a residential-commercial road) and Chamran highway. 30 samples from five tree species each. Tree species were *Morusalba*, *Ailanthus altissima*, *Platanusorientalis*, *Robinia pseudoacacia* and *Ulmusminor*, which are the frequently-found trees in these areas. Samples were collected randomly from each site with a minimum distance from the street.

The sampling was done in summer as the most suitable sampling time for dust accumulation over the leaves and stem at the end of dry season. Samplings were done from the lower part of the canopy.

Leaves were all sealed and labeled separately in plastic containers to avoid the contamination after sampling. This resulted in total untouchedness of the leaves. There was no particle fallen off during sampling. The leaves were transferred to the laboratory and kept in a refrigerator at a low temperature (4 °C) [29].

To determine the amount of deposited dust on the leaves, they were washed with ethanol and distilled water (1.5:10 ml) in order to collect up taken deposited dust. Ethanol in eluted samples was evaporated at 70 °C. To determine the amount of DS, it was transferred to the falcon and centrifuged for 5 minutes at 3000 rpm, and the upper liquid layer was removed. Then samples were oven-dried at 105 °C [30]. In addition, to calculate the power of species dust uptake, the amount of dust was divided by leaf area that was measured by Image J software (Image J 1.44p) and using statistical analysis (SPSS software).

To analyze total carbon of dust, the samples were combusted at 550 °C for 2 hours in a muffle furnace, because carbonates remain stable at temperatures <550° C [11]. Samples were transferred after the 2-h combustion period to an oven at 105 °C for several hours. Samples were then cooled in desiccators and weighed. Loss-on-ignition was calculated using (1):

$$\left(\frac{dust\ \text{mass}\ beforecombustion - dust\ \text{mass}\ aftercombustion}{dust\ \text{mass}\ beforecombustion}\right) \times 100 \quad (1)$$

III. Results

Analyzed data include results of dust and total carbon uptake separately. It was revealed that species differed in the accumulation of dust in both sites and the differences were considerable for species.

Results showed that the average leaf area in *Morus alba*, *Ulmus minor*, *Platanusorientalis, Robinia pseudoacacia* and *Ailanthus altissima* in Gandi Street were 115.3 cm^2, 14.1 cm^2, 100.5 cm^2,4.7 cm^2, and 19.3 cm^2 respectively whilst the average leaf area in *Morus alba*, *Ulmus minor*, *Platanusorientalis, Robinia pseudoacacia* and *Ailanthus altissima* in Chamran Highway were 108cm^2, 13.9 cm^2, 100.5 cm^2, 4.7 cm^2, and 19.3 cm^2, respectively.

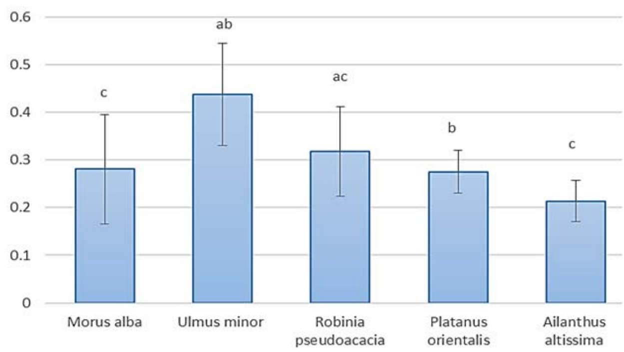

Fig. 1 The average amount of dust for different species in Gandi Street (mg/cm^2)

The average amounts of dust uptake per average leaf area in

Morus alba, *Ulmus minor*, *Platanusorientalis, Robinia pseudoacacia* and *Ailanthus altissima* in Gandi Street were 0.28 mg/cm^2, 0.43mg/cm^2, 0.27 mg/cm^2, 0.31 mg/cm^2, and 0.21 mg/cm^2 respectively (Fig. 1). The average amounts of dust uptake per average leaf area in *Morus alba*, *Ulmus minor*, *Platanusorientalis,Robinia pseudoacacia* and *Ailanthus altissima* in Chamran Highway were 0.51 mg/cm^2, 0.4 mg/cm^2, 0.39 mg/cm^2, 0.23 mg/cm^2 and 0.27 mg/cm^2, respectively (Fig. 2).

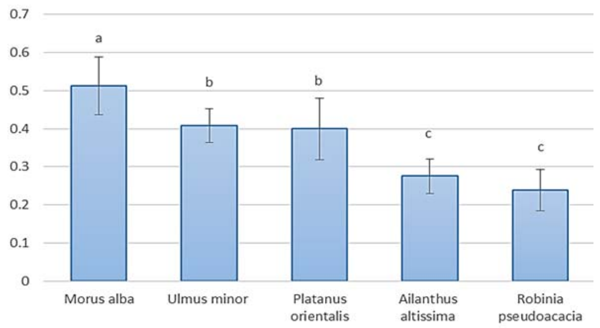

Fig. 2 The average amount of dust for different species in Chamran Highway (mg/cm^2)

Results showed that *Ulmus minor and Robinia pseudoacacia* had significantly more uptake than all other species in Gandi Street and *Morus alba* had significantly more uptake than all other species in Chamran highway. Finally, *Robinia pseudoacacia*, *Ulmusminor* and *Morus alba* had the lowest amount of uptake.

