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Efficiency of some plants to reduce dust pollution in some areas of Baghdad, Iraq

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Abstract:

The efficiency of some plant species and their ability to trap dust particles in the areas of Al-Mashtal and New Baghdad were tested, represented by plants (*Anastatica hierochuntica, Bougainvillea glabra, Citrus aurantium, Conocarpus lancifolius, Eucalyptus tereticornis, Morus alba, Myrtus communis, Nerium oleander, Phoenix dactylifera, Sesbania sesban, Washingtonia robusta, Ziziphus*). The results showed the variation of the values of sedimentation rates on the surface area of the leaf in grams per plant, the results of the study proved that the best among the studied plants accumulating dust in the summer is *Morus alba* plant, as it reached 5500 g/plant, followed by *Ziziphus* 1655.3 g/per plant, then *Sesbania sesban* 1303.112 g/per plant, then *Eucalyptus tereticornis* 1190 g/per plant, then *Myrtus communis* 345.50 g/per plant, followed by *Conocarpus lancifolius* 210.25 g/ per plant as recorded *Nerium oleander* 77.34 g/per plant and Citrus aurantium 67.57 g/per plant and *Phoenix dactylifera* record 40.24 g/per plant followed by *Bougainvillea glabra* 21.5 g/per plant then *Washingtonia robusta* 16.7 g/per plant and was ordered last plant *Anastatica hierochuntica* 9.98 g/per plant. In winter, the best of them was the *Morus alba* 3332.55 g/plant, followed by *Ziziphus* 1421.55 g/plant, then *Eucalyptus tereticornis* 879 g/plant, then *Sesbania sesban* 567.65 g/plant, then *Myrtus communis* 256

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g/plant, then *Conocarpus lancifolius* 149 g/plant, then *Nerium oleander* 55 g/plant, then *Citrus aurantium* 41.13 g/plant, followed by *Phoenix dactylifera* 31.2 g/plant, then *Bougainvillea glabra* 15 g/plant, then *Washingtonia robusta* 8.2 g/plant and finally *Anastatica hierochuntica* 4.7 g/plant per plant.

Keywords: Sedimentation rates, Plant, Air pollution, leaf surface area.

The research

Introduction:

Any substance that spreads in the atmosphere is called dust and includes particles of dust, smoke, soot and fog, as it consists of inorganic and organic materials of terrestrial origin such as dust storms, forest fires, factory smoke, pollen, bacteria and volcanic fumes [1] (Al-Kawaz *et al*., 2011). The term dust is defined as solid particles suspended in the atmosphere formed as a result of the breakdown and decay of materials with diameters between 1 and 76 microns [2] (Porteous, 2013).

The process of dust emission in Iraq occurs throughout the year, increasing in the spring and summer, decreasing in the autumn, and recording the lowest value during the winter. It occurs most frequently in months and years when winds speed, air temperature, and evaporation increase, and rainfall decreases [3] (Al-Jubouri, 2012).

Despite the effect of dust on plants, plants were able to be an indicator of air pollution through changes in physiological factors such as pigment breakdown, membrane damage, production of antioxidant metabolism and change in the activities of antioxidant enzymes [4] (Lhotská *et al*., 2022).

Plants have also been used to monitor air pollution, some of which are sensitive to pollutants and can be used as a biological indicator and other tolerant of air pollutants in urban areas to be a green cover surrounding cities to improve air quality and reduce pollutants [5] (Santunione *et al*., 2024). This vegetation cover acts as drains for air pollutants not only gaseous but even particulate pollutants, including dust [6] (Miria and Khan, 2013).

Plants have the ability to collect dust in the atmosphere and reduce the concentration of toxic and harmful gases, heavy metals and others, after absorbing air pollutants, plants change them into harmless metabolic products through destructive physiological processes, and each plant can not only be a

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factor in controlling air pollution, but can tolerance pollutants and work to reduce them [7] (Govindaraju *et al*., 2012).

Among the mechanisms that plants have to remove pollutants is absorption, such as the absorption of oxides, heavy metals and small-sized particles by leaves, as well as sedimentation, where particles are sent on the surfaces of plants, especially leaves, and the formation of barriers to repel pollutants, where green belts repel pollutants, especially dust particles and sandstorms [8] (Wróblewska and Jeong, 2021).

