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Leaf geometric design of urban trees: potentiality to capture airborne particle pollutants

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Abstract
The geometric features and particles burdens of the leaf of twenty-seven common tree species were studied. Three different tree categories including coniferous, broad and bisect leaf were recorded. These categories exhibited significant differences in their particle burdens of TDP, PM10 and PM2.5. The value of TDP appears to affect strongly by leaf macro-morphology such as leaf direction, flatness and hardness. Micro-roughness of the leaf surface such as trichomes, ridges and furrows formed by epidermal cell lining , veins projections, stomata protected with wax rings, cuticular arches, hairs or scales and sunken position stimulated the capturing of fine and ultrafine particles. Accordingly, *Thuja orientales*, *Ficus carica* and *Morus nigra* dominated other species in their TDP burdens. *Bougainvilla glabra, Tipuana tipu, Eucalyptus globulus, Bauhinia variegate, Ficus religosa, Jacaranda acutifolia* have higher PM10 burdens than other species. High PM 2.5 burdens were recorded in species of *Ficus religiosa, Dalbergia sissoo, Bauhinia variegate* and *Psidium guajava.*

Keywords: Micro-roughness, Capturing efficiency, Particulate matter, Deposition velocity

Introduction

Urban ecosystems are comprised of diverse land uses including commercial, industrial, residential, transport, recreational, agricultural and nature areas, resulting in different habitats for plants, animals and humans within the urban landscape. Urban habitat quality comprises the integration of different abiotic and biotic components making up the habitat, such as air, soil and water quality, microclimate and the presence of vegetation. Due to variations in both the abiotic and biotic components urban habitat quality will vary between different land uses. Nowadays, urban environment become undergo severe air pollution due to anthropogenic and natural activities. Urban air pollution is rapidly becoming an environmental problem of public concern, and many studies concern with this important problem especially in the last few decades were done (Iqbal *et al*., 1996; Frost *et al*., 1997; Markert *et al*., 2000; Moraes *et al*., 2003; El-Khatib, 2003; Markert *et al*., 2003; Carlsson *et al*., 2005 and El-Khatib *et al*., 2011). These pollution circumstances contribute directly or indirectly to the environmental health and welfare of the inhabitants.

Urban trees and shrubs act as efficient biological filters for removing significant amounts of particulate pollutants from urban atmospheres. The efficiency of trees/shrub to do this depends on their leaf geometry and surface characteristics such as cuticle, epidermis, epicuticular wax, stomata and the tricomes (Neinhuis & Barthlott, 1998; Beckett *et al*., 1998 and Meusel *et al*., 1999). When compared to other biomonitors such as mosses and epiphytic lichens, urban trees comparatively toxitolerant and are therefore very useful in urban and industrial environments. There are several examples of trees used as biomonitors for air and soil pollution, e.g. *Phoenix dactylifera* (Askoy & Öztürk, 1997 and Al-Shayeb *et al*., 1995). *Pinus sylvestris* (Dmuchoswski & Bytnerowicz, 1995). *Populus nigra* (Djingova *et al.,* 1995, 1996, 1999, 2001). *Tibouchina pulchra* (Moraes *et al*., 2003). *Ficus nitida* (El-Khatib, 2011). as well as several tree species of urban environments in Greece (Sawidis *et al.,* 1995, 2001). and in Hong Kong (Lau & Luk, 2001).

As one of metropolitan cities in the developing countries, Sohag city, Egypt is suffering continuous deterioration of environmental quality in general and of air quality in particular due to high rate of

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urbanization synchronized with demographic explosion, poor urban planning and rapid random development. The concentration of TSP is high in relation to the criteria of the Egyptian Environmental Affairs Agency (EEAA) (El-Khatib, 2001). Early studies by (El-Khatib *et al.,* 2007, 2008). reported that the airborne particles prevailing at sohag city include species of PM 50, PM10 and PM 2.5. These particles found to cause serious environmental and related health consequences because wide range of toxic metals and toxic organic contaminants that they are containing (Noghissi, 1997; Bem *et al.,* 2003; Beavington *et al.,* 2004; Al-Masri *et al.,* 2006). Although more than 40 tree species were growing within the city, no previous studies concerning by the effect of leaf geometry on their capturing efficiency were done. Therefore, the present study was amid to study the macro-and micro-morphology of 27 common tree species of them, as well as the possibility of their using as biomonitors of airborne particles pollution.

Materials and Methods

Sampling

Following the standard sampling methodology (Kovacs, 1992). four branches from 27 tree species were selected at 2m above the ground from individual tree of each species at each site. Four branches in the four dimensions from each tree species selected. Three shoots were taken from each branch and one leaf (leaf no. six characterized by dark green color) removed from each of these. This resulted in 12 leaves for analysis from each individual tree. To overcome the variations within the site, three individuals of each species were sampling there. As composite samples (May, 2010; may, 2011), the leaves were detached and kept in plastic bags and carried to the laboratory for further analyses.

gravimetric estimation of the leaf deposits

For quantitative analyses of the surface deposits, leaves collected from the tree individuals of each species per site and combined into a single sample (one bulk sample per site per species). According to the technique used by (Beckett *et al.,* 1998). the leaves of each bulk sample were washed by 400 ml Millipore filtered distilled water (sometimes toluene was used) in collection container which placed for one hour on a flat bed shaker. Then, the leaves rinsed with more Millipore water. The final volume of the wash solution made up to 500 ml. According to (Chow *et al*., 1996). the resultant solutions filtered through pre-weighted filters (10, 2.5 and 0.22 µm pore diameter) to remove, PM50, PM10 and PM 2.5, respectively. Then, the filters dried at room temperature and re-weighted by digital microbalance. The collected particles mass expressed in g/m^2 (based on the used leaf areas).

characterization of leaf micro-roughness

The surface microstructure of the tree leaves was studied using a scanning electron microscope (SEM) type (FEI NOVA NANOSEM-200 with an acceleration voltage equal to 15 KV).

