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Abdul-Hameed M.J. Al-Obaidy
Environmental Research Center, University of Technology, Baghdad, Iraq.
10929@uotechnology.edu.iq
Israa M. Jasim
Department of Biology, College of Science for Women, University of Baghdad, Baghdad, Iraq
Abdul-Rahman A. Al-Kubaisi
Department of Biology, College of Science for Women, University of Baghdad, Baghdad, Iraq

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Air Pollution Effects in Some Plant Leaves Morphological and Anatomical Characteristics within Baghdad City. Iraq

Abstract- *The present study examined the air pollutants effects in seven plant species leaves, Olea europea L., Zizphus spina-christi L. Desf., Conocarpus lancifolius Engl., Albizia lebbeck L. Benth., Eucalyptus camaldulensis Dehnh., Clerodendron inermis L. Graeth and Dodonaea viscasa Jacq., distribute within Baghdad city. The leaves sample were collected from May (2016) to April (2017) in five regions within Baghdad city, which are Karrada, Sadr City, Shoula and Mansur, as well as Baghdad tourist island as a control region. The Sulfur dioxide (SO_2), Nitrogen dioxide (NO_2), Carbone monoxide (CO), Volatile organic compounds (VOC_s) and Suspended particulate matter (PM) were measured in all study regions. The present study results showed an increase in concentration of all air pollutants in the four study regions compared to Baghdad tourist island, (SO2) average was (0.56) ppm, while (NO_2) average was (0.80) ppm, (CO) average was (27.69) ppm, (VOC_s) average was (5.99) ppm, while (PM) average was (480.80) µg /m3. The morphological and anatomical characteristics include length, width, area, number of stomata; the number of epidermis cells, and stomatal index were measured in plant leaves. E. camaldulensis leaves were recorded highest length rate (11.03) cm, while highest width rate (5.51) cm and leaf area rate (49.63) cm2 were recorded in A. lebbeck leaves. The highest number of stomata and epidermal cells were also recorded in A. lebbeck leaves (101.25 and 738.85) in respectively. But highest stomatal index value was recorded in D. viscasa leaves (14.21).*

Keywords- *Air pollution, Plant leaves, Morphological characteristics, Anatomical characteristics.*

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1. Introduction

Air pollution is a major problem in modern society. It is also a bigger problem in cities, as air pollutants spread everywhere. These pollutants include different gases and particulate matter that can harm human health and the environment. The relationship between plants and different types of contaminants has been investigated by many researchers [1-6]. Emissions from cars, buses, minibusses, wagons, motorcycles, and trucks may be a major source of urban air pollution. These sources produce different types of pollutants in the environment such as (nitrogen oxides, sulfur oxides, hydrocarbons, ozone, particulate matter, etc.). These pollutants not only affect human and animal health but also threaten plant life in any areas [7]. Emissions from automobiles can directly affect the plant by entering the leaf, destroying its cells, and thereby limiting the ability of the plant to produce food. Urban air pollution is a major environmental problem, especially in developing countries [8]. The leaf is the most sensitive part of the plant that is affected by air pollutants compared to other parts such as stem and roots. This sensitivity is due to the fact that the most important physiological processes of the plant occur in leaves [9].

Pollutants from automobile have long-term effects on plants by affecting the content of carbon dioxide, light intensity, temperature and precipitation. Therefore, plants need special protection because they are not only a source of food but also play a role in purifying and softening environment [10,11].

The air pollutants effects in plants are studied in many types of research as one of plant environmental interference. This may be due to fact that plants are most living organisms that suffer from the effect of air pollution due to their stability within their environments and their long exposure to air pollutants when compared with other organisms [12]. The basic plants role in research related to air pollution was in several directions, including giving early pollution presence signal or warning in a given area and thus help in assessing air quality, and through the plants diversity can determine geographical distribution of air pollutants, and helps to concentrations estimate of those contaminants, if accumulated in plant tissues, and facilitate direct diagnosis of

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

different pollutants depending on plant response types to contaminants [13].