The suspended particles are deposited under the influence of gravity and precipitation on the surfaces of the plant and the speed of sedimentation varies as a result of the difference in particles in density, shape and other characteristics and regulates the rate of transfer of polluting gases from the air to the leaf cells through stomatous factors, specifically wind speed, leaf size, geometric shape and diffusion, and regulates the stomata resistance through stomata openings, which may be affected by decreasing water, carbon dioxide concentration and light intensity (Santunione *et al*., 2024).

Many researches have studied the evaluation of the role and quality of indumentum of plant leaves in the detention and gripping of dust particles, including the studies of Abdul Wahid and Wadi [9] (2011) in Diyala Governorate, Al-Hasnawi and Salman [10] (2015) in Karbala Governorate, Darazi [11] (2018) in Baghdad Al-Shaab Region, as well as the study of Irshad *et al*. [12] (2020) in the Pakistani capital Islamabad, the study of Jassem [13] (2021) in some region of Al-Rusafa, Baghdad (Zayona, Al-Baladiyat and Shuhada Al-Obaidi), the study of Prigioniero *et al*. [14] (2023) in the Italian city of Naples and the study of Li *et al*. [15] (2024) in China. Due to the importance of this topic and the spread of dust storms in Iraq, the aim of the current article to study the ability of 12 plant species to trap dust particles and assess their tolerance and the effect of these particles on the environment and the exact composition of the leaf surface.

Materials and Methods

Study area

The study area is located in the areas of Al-Mashtal and New Baghdad in eastern Baghdad on the Rusafa side (Figure 1), where each area is divided into three streets: a main street, a service street and a residential street.

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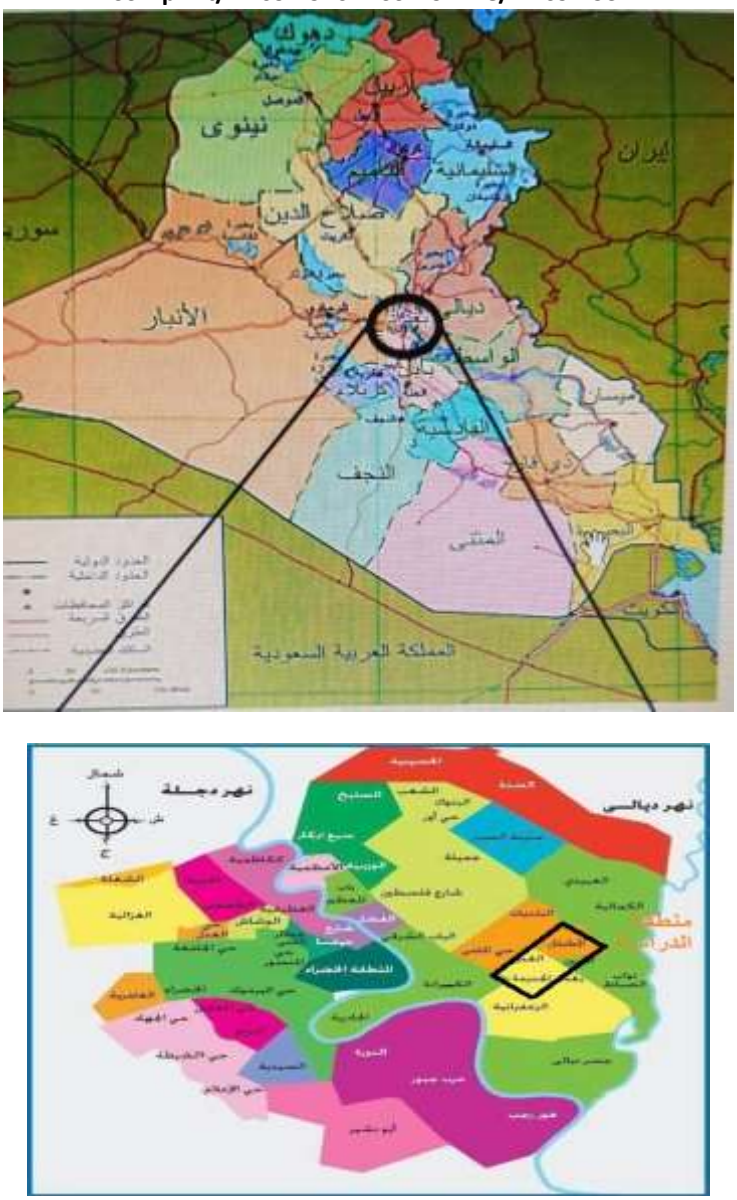


Figure 1. Map of Iraq, including the study area in Baghdad Governorate (www.Googlemap.com, 2023).