Statistical analysis

Data of TDP were subjected to statistical analysis of using Minitab®14 software for Windows. Comparisons of TDP means were carried out using the analysis of variance (ANOVA), differences were considered to be significant at level $P<0.05$, $P<0.01$.

Results and Discussion

Based on the leaf characteristics, three different tree categories were recorded in the present study. These are coniferous, deciduous and bisect type (Table 1).

Coniferous trees	Broad leaves	Bisect trees
Thuja orientalis	*Ficus carica*	*Khaya sengalensis*
Casuarina equisetifolia	*Morus nigra*	*Jacaranda acutifolia*
	Vitis Sp.	*Albizia lebbek*
	Psidium guajava	*Poinciana regia*
	Morus alba	*Cassia glauca*
	Ficus elastica	*Dalbergia sissoo*
	Ficus nitida	*Tipuana tipu*
	Nerium oleander	
	plumeria alba	
	Ficus platyphylla	
	Bauhinia variegata	
	Ficus religiosa	
	Luffa Sp.	
	Mangifra indica	
	Ipomoea cordata	
	Bougainvilla glabra	
	Eucalyptus rostrata	
	Ziziphus spina-christi	

Table. (1): Different categorizes of the studied tree species

These categories varied significantly ($P< 0.01$) in between, in relation to their burden of captured airborne particles (Fig. 1). In general, the average concentration of the total deposit particles (TDP) collected by leaves of studied species was 13.28±6.33 g/m2, i.e. 4 times the average concentration (3.22±2.13) estimated for the reference sites. This reflects the high pollution status that the city environment undergoes. Coniferous and broad leaf species appeared to co-dominate other types in their leaf total deposits of airborne particles (TDP). In comparison, bisect leaves appears to capture lower mass of TDP. It is important to mention that, each group includes species that have leaf macro morphological characteristics of their owner. Many studies interest on comparing the efficiency of broad leaves, bisect leaves and coniferous trees (ex. Becket *et al*., 2000).

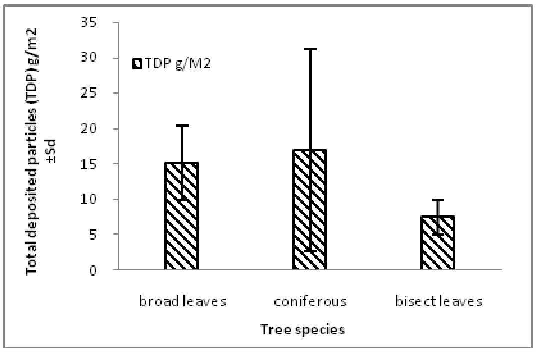

Figure. (1): Average particulate burden (Mean ±SD) of the different tree categories.

Geometric design including macro and micromorphology of the studied trees appeared to be affecting the process of removal. Leaf macro morphology includes the leaf direction, flatness (flat, concave and convex) and hardness. Trees with hard leaves toward upward or horizontally with concave surface (*Ficus carica*, *thuja orientalis*, *Morus nigra, Vitis Sp., Psidium guajava, Morus alba, Ficus elastic, Ficus nitida, Nerium oleander, plumeria alba, Ficus platyphylla, and Bauhinia variegate*) receive more particles and favor consistency than thin leaves in weeping position or vertical with flat or convex surfaces (*Ficus religiosa, Ipomoea cordata, Bougainvilla glabra, Eucalyptus rostrata, Cassia glauca, Dalbergia sissoo and Tipuana tipu)* that increase the opportunity of reemitting of the particles due to wind movements and erosion (Fig. 2). In their study, (Freer-Smith *et al*., 2004). reported the advanced of coniferous type in capturing particulate pollutants than other tested plant species, where species with more complex stem structure and smaller leaves had greater relative deposition velocities.