Materials and Methods

I. Air pollutants concentration

Air pollutants were measured and plant's samples were collected for five regions within Baghdad City Karada, Sadr City, Shula and Mansour as well as the control region (Baghdad tourist island), during one year from May 2016 to April 2017. The air pollutants were measured by using specialized digital devices GFG – Quality control G460MICROTECTOR II Germany for gaseous pollutants (SO_2 and NO_2) and Particle mass counter Met One Instrument. USA for particulate pollutants.

II. Plants indicators

The plant samples included *O. europea* L., *Z. spina-christi* L. Desf., *C. lancifolius* Engl., *A. lebbeck* L. Benth., *E. camaldulensis* Dehnh., *C. inermis* L. Graeth and *D. viscasa* Jacq., were selected due to their abundance and dispersal in all study regions within Baghdad City and also exposed to air pollutants continually. In addition, plant leaf morphological characteristics, which included length, width and area, were measured according to [14], [15]. While plant leaf anatomical characteristics, which included epidermal cells number, stomata number and stomatal index were measured and calculated according to [16].

III. Statistical analysis

Statistical Analysis System (SAS) was used to analyze data and study location and plant type effect on studied plant characteristics [17].

2. Results

Table 1 shows the concentrations average of examined air pollutants, namely (SO_2), (NO_2) and (TSP). The seasonal differences in these pollutants values were observed in all studied regions, sulfur dioxide highest concentrations were recorded in spring in p_2 region and reached (1.23) ppm, but lowest concentration was recorded in C region in autumn (0.03) ppm, while sulfur dioxide value in proposal Central Pollution Control Board, Baghdad, Iraq is (0.1) ppm, but nitrogen dioxide highest concentration recorded in winter and reached (1.47) ppm in p_1 and p_4 regions, while C region recorded low concentration in spring and autumn reached (0.04) ppm, nitrogen dioxide value in proposal Central Pollution Control Board, Baghdad, Iraq is (0.25) ppm. The highest suspended particulate matter concentration recorded in autumn was (235.3) µgm-3 in p_2 region, but C region had lowest value in autumn (45) µgm-3.

Table 1: Ambient air pollutants recorded from polluted and control sites during the study period

pollutants	SO_2 (ppm)				NO_2 (ppm)				TSP (μgm^{-3})			
Site	**S**	**A**	**W**	**SP**	**S**	**A**	**W**	**SP**	**S**	**A**	**W**	**SP**
P_1	0.63	0.50	0.40	0.80	1.20	0.70	0.73	0.97	97.2	86.6	112.3	183.6
P_2	0.67	0.60	0.70	1.23	0.60	0.80	1.47	0.11	221.9	235.3	224.5	221.4
P_3	0.47	0.43	0.33	0.63	0.20	0.63	1.23	0.53	153.9	140.5	167	233.1
P_4	0.60	0.43	0.20	0.37	0.73	0.60	1.47	0.77	106.7	121.5	116.7	142
C	0.04	0.03	0.04	0.05	0.04	0.04	0.05	0.07	48.9	45	50	58.75
CPCB standard	0.1				0.25				150			

Where: P = polluted sites (P_1=Karda region, P_2 = Al-Sader city region, P_3 = Al-Shula region, P_4 = Mansour region), C = Control site (Baghdad tourist island), S = summer, A = autumn, W = winter, SP = spring, CPCB = Central Pollution Control Board, Baghdad, Iraq, TSP = Total Suspended Particulate Matter.

Table 2 shows that the highest leaf length rate in *O. europea* was recorded in p_4 region (5.27) cm and lowest rate record in C region (4.27) cm. the highest rate in *Z. spini-christi* reached (5.46) cm in p_1 region and lowest in p_4 region (4.87) cm, while the highest rate of *C. lancifolius* reached (8.62) cm in p_2 region and lowest rate (7.52) cm in p_4 region, highest rate in *A. lebbeck* was (11.41) cm in p_1 and lowest rate (8.75) cm in p_2, While the highest rate in *E. camaldulensis* in C region (15.59) cm and lowest rate (10.35) cm was recorded in p_3, while *C. inermis* and *D. viscasa* reached highest rate (8.83 and 8.49) cm respectively in C region and lowest rate (5.84 and 5.03) cm respectively in the p_3.