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Plant samples collection

Plant leaves were collected from all plant species selected for the study for the purpose of measuring the amount of dust accumulated on them and knowing the extent of the ability of each plant species to deposit dust on the surfaces of its leaves, where (25-50) leaves were collected and cut from the peduncle area carefully and using steel scissors and placed in plastic bags and transported to the laboratory according to the method of Kaler *et al*. [16] (2016).

Measurement of dust accumulated on plants

The method was done according to the method of Matodzi [17] (2019) for the purpose of estimating the percentages of dust accumulated on the surface of these leaves, the leaves were weighed and their weight was recorded before and after washing with distilled water well to remove dust from them and left to dry at laboratory temperature and the following equation was used to calculate the weight of dust on plant leaves:

$$D = \frac{A - B}{C}$$

Whereas:

D: represents the dust falling on the surface of the leaf in units (gm/cm^2).

A: represents the first weight of the leaves (before washing) in gm.

B: represents the second weight of the leaves (after washing) in gm.

C: represents the average area of the sheet in units (cm^2).

The surface area of each plant leaf was measured by calibration of the leaf blade on the known area graph [18] (Al-Salman and Al-Muthanani, 2007).

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The area of two leaves for each plant (the largest and smallest leaf) was calculated by drawing the two sheets on the graph paper, counting the squares representing the area of the plant leaf, and then calculating and recording the average area of the two leaves. In the present study, the following plant species were used to estimate the amount of dust accumulated on their leaves from the vegetation cover cultured in the study areas, and the description and classification of these plants was based on the following sources: Townsend *et al*. [19] (1980), Al-Moussawi [20] (1987), and Al-Katib [21] (2000) as shown in Table (1).

Table 1. Plant species used in the study to estimate the dust accumulated on their leaves.

No.	Scientific name of the plant	Common name	Family name
1	*Anastatica hierochuntica*	Mary's hand	Lamiaceae
2	*Bougainvillea glabra*	Paperflower	Nyctaginaceae
3	*Citrus aurantium*	Bitter orange	Rutaceae
4	*Conocarpus lancifolius*	Conocarpus	Cambretaceae
5	*Eucalyptus tereticornis*	River red gum	Myrtaceae
6	*Morus alba*	White mulberry	Moraceae
7	*Myrtus communis*	Myrtle	Myrtaceae
8	*Nerium oleander*	Oleander	Abocyanceae
9	*Phoenix dactylifera*	Date palm	Arecaceae
10	*Sesbania sesban*	Sesban	Ieguminosae
11	*Washingtonia robusta*	Mexican washingtonia	Arecaceae
12	*Ziziphus*	Ceder	Rhamnaceae

Statistical Analysis

The results were analyzed statistically using the Pearson Chi-Square coefficient ($\chi 2$) for correlation according to the IBM SPSS Statistics 24. All

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tests were conducted at $p \leq 0.01$, $p \leq 0.05$ and $p \leq 0.001$ as these values were considered statistically significant and there is a relationship between the surface area of the leaf and the amount of dust sediment.

RESULTS AND DISCUSSION

The surface area of the leaves of the studied plants:

The surface area of the leaves of the studied plant species was calculated, and then the average surface area of the leaves of each type of plant studied was extracted, namely: (*Anastatica hierochuntica, Bougainvillea glabra, Citrus aurantium, Conocarpus lancifolius, Eucalyptus tereticornis, Morus alba, Myrtus communis, Nerium oleander, Phoenix dactylifera, Sesbania sesban, Washingtonia robusta, Ziziphus*) (Table 2).