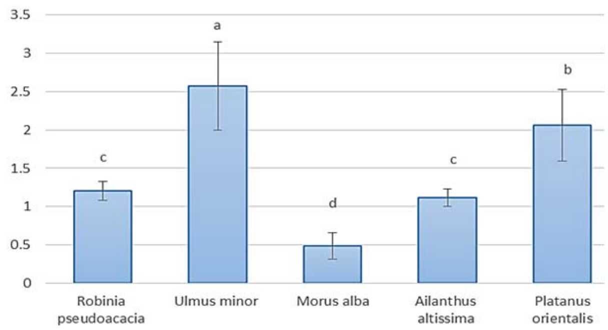

Fig. 3 The amount of total carbon uptake on the studied species leaves in Gandi Street

Total carbon uptake in *Morus alba*, *Ulmus minor*, *Platanusorientalis, Robinia pseudoacacia* and *Ailanthus altissima* in Gandi street were 0.48 mg/cm^2, 2.57 mg/cm^2, 2.05 mg/cm^2, 0.31 mg/cm^2 and 1.11 mg/cm^2, respectively (Fig. 3), while total carbon uptake in *Morus alba*, *Ulmus minor*, *Platanusorientalis, Robinia pseudoacacia* and *Ailanthus altissima* in Chamran highway were 0.65 mg/cm^2, 0.84 mg/cm^2, 0.83 mg/cm^2, 0.96 mg/cm^2 and 1.09 mg/cm^2 respectively (Fig. 4).

Statistical analysis showed *Ulmus minor* had significantly higher uptake than all other species in Gandi Street and *Ailanthus altissima* had significantly higher uptake than *Morus alba* in Chamran high way, but three others had an intermediate amount among them.

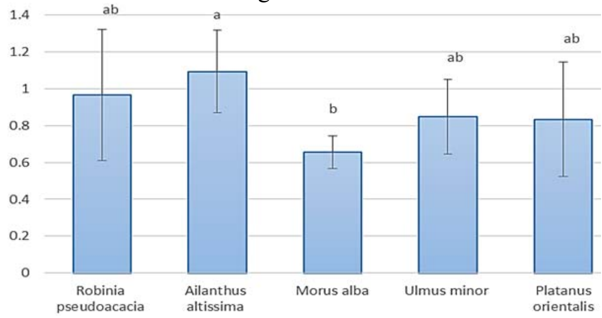

Fig. 4 The amount of total carbon uptake on the studied species leaves in Chamran Highway

IV. Discussion

It could be hypnotized that species with higher capacity of dust uptake are needed to be considered in the planning of urban green areas designed to capture air pollutants. Leaf hair and wax content were traits with a positive correlation with dust uptake [22].

The dust uptake ability by studied species is demonstrated that is different [5], [12], [20], [21]. It depends on many different factors such as leaf morphology, leaf anatomy such as crack or trichrome, the number of stomata, etc. The structure of vegetation and leaf shape is the most significant factor in dust uptake [16]. Reference [21] showed that the green belt of vegetation acts as a dust barrier and cleans the air from dust in urban areas effectively. Reference [6] shows that the dust uptake on the leaf surface of *Platanusorientalis* was significantly higher than *Fraxinus rotundifolia* and *Robinia pseudoacacia*. Our results showed that *Morus alba* had a significantly higher uptake in comparison with other species whereas *Platanus orientalis* and *Ailanthus altissima* had the same amount of uptake. Therefore, *Morus alba* is a suitable species for dust uptake, whereas *Platanus orientalis* and *Ulmus minor* had considerable dust uptake potential. The total carbon absorption showed that *Platanus orientalis* had absorbed significantly higher amount than *Morus alba,* while the three others did not have any significant difference. Therefore, it could be concluded that both of *Morus alba* and *Platanus orientalis* are suitable species based on dust and carbon uptake capacity on their leaves. It must be mentioned that the amount of dust uptake by leaves increases with a rise in ambient dust concentration. Also, dust characteristics such as diameter and shape and climatic factors such as humidity, wind speed and turbulence alter the amount of dust uptake by leaves and species.

V.Conclusion

Trees can act as biological filters, removing considerable amounts of dust from urban atmospheres. The comparative analysis of uptake dust and total carbon by important tree species in Tehran revealed that *Platanus orientalis* should be illustrated as a high-quality species in dust uptake capacity inside the densely populated and polluted cities. Decision making about the green space and choosing the suitable species depend on many different parameters. Some of the parameters such as dust, total carbon, and heavy metal uptake and air filtration are very effective indicators for choosing suitable species.

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