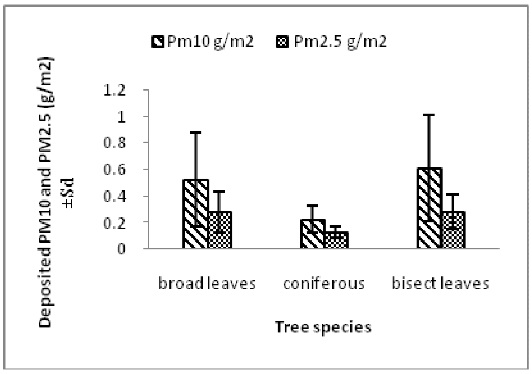

Fig. (2): concentration of deposited PM10 and PM2.5 particles

Micro-roughness of the epidermis in the studied species is shown in figure (3). As described by (Chaphekar, 2000 and Jamil *et al*., 2009). It is showed in the present study by the presence of trichomes *(ex. ficus carica*, *thuya orientalis*, *Morus nigra, and Luffa Sp.)* ridges and furrows formed by epidermal cell lining (*Bougainvilla glabra, Luffa Sp., Psidium guajava and Jacaranda acutifolia*), veins projections (*Bauhinia variegate)*, stomata protected with wax rings.*, Psidium guajava, Khaya sengalensis and ficus nitida)*, cuticular arches *(Jacaranda acutifolia, Mangifra indica, and Ficus religiosa*) hairs or scales (*Ipomoea cordata Poinciana regia, Bauhinia variegate and Tipuana tipu)* and sunken position *(Eucalyptus rostrata, Mangifra indica, Ficus elastica, and Nerium oleander* (sunken stomata with hairs). Surface roughness deals mainly with fine and ultra-fine particles depending on Brownian diffusion. The presence of epidermal hairs (trichomes) on both the leaf surfaces (the abaxial and adaxial) enabled the leaves to trap bigger size particles however, the ridges and grooves formed due to epidermal cells lining, veins projections, stomata protected with wax rings, cuticular arches, hairs or scales and sunken position enable smaller particles to get trapped in between (Jamil *et al.,* 2009).

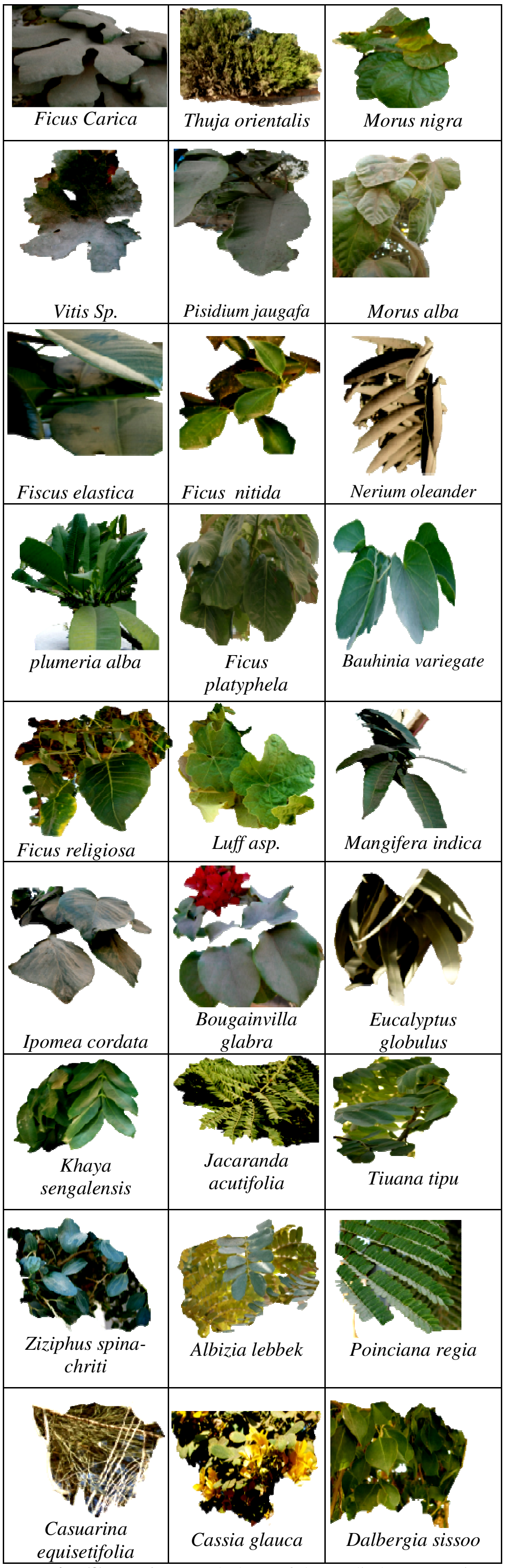

Fig. (3): Leaf macrophology of the studied tree species.

Species name	TDP	PM10	PM2.5
Ficus carica	31.72±1.46	0.35±0.14	0.14±0.03
Thuja orientalis	27.04±1.53	0.30±0.06	0.16±0.01
Morus nigra	21.50±5.25	0.35±0.13	0.32±0.18
Vitis Sp.	19.81±11.27	0.42±0.14	0.11±0.09
Psidium guajava	19.38±0.96	0.59±0.04	0.41±0.01
Morus alba	15.95±2.12	0.26±0.18	0.18±0.13
Ficus elastica	15.72±3.55	0.45±0.13	0.33±0.07
Ficus nitida	15.34±1.55	0.52±0.11	0.38±0.15
Nerium oleander	14.43±0.91	0.20±0.12	0.11±0.10
plumeria alba	13.76±4.27	0.49±0.03	0.24±0.02
Ficus platyphylla	13.18±1.43	0.11±0.01	0.06±0.03
Bauhinia variegata	12.46±1.46	0.97±0.24	0.41±0.11
Ficus religiosa	12.05±5.52	0.86±0.13	0.67±0.02
Luffa Sp.	11.94±2.67	0.33±0.11	0.29±0.04
Mangifra indica	11.78±2.48	0.22±0.03	0.16±0.04
Ipomoea cordata	11.77±2.63	0.53±0.09	0.20±0.01
Bougainvilla glabra	11.32±3.35	1.46±0.29	0.49±0.27
Eucalyptus rostrata	11.04±6.68	1.04±0.17	0.35±0.13
Khaya sengalensis	10.80±1.80	0.26±0.11	0.19±0.02
Jacaranda acutifolia	9.95±1.55	0.74±0.05	0.21±0.19
Ziziphus spina christi	9.33±2.20	0.26±0.08	0.19±0.11
Albizia lebbek	8.63±3.40	0.18±0.04	0.08±0.03
Poinciana regia	7.74±0.36	0.41±0.08	0.27±0.05
Casuarina equisetifolia	6.81±4.08	0.15±0.02	0.10±0.04
Cassia glauca	5.57±2.50	0.31±0.02	0.22±0.02
Dalbergia sissoo	5.20±2.92	0.62±0.03	0.49±0.15
Tipuana tipu	4.42±2.94	1.41±0.16	0.34±0.27