Table 3 shows that the highest width leaves rate in *O. europea* recorded in p_4 region (1.49) cm and lowest in p_3 region (1.32) cm. *Z. spini-christi* and *C. lancifolius* reached the highest rate (5.08 and 3.44) cm respectively in C region and the lowest

rate (3.12 and 1.85) cm respectively in p_4 region, highest rate *A. lebbeck* in p_2 region (5.91) cm and lowest rate (5.29) cm in p_3 region, and highest rate of *E. camaldulensis* in C region (3.55) lowest rate (2.53) cm was recorded in p_2 region, while *C. inermis* reached the highest rate (4.52) cm and *D. viscasa* reached the highest rate (1.64) cm in p_1 region and lowest rate of both species (2.99 and 1.32) cm recorded in p_3 region.

Table 4 shows that the highest leaf area rate in *O. europea* recorded in p_2 region (4.81) cm^2 and the lowest rate (4.22) cm^2 in p_4. In *Z. spini-christi* and *C. lancifolius* highest rate was (24.02 and 25.31) cm^2 respectively in C region, but lowest rate was (9.66 and 8.69) cm^2 respectively in p_4 region. Highest rate of *A. lebbeck* was in p_1 region (50.81) cm^2 and lowest rate was (44.57) cm^2 in C region, while the highest rate of *E. camaldulensis* in C region was (30.68) cm^2, and lowest rate (16.46) cm^2 recorded in p_2 region, while *C. inermis* and *D. viscasa* reached the highest rate (25.05and 7.92) cm^2 respectively in C region, but lowest rate for both plants (10.79 and 4.33) cm^2 respectively in p_3 region.

Table 2: Comparison of annual rates of leaf length (cm) in plants during the study period

site	Plant species							
	O. europea	*Z. spini-christi*	*C. lancifolius*	*A. lebbeck*	*E. camaldulensis*	*C. inermis*	*D. viscasa*	LSD value
P_1	5.14	5.46	8.51	11.41	11.37	7.72	7.15	2.35 *
P_2	4.92	5.01	8.62	8.75	10.85	5.99	6.92	2.81 *
P_3	4.58	5.19	8.35	10.54	10.35	5.84	5.03	3.07 *
P_4	5.27	4.87	7.52	11.06	11.55	7.69	6.52	3.47 *
C	4.27	7.38	11.03	8.86	15.59	8.83	8.49	2.94 *
LSD value	1.86 NS	2.08 *	2.71 *	2.15 *	3.08 *	2.44 *	2.61 *	---

) *P<0.05 ،(NS :Non-Significant

Table 3: Comparison between the annual rates of leaf width (cm) in plants during the study period

site	Plant species							
	O. europea	*Z. spini-christi*	*C. lancifolius*	*A. lebbeck*	*E. camaldulensis*	*C. inermis*	*D. viscasa*	LSD value
P_1	1.41	3.81	2.26	5.46	3.31	3.44	1.64	2.09 *
P_2	1.47	3.21	2.04	5.91	2.53	3.17	1.54	1.76 *
P_3	1.32	3.69	2.13	5.29	2.95	2.99	1.32	2.17 *
P_4	1.49	3.12	1.85	5.39	3.33	3.19	1.51	2.08 *
C	1.46	5.08	3.44	5.34	3.55	4.52	1.48	2.17 *
LSD value	0.52 NS	1.86 *	1.31 *	0.74 NS	1.29 NS	2.06 NS	0.81 NS	---

) *P<0.05 ،(NS :Non-Significant

Table 4: Comparison between the annual rates of leaf area (cm 2) in plants during the study period

site	Plant species							
	O. europea	*Z. spini-christi*	*C. lancifolius*	*A. lebbeck*	*E. camaldulensis*	*C. inermis*	*D. viscasa*	LSD value
P_1	4.47	14.76	11.58	50.81	22.45	16.53	7.74	7.51 *
P_2	4.81	10.69	10.49	49.11	16.46	11.29	6.53	6.84 *
P_3	4.34	12.76	10.66	48.37	19.17	10.79	4.33	6.39 *
P_4	4.22	9.66	8.69	50.24	22.65	13.17	6.24	7.09 *
C	4.12	24.02	25.31	44.57	30.68	25.05	7.92	6.22 *
LSD value	1.57 NS	4.73 *	4.61 *	5.96 *	5.83 *	6.13 *	3.29 *	---