Anastatica hierochuntica plant had a surface area of 24.29 cm^2, and the average surface area of the *Bougainvillea glabra* plant was 22.45 cm^2, and the average surface area of the *Citrus aurantium* is 41.35 cm^2, and for the *Conocarpus lancifolius* plant 9.55 cm^2, and for the *Eucalyptus tereticornis* plant 9.50 cm^2, while the average area for the *Morus alba* plant was 35.10 cm^2, as for the leaves of the *Myrtus communis* plant and since its leaves are compound, so the surface area of the leaflet was calculated and the rate of the leaves in each leaf was taken as the average surface area of the leaf was 2.66 cm^2 and the rate of leaves in each 15 leaflets. The surface area of the *Nerium oleander* plant was 12.43 cm^2, and for the *Phoenix dactylifera* plant and since its leaves are compound pinnate, the average surface area of the leaflets is 33.32 cm^2 and the rate of leaves per leaflet is 85, and the average surface area of the *Sesbania sesban* plant is also its compound leaves, so the rate for its leaves was calculated was 2.69 cm^2, while the average surface area of the leaves of the *Washingtonia robusta* is 82.23 cm 2 and finally the average surface area of the leaves of the *Ziziphus* plant 13.45 cm^2.

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Table 1. Leaf area of study samples in cm^2.

No	Plant	Leaf area in cm^2
1	*Anastatica hierochuntica*	24.29
2	*Bougainvillea glabra*	22.45
3	*Citrus aurantium*	41.35
4	*Conocarpus lancifolius*	9.55
5	*Eucalyptus tereticornis*	9.50
6	*Morus alba*	35.10
7	*Myrtus communis*	2.66
8	*Nerium oleander*	12.43
9	*Phoenix dactylifera*	33.32
10	*Sesbania sesban*	2.69
11	*Washingtonia robusta*	82.23
12	*Ziziphus*	13.45

Through the results, it was found that there is a strong correlation or a positive relationship between the amounts of dust deposited on the leaf surfaces of each plant and the surface area of the leaves. The cumulative capacity of the studied plants varied depending on the size of the plant, the number of main and secondary branches, the number of twigs in each branch and the number of leaves in each branch [22] (Weerakkody *et al.*, 2018). The amount of dust accumulated in the summer and winter on the leaves of the plant is in proportions that vary from one plant to another according to the type of plant, the shape of the leaf and the nature of its surface, that is, the extent to which each plant is able to accumulate dust varies from one plant to another, and the percentage of accumulation increases with the increase in the surface area of its leaves [23] (Wang *et al.*, 2021).

The amount of dust deposited on the plant leaves

The rates of the amount of dust deposited on the surfaces of the studied plant leaves varied. The amount of dust deposited on the surface of the leaves of *Washingtonia robusta* was 0.02500 g/cm^2, while the rate on the surfaces of the leaves of *Eucalyptus tereticornis* plant was 0.00717 g/cm^2, followed by the amount of dust deposited on the surface of the leaves of *Nerium oleander* plant 0.00531 g/cm^2, then the rate of dust deposition on the leaves of *Ziziphus*

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plant was 0.00411 g/cm^2, and the rate of dust deposition on the surface of the leaves of *Conocarpus lancifolius* was 0.00332 g/cm^2, while the rate of dust was deposited on the leaf surface of *Bougainvillea glabra* 0.00321 g/cm^2. The rate of dust deposition on the surface of *Morus alba* leaves was 0.0031 g/cm^2, followed by the rate of dust deposition on the surface of the leaves of *Citrus aurantium* plant, which amounted to 0.00229 g/cm^2, then the rate of dust deposition on the surface of the leaf of *Anastatica hierochuntica* was 0.00220 g/cm^2, and the rate of dust deposition on the surface of the leaves of *Sesbania sesban* plant was 0.00212 g/cm^2, and the rate of dust accumulation on the surface of the *Phoenix dactylifera* leaves comes after that at a rate of 0.00203 g / cm^2, and in the last place, the rate of dust deposition on the surface of the leaves *Myrtus communis* 0.00200 g/cm^2.