Table. (2): Capture efficiency (g/m^2) of the studied tree species

Based on morphological variations, species exhibited gravimetrically variations in their capture of TDP (Table, 2).

Ficus carica, *Thuja orientalis* and *Morus nigra*, exhibited higher amount of TDP than other tested species (Fig. 5). Morphological features and particulate burden of these species are outline in the following:

1- *Ficus carica* tree forms of rounded head to umbrageous crown with very dense twigs and approximate horizontal that allow maximum intercepting surface for the downward air current layers and maximum changing in the inertia of the particles via collapsing. Leaves are very hard and broad and may reach 30cm wide (Badr, 2003). arranged horizontally with flat surface allow high sedimentation receptors for the particles. The micro morphology (Fig.4.a.$_1$&4.b.$_1$) is rough characterized by trichomes on the adaxial and abaxial surfaces. Macro and micromorphology of *F. carica* enable the leaves to trap high load of particles with tendency to bigger size particles and that well explain its low burden of small particulate fraction of PM10 and PM2.5 relatively to TDP (31.72±1.46g/m^2).

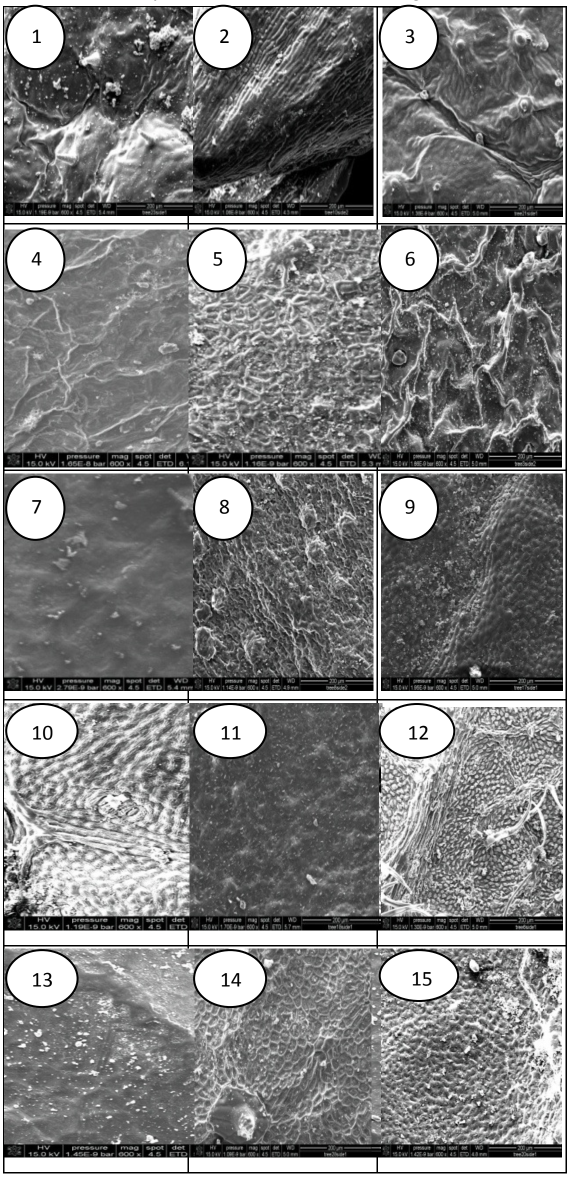

Fig. (4.a): Micro-morphology of the abaxial surface of the leaves of: 1) *Ficus Carica,*(spiny trichomes and domed like surface formed by high cuticular arches)) *2) Thuja orientalis,*(ridges and furrows formed by epidermal cell lining) 3) *Morus nigra,* (spiny trichomes and domed like surface formed by high cuticular arches) *4)Vitis Sp.*(semi rough surface (chrochet like) formed by irregular cuticular deposits), 5) *Pisidium jaugafa*, (epidermal cell lining forms molds for fine particulate trapping) 6) *Morus alba* (rough surface (hard chrochet like) formed by irregular cuticular deposits), 7) *Fiscus elastica*, (waxy smooth surface with low relief) 8) *Ficus nitida*,(smooth surface with high relief formed by irregular waxy deposits9) *Nerium oleander*, (rounded scares formed by cuticular arches) 10) *plumeria alba*, (deep ridges and furrows formed by epidermal cell lining, cuticular arches, sunken stomata, and viens projection) 11) *Ficus platyphela*, (smooth surface with waxy appendages) 12) *Bauhinia variegate*(hairs and deep ridges formed by scaly ripsy cuticular arches and veins projection) 13) *Ficus religiosa* (smooth waxy surface), 14) *Luff sp.*, (trichomes and deep ridges and furrows made by epidermal cell lining forms molds for particulate trapping) 15) *Mangifera indica* (rough surface formed by cuticular archs) (continued …..)