Non-Significant :NS ،(P<0.05) *

We observe from Table 5 highest plant leaf stomata number rate in *O. europea* recorded in p_2 region (91.42) and the lowest rate (53.01) in C region, while in *Z. spini-christi* highest rate was

(51.11) in C region and the lowest rate (37.83) in p_1 region. Highest rate in *C. lancifolius* was(40.25) in p_3 region and lowest rate (30.58) in p_2 region, while highest rate in *A. lebbeck* in C region (115.02) and lowest (92.5) in p_3 region, but highest rate in *E. camaldulensis* was (53.92)) in p_1 region and lowest rate (34.25) was recorded in p_2 region, while *C. inermis* reached highest rate (36.92) p_4 region and *D. viscasa* reached highest rate (46.22) in C region, while lowest *C. inermis* rate (23.67) in p_3 and *D. viscasa* (31.33) in p_2 region.

Table 6 shows that highest epidermal cell number rate in *O. europea* was recorded in p_2 region (700.51) and recorded lowest rate (420.02) in C region, while *Z. spini-christi* reached the highest rate (332.42) in p_4 and lowest rate was (233.42) in p_1 region, but the highest rate of *C. lancifolius* was (569.42) in p_3 and the lowest rate was (422.17) in p_2 region. highest rate in C region (848.33) and lowest (662.00) in p_3 region in *A. lebbeck* leaves, while the highest rate in *E. camaldulensis* (357.33) in p_1 and lowest rate (220.42) recorded in p_2, *C. inermis* reached highest rate (511.67) in p_4 and lowest rate (351.42) in p_3, and *D. viscasa* it reached the highest rate (291.01) in C region and lowest rate (196.83) in p_2.

Table 7 shows the highest stomatal index rate of *O. europea* leaf recorded in p_3 region (11.71) and lowest (11.47) in p_1. And highest rate reached in *Z. spini-christi* leaf (14.21) in p_1 and lowest record rate (13.34) in p_3, While highest rate of *C. lancifolius* recorded in p_2 (6.82) and lowest (5.63) in C region. *A. lebbeck* recorded highest rate in p_4 (12.59) and lowest (12.15) in p_1, but the highest rate of *E. camaldulensis* (14.19) in p_4 and the lowest rate (12.69) recorded in C region, while *C. inermis* reached highest rate (6.81) in p_2 and the lowest rate (5.78) in C region. The *D. viscasa* reached the highest rate (14.61) in p_4 and the lowest rate (13.52) in C region.

Table 5: Comparison between the annual rates of the number of stomata in plant leaves during the study period

site	Plant species							
	O. europea	*Z. spini-christi*	*C. lancifolius*	*A. lebbeck*	*E. camaldulensis*	*C. inermis*	*D. viscasa*	LSD value
P_1	70.67	37.83	32.83	100.25	53.92	32.92	35.08	9.54 *
P_2	91.42	39.92	30.58	99.58	34.25	26.00	31.33	8.93 *
P_3	83.67	41.33	40.25	92.5	43.42	23.67	35.5	9.28 *
P_4	73.33	50.75	30.75	112.67	44.67	36.92	35.67	9.96 *
C	53.01	51.11	37.21	115.02	46.01	27.12	46.22	8.35 *
LSD value	6.82 *	6.51 *	5.93 *	10.75 *	6.83 *	6.05 *	7.47 *	---

) *P<0.05.(

Table 6: Comparison of annual rates of epidermal cell number in plant leaves during the study period

site	Plant species							
	O. europea	*Z. spini-christi*	*C. lancifolius*	*A. lebbeck*	*E. camaldulensis*	*C. inermis*	*D. viscasa*	LSD value
P_1	542.17	233.42	464.08	775.25	357.33	486.58	221.51	127.46 *
P_2	700.51	257.33	422.17	707.08	220.42	367.17	196.83	97.33 *
P_3	628.42	267.25	569.42	662.00	272.00	351.42	227.42	162.84 *
P_4	567.58	332.42	443.75	811.08	286.00	511.67	217.42	136.92 *
C	420.02	327.22	503.03	848.33	310.12	453.31	291.01	149.22 *
LSD value	109.52 *	86.41 *	116.79 *	127.50 *	108.56 *	138.92 *	85.06 *	---