It is clear from the results of the current study (Table 3, Figure 2) that the rate of dust deposited on the surface of different plant leaves varies from one plant to another, and this is due to the different nature of the indumentum of plant leaves in the first place and to other plant characteristics such as leaf arrangement, shape and height of plants. This supports with what Abdel Wahed and Wadi [9] (2011) mentioned in their study the effect of indumentum of plant leaves on holding or trapping dust pollutants and sulfur oxides in the atmosphere and Al-Hasnawi and Al-Salman [10] (2015) in his study conducted in Karbala, Iraq to study the properties of plant leaves and the nature of the indumentum of the plant, and Darazi [11] (2018) in her study conducted in Al-Shaab area in Baghdad, Iraq and showed the difference of plants in the accumulation of heavy elements according to the nature of the indumentum of the plant.

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Table 3. Amount of dust accumulated in summer.

No.	Plant	The amount of accumulation per square centimeter in summer
1	*Anastatica hierochuntica*	0.00220
2	*Bougainvillea glabra*	0.00321
3	*Citrus aurantium*	0.00229
4	*Conocarpus lancifolius*	0.00332
5	*Eucalyptus tereticornis*	0.00717
6	*Morus alba*	0.00310
7	*Myrtus communis*	0.00200
8	*Nerium oleander*	0.00531
9	*Phoenix dactylifera*	0.00203
10	*Sesbania sesban*	0.00212
11	*Washingtonia robusta*	0.02500
12	*Ziziphus*	0.00411

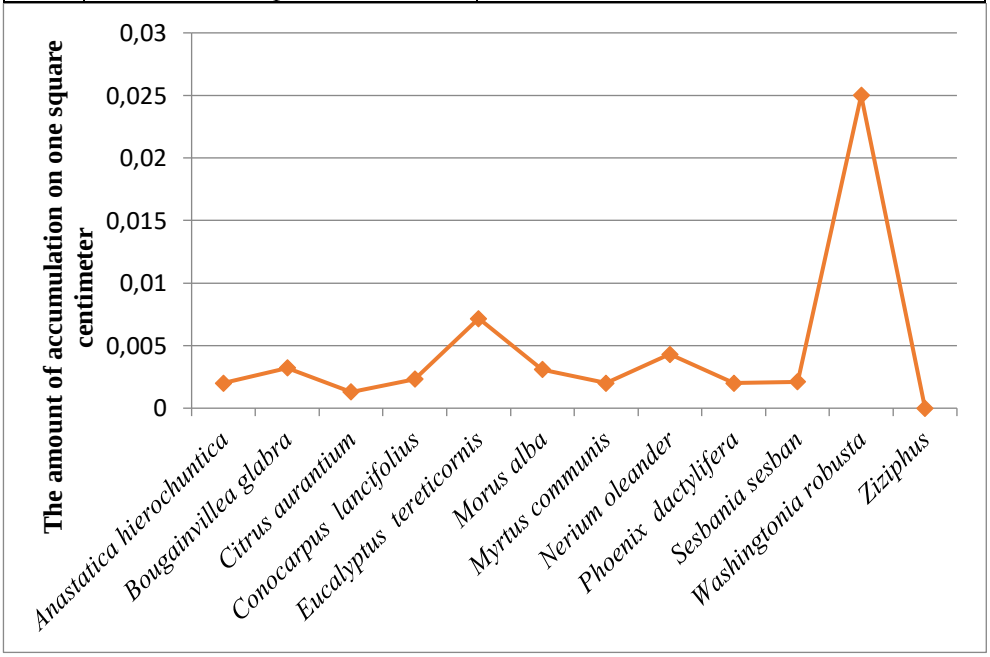


Figure 2. The amount of accumulation per square centimeter in summer

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The amount of dust accumulated on the vegetative parts of the studied plants:

The ability of the studied plants differed in their capacity to deposit dust depending on the size of the plant, the number of main and secondary branches, and the number of twigs in each branch and the number of leaves in each branch, as the amount of dust accumulated by each plant in the summer was recorded as follows:

Morus alba (5500 g /per plant), while *Ziziphus* plant recorded (1655.3 g /per plant), while for *Sesbania sesban* plant the amount of dust deposited (1303.112 g / per plant), whereas *Eucalyptus tereticornis* plant (1190 g / per plant), and the amount of dust deposited for *Myrtus communis* plant (345.50 g / per plant). For *Conocarpus lancifolius* plant, the amount of dust deposited was (210.25 g/per plant), *Nerium oleander* plant (77.34 g/per plant), *Citrus aurantium* (67.57 g/ per plant), *Phoenix dactylifera* (40.24 g/ per plant), *Bougainvillea glabra* plant (21.5 g/per plant), the *Washingtonia robusta* (16.7 g/per plant), and the last plant was *Anastatica hierochuntica*, with the amount of it deposited (9.98 g/per plant) (Table 4 and Figure 3).