2- *Thuja orientales* tree has its very convincing reason for high-recorded TDP (27.03±1.52 g/m^2). The crown is a combat pyramidal with no layers and very dense leaves allow high decrease in the air velocity entire the crown that makes it acting as settling chamber device. The leaves are in upright direction with very special pocket like feature allow high storing capacity of particulate. The micro morphology is rough (Fig.4.a.$_2$&4.b.$_2$) characterized by epidermal cells lining, stomata protected with wax rings and cuticular arches. Macro and micromorphology of *T. orientales* enable the leaves to trap high load of particles with relatively high ratio of PM10 and PM2.5.

3- *Morus nigra* tree forms of crown, which is of round head, combat with no layers and dense leaves. Leaves are hard of 12.5cm width (Badr, 2003). They arranged horizontally with flat surface that allow high sedimentation receptors for the particles. The micro morphology is very rough (Fig.4.a.$_3$&4.b.$_3$) seems with those of *F. carica*, where it characterized by trichomes on adaxial and abaxial surfaces. Macro and micromorphology of *M. nigra* enables leaves to trap high load of particles with tendency to bigger size particles. This explains well its low burden of small particulate fraction of PM10 and PM2.5 relatively to TDP (21.49±5.24 g/m^2).

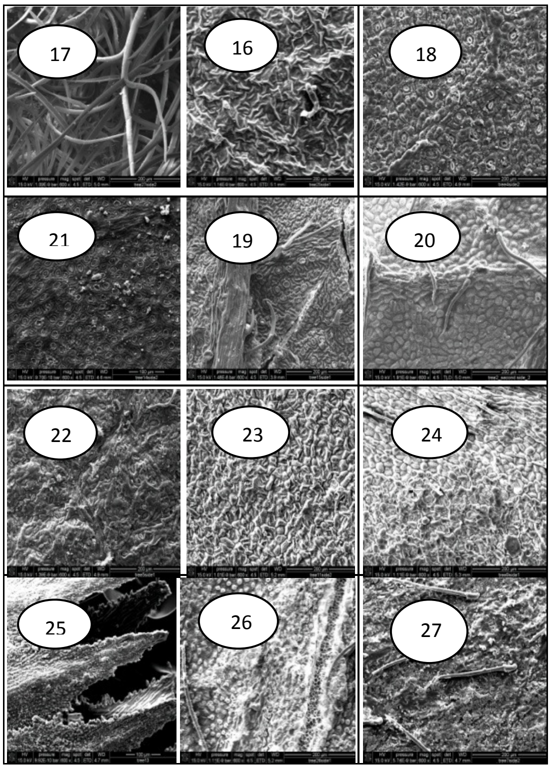

Fig. (4.a continue….) 16) *Ipomea cordata*(rough surface (hard chrochet like) formed by irregular cuticular deposits), 17) *Bougainvilla glabra*,(deep ridges and furrows formed by epidermal cell lining) 18) *Eucalyptus globules* (deep ridges and furrows formed by epidermal cell lining, cuticular arches, sunken stomata, and viens projection) 19) *Khaya sengalensis* (smooth surface with lined waxy deposits) 20) *Jacaranda acutifolia* (trichomes; and deep ridges and furrows made by epidermal cell lining) 21) *Tipuana tipo* (deep ridges and furrows formed by scaly ripsy cuticular arches and veins projection in high ornamentation) 22) *Ziziphus spina- Christi* (semi rough surface (chrochet like) formed by irregular cuticular deposits and sunken stomata) 23) *Albizia lebbek* (deep ridges and furrows formed by scaly ripsy cuticular arches in high ornamentation) 24) *Poinciana regia* (deep ridges and furrows formed by scaly ripsy cuticular arches) 25) *Casuarina equisetifolia* (rounded scares formed by cuticular arches) 26) *Cassia glauca* (granular surface with veins projection), and 27) *Dalbergia sisso* (smooth surface with lined waxy deposits and veins projection)