.(P<0.05) *

Table 7: Comparison between the annual rates of the leaf stomatal index in plant leaves during the study period

site	Plant species							
	O. europea	*Z. spini-christi*	*C. lancifolius*	*A. lebbeck*	*E. camaldulensis*	*C. inermis*	*D. viscasa*	LSD value
P_1	11.47	14.21	6.58	12.15	13.56	6.49	13.97	3.62 *
P_2	11.62	13.59	6.82	12.44	13.43	6.81	14.11	3.51 *
P_3	11.71	13.34	6.56	12.47	14.15	6.21	14.14	4.09 *
P_4	11.52	13.91	6.57	12.59	14.19	6.73	14.61	3.78 *
C	11.48	13.62	5.63	12.18	12.69	5.78	13.52	3.96 *
LSD value	2.47 NS	2.62 NS	1.96 NS	1.75 NS	2.36 NS	1.86 NS	2.07 NS	---

3. Discussion

Plants are exposed in their environments to many external stress factors. These stresses may occur either simultaneously or sequentially within varying intensity and frequencies. The leaves are first parts of the plant that exhibit usually symptoms of these stresses including air pollution, so the evaluation of morphological characteristics such as length, width and area are the most important steps in monitoring programs[18],[19]. The present study results show variation in length, width and area studied plant leaves values through comparing polluted regions with less polluted region. These results have been interpreted as one of the plants morphological characteristics response form to exhaust pollution as external stress [18]. And also explained the reduction of plant leaves characteristics length, width and area as one of plant adaptation mechanisms to survive under severe environmental stress as exhausts air pollution[20]. As well as this reduction in leaf size may be due to the air pollution effect on leaf growth and elongation[21]. This decrease in morphological properties is explained as one of plant leaves resistance ways to air pollutants and maintain the water balance of plant leaf tissues by reducing leaf area; plant leaves area decreases with more plant leaves the stress and little water leaves loss and increases plant resistance [22]. Leaves area, length and width reducing may lead to reduced contact between air pollutants and plant leaves and thus protect the plant from pollution [23]. In another study, the reason for leaf area reducing in *Albizia lebbeck* growing in high-polluted industrial areas in Khuzestan, Iran, was attributed to plant's suffering from some physiological disturbances resulting from its exposure to pollution, so plant leaf area is described as an important feature that reflects of plant response degree to external stresses [24]. This effect was attributed to the level of dust rising from the intensity of traffic in city streets [25].

The present study results show a decrease in the number of stomata and epidermal cells in most plant leaves when compared between polluted and less polluted regions. While stomatal index values of majority plant leaves showed an increase in polluted regions compared with less polluted region. This variation in results may be due to plant response degree to air pollutants and also their differences between studied species.

The decrease in stomata and epidermal cells number in plant leaves may be due to reduced leaf area [26]. These changes explained that urban environmental conditions have an effect on plant leaf morphological and anatomical characteristics. And also considered as a plant resisting means to drought or air pollutants because of low leaf area low stomata number and low water loss rate by transpiration and low plant leaf gas exchange rate and thus reduced polluting gases penetration rate into leaf [21]. Stomatal index can be considered as one of good anatomical adaptations shown by the plant to air pollution [27]. Low stomata number has been considered to be a sign of plant adaptation to air pollution, because of lower stomata number, lower of gaseous pollutants absorption from the air [28].

4. Conclusion

From current study can conclude the important effect of air pollutants on morphological and anatomical characteristics of leaves more than physiological characteristics. Thus, the study of

leaves morphological and anatomical characteristics gives a more credible description of environmental effects on the plant. The plant's response to air pollution is different, so it is possible to count plants as quantitative and qualitative indices for air pollution.

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