In winter, the best of them was *Morus alba* plant, which it recorded 3332.55 g / per plant, followed by *Ziziphus* 1421.55 g / per plant, then *Eucalyptus tereticornis*, which recorded 879 g / per plant, followed by *Sesbania sesban*, which recorded 567.65 g / per plant, then *Myrtus communis* 256 g / per plant, followed by *Conocarpus lancifolius* 149 g / per plant, then *Nerium oleander* 55 g / per plant, then *Citrus aurantium* 41.13 g / per plant, followed by *Phoenix dactylifera* 31.2 g / per plant, then *Bougainvillea glabra* 15 g / per plant, then *Washingtonia robusta* 8.2 g / per plant and finally *Anastatica hierochuntica* plant record The lowest amount of accumulated dust was 4.7 g / per plant.

The ability of plants to retain dust is directly related to the microstructure of foliar trees and was the result of a synergistic effect of

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various factors, such as folds, grooves, stomata, length of trichomes and wax on the leaf surface [24] (Zhang *et al*., 2018). In general, the rougher the leaf surfaces, the greater the differences in the depths of folds and grooves, and the greater the number of trichomes and waxy structures, the more favorable these conditions are for intercepting dust particles and improving dust retention capacity. In contrast, leaves with relatively smooth surfaces, low stomata density, and shallow grooves were less able to absorb dust [22] (Weerakkody *et al*., 2018).

Trichomes bristles increase sheet area by increasing folds and provide an additional surface for dust retention [14] (Prigioniero *et al*., 2023). The morphological composition of the leaf also affects the amount of dust trapped in the leaf and the stability of the absorbed dust particles on the surface of the leaf [23] (Wang *et al*., 2021).

Through this, we can deduce a relationship between the amount of each plant deposited and what the municipality or the municipality of Baghdad needs from the plants that must be planted in each area for the purpose of reducing dust pollution, taking into account the ability of each plant to the amount of dust it deposits and the amount of toxins it absorbs released into the air and soil.

For example, when planting 10 *Morus alba* trees that can deposit 55,000 grams of dust falling per month, equivalent to 55 kg, and planting 10 trees of *Ziziphus* plant that can deposit 16,335 grams of dust falling per month, equivalent to 16.335 kg of dust falling during the month, and knowing the amount of dust falling in each street in the area, it is possible to calculate what it requires to plant from the trees necessary to deposit the falling dust and reduce the phenomenon of dust pollution that causes many health problems.

Number of trees needed = amount of dust falling per month / amount of deposition per plant.

But if it was want to plant more than one type and after knowing the amount of dust falling or stuck, we distribute the amount of dust to each group

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of plants desired to be planted [13] (Jassem, 2021).

Table 4. Amount of dust accumulated in summer.

No.	Plant	Dust accumulation rate in summer/ gm	Dust accumulation rate in winter/ gm
1	*Anastatica hierochuntica*	9.98	4.7
2	*Bougainvillea glabra*	21.5	15
3	*Citrus aurantium*	67.57	41.13
4	*Conocarpus lancifolius*	210.25	149
5	*Eucalyptus tereticornis*	1190	879
6	*Morus alba*	5500	3332.55
7	*Myrtus communis*	345.50	256
8	*Nerium oleander*	77.34	55
9	*Phoenix dactylifera*	40.24	31.2
10	*Sesbania sesban*	1303.112	567.65
11	*Washingtonia robusta*	16.7	8.2
12	*Ziziphus*	1655.3	1421.55