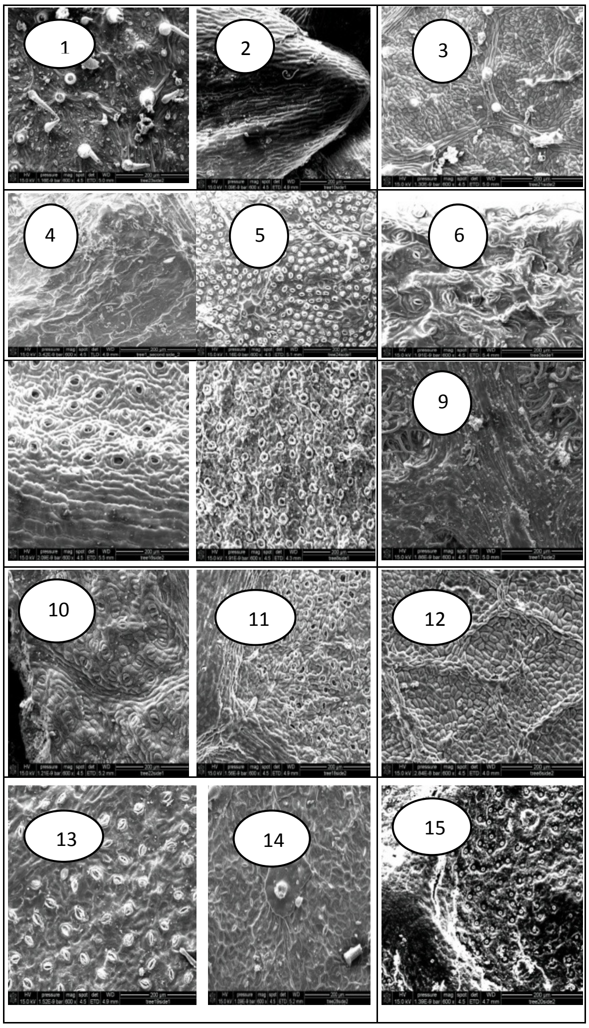

Fig. (4.b): Micro-morphology of the abaxial surface of the leaves of: 1) *Ficus Carica,*(spiny trichomes, lined waxy surface and stomata) *2) Thuja orientalis,*(ridges and furrows formed by epidermal cell lining) 3) *Morus nigra,* (spiny trichomes; and ridges and furrows formed by epidermal cell lining, cuticular arches, stomata, and viens projection) *4)Vitis Sp.* (semi rough surface (chrochet like) formed by irregular cuticular deposits and stomata), 5) *Pisidium jaugafa*, (hairs and epidermal cell lining forms molds for fine particulate trapping and stomata protected with wax rings) 6) *Morus alba* (rough surface (hard chrochet like) formed by irregular cuticular deposits and sunken stomata), 7) *Fiscus elastica*, (cuticular archs and sunken stomata) 8) *Ficus nitida*, (stomata protected with wax rings) 9) *Nerium oleander*, (sunken stomata with hairs) 10) *plumeria alba*, (deep ridges and furrows formed by epidermal cell lining, cuticular arches, stomata, and viens projection) 11) *Ficus platyphela*, (ridges and furrows formed by epidermal cell lining, cuticular arches, sunken stomata, and viens projection) 12) *Bauhinia variegate* (hairs and deep ridges formed by scaly ripsy cuticular arches, stomata and veins projection) 13) *Ficus religiosa* (stomata protected with wax rings), 14) *Luff sp.*, (trichomes and deep ridges and furrows made by epidermal cell lining and stomata forms molds for particulate trapping) 15) *Mangifera indica* (sunken stomata protected with wax rings and deep viens projection) (continued …..)

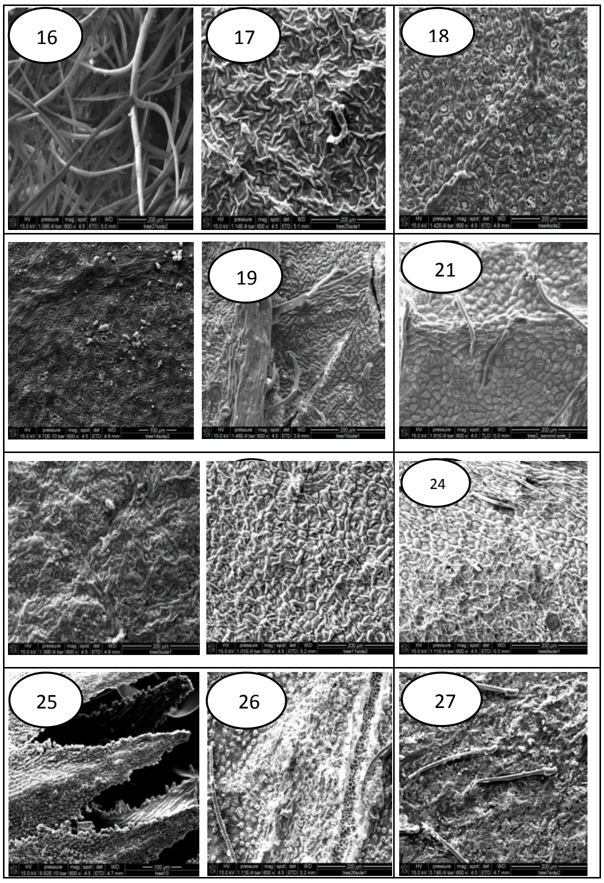

Fig. (4.b continue….) 16) *Ipomea cordata* (hairy surface), 17) *Bougainvilla glabra*,(deep ridges and furrows formed by epidermal cell lining and stomata) 18) *Eucalyptus globules* (deep ridges and furrows formed by epidermal cell lining, cuticular arches, sunken stomata, and viens projection) 19) *Khaya sengalensis* (sunken stomata protected with wax rings and deep viens projection) 20) *Jacaranda acutifolia* (trichomes; and deep ridges and furrows made by epidermal cell lining and stomata protected with wax rings) 21) *Tipuana tipo* (ridges and furrows formed by scaly ripsy cuticular arches and stomata, and veins projection in high ornamentation) 22) *Ziziphus spina- Christi* (ridges and furrows formed by epidermal cell lining, cuticular arches, sunken stomata, and viens projection) 23) *Albizia lebbek* (ridges and furrows formed by scaly ripsy cuticular arches in high ornamentation and stomata) 24) *Poinciana regia* (hairs, and deep ridges and furrows formed by scaly ripsy cuticular arches and stomata) 25) *Casuarina equisetifolia* (rounded scares formed by cuticular arches and apendages) 26) *Cassia glauca* (granular surface with hairs, stomata protected with wax rings and veins projection), and 27) *Dalbergia sisso* (hairs and waxy deposits)

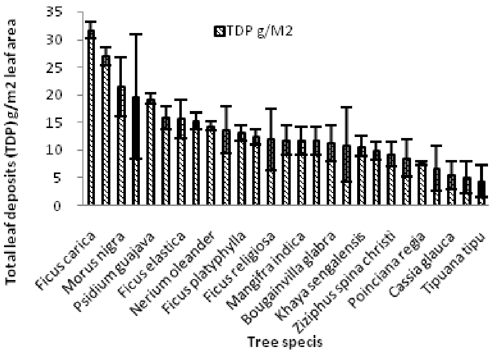

Fig. (5): Concentration of total deposited particles in the leaves of tested trees

Other species exhibited low TDP values. Of which *Vitis Sp., Psidium guajava, Morus alba, Ficus elastic, Ficus nitida, Nerium oleander, plumeria alba, Ficus platyphylla, Bauhinia variegate, Ficus religiosa, luffa, Mangifra indica, Ipomoea cordata, Bougainvilla glabra, Eucalyptus rostrata, Ziziphus spina-christi, Khaya sengalensis*, *Jacaranda acutifolia*, *Albizia lebbek*, *Poinciana regia, Casuarina equisetifolia*, *Cassia glauca, Dalbergia sissoo* and *Tipuana tipu*.

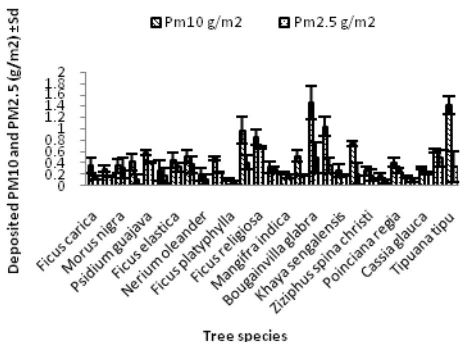

Fig. (6): Concentration of PM10 and PM2.5 deposit particles in the leaves of tested trees.

Based on the gravimetric results, some tested species showed high load of PM10 (Fig, 6). Their morphology and particulate load are outlined in the following:

1- *Bougainvilla glabra* recorded maximum value of 1.46±0.28g/m^2. The crown has no distinct structure as the tree planted for covering walls and gates. The leaves are not the main cover of the crown, which consists mainly of dense groups of inflorescences with different colors. The leaves are thin flat and weep downward. The micro morphology is rough characterized by epidermal cells lining, stomata protected with wax rings and cuticular arches. Macro morphology of *B. glabra* (Fig.4.a.$_{17}$&4.b.$_{17}$) gives the leaves minimum chance to receive particles via sedimentation and inertial deposition with very low equilibrium and this obviously explain the very low total deposited particles burden. However, in contrast the micromorphology enables the leaves to trap high load of fine particles via Brownian motion demonstrated in the high ratio of PM10 and PM2.5.

2- *Tipuana tipu* tree was with average value of 1.40±0.16 g/m^2. The crown is columnar shape with distinct two or three approximate layers with medium dense twigs. The leaves are compound imparipinate weep downward while, the leaflet is ovate, slightly concave and directed horizontally. The micro morphology of both the adaxial and the abaxial surface is rough (Fig.4.a.$_{21}$&4.b.$_{21}$) characterized with scales gives a ribsy form and the adaxial characterized with fine hairs especially beside the veins. The epidermal cells lining, stomata protected with wax rings and cuticular arches form a special ornamented feature especially for the abaxial surface.

3- *Eucalyptus globulus* exhibited average value of 1.04±0.17 g/m^2. The crown is huge with broad upright shape with many distinct broad layers of low dense twigs. The leaves are thick, flat, lanceolate and weep downward. Besides the high roughness formed by the epidermal cells lining, the wax rings and the cuticular arches, both the adaxial and abaxial surface (Fig.4.a.$_{18}$&4.b.$_{18}$) showed high stomatal frequency (4–5 stomata per 100 µm2 leaf area and the stomata in sunken form) High stomatal frequency enables plants to capture particles on the film of moisture produced by transpiration (Tong, 1991 and Jamil *et al*., 2009).

4- *Bauhinia variegate* exhibited average value of 0.96±0.23 g/m^2. The crown is round headed, combat with no layers and dense leaves. Macro-morphology of this tree species plays obvious role in its ability for particles capturing. The leaves are broad, hard, and flat to very concave due to the reniform blade form bifolded in two closed lobs. Micro morphology of both the adaxial and the abaxial surface (Fig.4.a.$_{12}$&4.b.$_{12}$) is very rough characterized with scales gives a ribsy form allow ultra-fine particles to squeeze and trapped in between. The adaxial surface characterized with fine hairs especially beside the veins. The epidermal cells lining, wax rings and cuticular arches form a special ornamented feature especially for the abaxial surface.