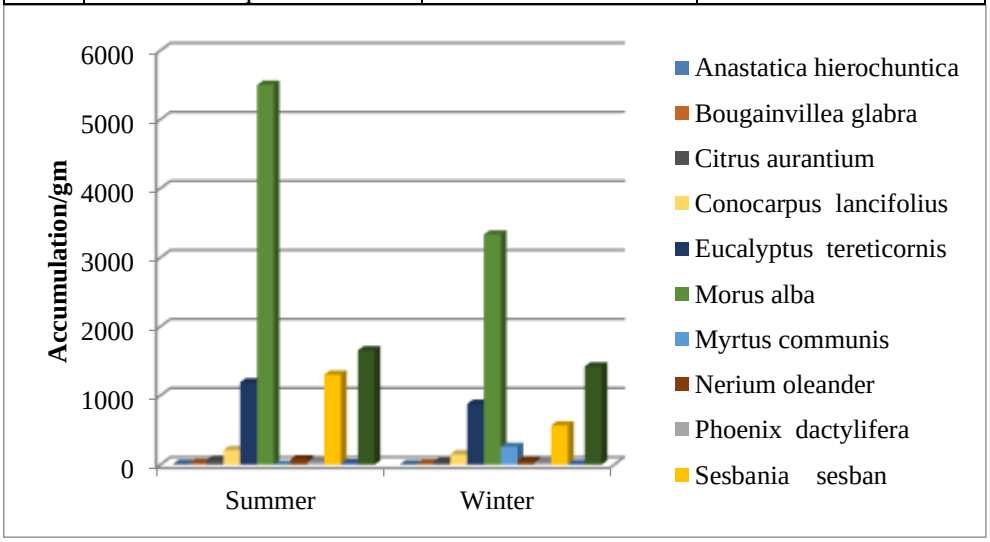


Figure 3. The amount of accumulation per square centimeter in summer

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CONCLUSION

The study showed a difference in the efficiency of plant genera and species in their ability to sediment dust on the surfaces of their leaves, the best of which was the *Morus alba* plant, and the least able to sediment dust was *Anastatica hierochuntica* plant, while the other species occupied intermediate values between the two.

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كفاءة بعض النباتات للتقليل من التلوث بالغبار في بعض مناطق بغداد، العراق

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ملخص:

تم اختبار كفاءة بعض الانواع النباتية وقدرتها على احتجاز دقائق الغبار في منطقتي المشتل وبغداد الجديدة والمتمثلة بنباتات (كف مريم، الجهنمي، النارنج، الكونوكاربيس، اليوكالبتوز، التوت، الياس، الدفلة، النخيل، السيسبان، نخيل الواشنطونيا، السدر)، أظهرت النتائج تباين قيم معدلات الترسيب على المساحة السطحية للورقة بالغرام لكل نبات، فأثبتت نتائج الدراسة أن الأفضل من بين النباتات المدروسة مراكمة للغبار في فصل الصيف هو نبات التوت إذ بلغ 5500 غم /نبات ويليه السدر 1655.3 غم /نبات ومن ثم السيسبان 1303.112 غم /نبات ثم اليوكالبتوز 1190 غم /نبات ثم الياس 345.50 غم / نبات ويأتي بعده الكونوكاربس 210.25 غم /نبات كما سجل نباتي الدفلة 77.34 والنارنج 67.57 غم /نبات وسجل النخيل 40.24 غم /نبات يليه الجهنمية 21.5 غم /نبات ثم نخيل الواشنطونيا 16.7 غم /نبات وكان بالمرتبة الأخيرة نبات كف مريم 9.98 غم /نبات. اما في فصل الشتاء كان افضلها نبات التوت 3332.55 غم /نبات يليه السدر 1421.55 غم /نبات ثم اليوكالبتوز 879 غم /نبات ثم السيسبان 567.65 غم /نبات ثم الياس 256 غم /نبات ثم الكونوكاربس 149 غم /نبات ثم الدفلة 55 غم /نبات ثم النارنج 41.13 غم /نبات يليه النخيل 31.2 غم /نبات ثم الجهنمية 15 غم /نبات ثم نخيل الواشنطونيا 8.2غم /نبات وأخيراً نبات كف مريم 4.7 غم /نبات الواحد.

الكلمات المفتاحية: معدل الترسيب، نبات، تلوث الهواء، المساحة السطحية للورقة.