5- *Ficus religiosa* comes in the fourth place with average value of 0.85±0.12 g/m^2. The crown is round headed, combat with no layers and dense twigs. The leaves are broad, acuminate, hard, weep downward. The adaxial (Fig.4.a.$_{13}$) surface has rougher surface with high stomatal frequency (4–5 stomata per 100 µm^2 leaf areas) and the stomata surrounded with prominent wax rings. The abaxial surface (Fig.4.b.$_{13}$) has smooth relief without any cuticular features, this in coupled with the weep downward direction of the leaf makes large particles difficult to fix and the equilibrium reached in very slow rate increasing the opportunity of PM10 and PM2.5 particles to adhere via Brownian motion.

6- *Jacaranda acutifolia* showed average value of 0.74±0.04 g/m^2. The crown is umpergeous with distinct layers and relatively low dense twigs. The leaves are thin, compound bipinnate, weep downward and the pines are in horizontal direction. The micro morphology of both the adaxial and the abaxial surface (Fig.4.a.$_{20}$&4.b.$_{20}$) is very rough due to ridges formed by epidermal projection, the epidermal cells lining, wax rings and cuticular arches form a special ornamented feature. The adaxial surface characterized with fine hairs around the prominent veins and the abaxial surface characterized with glands.

In the present study, *Ficus religiosa, Dalbergia sissoo, Bauhinia variegate* and *Psidium guajava* represented the high load PM 2.5 species (Fig.6). The morphology and particle burden of these species are outline in the following:

1- *Dalbergia sissoo* comes in the second place with average value0.48±0.15 g/m^2. The crown is cylendrical, combat with no layers and dense twigs. The leaves are imparipinate, hard, weep downward; the pines are ovate and broad. The abaxial surface (Fig.4.a.$_{27}$) has smooth relief without any cuticular featurs. However the adaxial surface (Fig.4.b.$_{27}$) has rougher surface with hairs and the stomata surrounded with prominent wax rings. The absence of micro-morphological features from the abaxial surface with the weep downward direction of leaf makes large particles difficult to fix and the equilibrium reached in very slow rate increasing the opportunity of fine and ultrafine PM10 and PM2.5 particles to adhere via Brownian motion.

2- *Psidium guajava* showed average value of 0.48±0.15 g/m^2. The crown is ambrigeous with distinct layers and low dense twigs. The leaves are broad, hard, and concave and directed horizontal (fig. 3.5). The micromorphology (Fig.4.a.$_5$&4.b.$_5$) favors the accumulation of fine and ultrafine particles were the epidermal cells lining, wax rings and cuticular arches form molds for particles accumulation.

Conclusion

In conclusion, the studied tree species exhibited different features of macro- and micro-morphology, the property that affects their capturing efficiency and hence their potentialities to remove particles from the atmosphere and air quality improvement. According to the present results, criteria includes such features should be considered in planting scheme used by the urban planning and decision makers for city landscape and urban ecology. Therefore, selective of tree species should be taken into consideration the load and source of air pollution prevails in the area of plantation (inner city, residential, industrial and commercial areas,...etc.) and the potential of trees to intercept and accumulate specific particulate air pollutants.

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الملخص العربى:

اهتمت الدراسة بالخصائص الجيومترية ل٢٧ نوع من أشجار المناطق الحضرية وعلاقتها بكمية الحبيبات المترسبة عليها. وشملت الأنواع اشجار من ذات الأوراق الإبرية وذات الأوراق العريضه وتللك ذات الأوراق المركبة. ولقد اظهرت الدراسة اختلافات معنوية بين تللك الأنواع من حيث كميات الجسيمات الجوية الكلية المترسبة على اوراقها وكذللك من الجسيمات ذات الفئات الحجمية اقل من ١٠ ميكرومترات واقل من ٢.٥ ميكرومترات.كما أظهرت الدراسة تأثيرا كبيراً للخصائص المورفولوجية الظاهرية للاوراق مثل الحجم والإتجاه والكثافة والتسطح على الكفاءة التجميعية للأوراق. وكذللك للخصائص المورفولوجية الدقيقة مثل الزوائد والشعيرات والثغور والترسيبات الشمعية وكذللك الشقوق الدقيقة والأخاديد المتكونة من التخطيطات الخلوية لخلايا طبقة البشرة وأقواس طبقة الأدمة على الكفاءة النوعية لتجميع الحبيبات الجوية العالقة لأوراق الأشجار. وبناءا عليه سادت اشجار التين البلدى والتوايا والتوت الأسود باقى الأنواع من حيث قدرتها على تجميع الحبيبات الكلية العالقة. وكذللك فاقت كل من أشجار الجهنمية وأبو المكارم و الكافور وخف الجمل والتين المذنب والجاكرندا من حيث كفائتها النوعية على تجميع الحبيبات العالقة من الفئة الحجمية أقل من ١٠ ميكرومترات وكذللك فاقت كل من أشجار التين المذنب والسرسوع و خف الجمل والجوافة باقى الانواع من حيث كفائتها النوعية على تجميع الحبيبات العالقة من الفئة الحجمية أقل من ٢.٥ ميكرومترات.