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Test the Efficiency of some Plants in the Tolerant of Air Pollution within the City of Baghdad. Iraq

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Abstract:

This study was designed to monitor the ambient air pollution in several sites within Baghdad City of Iraq. The readings started from May 2016 to April 2017. The highest concentration of sulfur dioxide (SO_2) was 2.28 ppmm^{-3} while nitrogen dioxide (NO_2) was 3.68 ppmm^{-3} and suspended particulate matter was 585.1 μgm^{-3}. This study also included estimating the value of the air pollution tolerance index (APTI) for four plant's species *Olea europaea* L., *Ziziphus spina-Christi* (L.) Desf, *Albizia lebbeck*(L.) Benth. and *Eucalyptus camaldulensis* Dehnh. Were cultivated on the road sides. The study includes four biochemical parameters, total chlorophyll content, ascorbic acid content, pH and relative water content of plant leaves. The results show that combining variety of these parameters give more certain results than those of single parameter. These four estimated parameters have positive correlation with each other and with the values of the air pollution tolerance index in all plants studied.

Keywords: Air pollution tolerance index, chlorophyll, pH.

Introduction:

Plants are very important in maintaining ecological balance by creating a healthy and clean environment for human life. They are the major centers of oxygen in the respiratory system of the globe. They constantly supply us with huge amounts of free oxygen (1). The regional damage of the air pollution problem in local plant species is one of the major environmental issues. The climatic conditions, physiological and chemical properties of air pollutants and their duration in the atmosphere have a significant impact on the life of surrounding plants and animals (2). When plants are exposed to air pollutants. Most of them show physiological changes before visible leaves damage (3). The physiological parameters were used such as the concentration of ascorbic acid (4), the concentration of the total chlorophyll content of the leaves (5), the pH of the plant extract (6), and the relative water content of the leaves (7).

These parameters do not give a clear picture of the effect of air pollution in the plant when used alone, where it was noted that it gives conflicting results for the same species of plants, as in the plant *Ailanthus altissima*, described as a sensitive plant for air pollution depending on one of those parameter (8), while it was describing as a tolerant plant in another study based on another parameter (9). Therefore, the equation of the four parameters were designed to determine the response of the different plants to the environmental stress resulting from air pollution. This equation was defined as the air pollution tolerance index (APTI) (10, 11). This index was used by environment's and plant's scientists to identify the most resist species against air pollution (12), as well as the arrangement of plant species according to the value of this index (13).

Materials and Methods:

Air pollutants were measured and plant's samples were collected for four sites in Baghdad City are Karda city, Al-Sader city, Al-Shula city and Mansour city as well as the control site (Baghdad tourist island), during one year from May 2016 to April 2017. The air pollutants were measured by using specialized electronic 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. The plant samples included

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Olea europaea L., *Ziziphus spina-Christi* (L.) Desf, *Albizia lebbeck* (L.) Benth. and *Eucalyptus camaldulensis* Dehnh , were selected due to their abundance and dispersal in all study sites in Baghdad City and also exposed to air pollutants continually. The plant tolerance degree to air pollutants was determined by calculating the values of plant physiological parameters. The content of ascorbic acid was measured by (14) and chlorophyll content(15) and pH by (16) and relative water content according to (17) in the plant's species leaves under study. The value of the air pollution tolerance index for each plant species was calculated by using the formula: APTI = [A (T+P) + R] /10, Where, A = Ascorbic acid (mg/100g dry wt.), T = Total Chlorophyll content (mg/g dry wt.), P = pH of leaf extract and R = Relative Water Content of leaf tissue (%) (13).

Results:

Table 1 shows the average concentrations of the main air pollutants, namely sulfur dioxide, nitrogen dioxide and suspended particulate matter. The seasonal differences in the values of these pollutants were observed in the studied sites, with the highest concentration of sulfur dioxide in the spring 2.28 ppmm^{-3} and then the summer by 1.78 ppmm^{-3} followed by autumn and winter 1.48 and 1.23 ppmm^{-3} respectively in the contaminated sites, while the value of sulfur dioxide in the proposal Central Pollution Control Board, Baghdad, Iraq is 0.1 ppmm^{-3}, and nitrogen dioxide concentrations reached the highest value in winter 3.68 ppmm^{-3}, in summer and autumn. Their values were 2.05 ppmm^{-3} while in spring it recorded the lowest value 1.79 ppmm^{-3}, but the value of nitrogen dioxide in the proposal Central Pollution Control Board, Baghdad, Iraq 0.25 ppmm^{-3}. The highest suspended particulate matter concentration was in spring 585.1 µgm^{-3}, while the other seasons had a similar value as winter, it was 465.4, autumn 437.9, and summer 434.8 µgm^{-3}, exceeding the value of the proposal Central Pollution Control Board, Baghdad, Iraq µgm^{-3}.

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

pollutants	SO_2 (ppmm^{-3})				NO_2 (ppmm^{-3})				TSP (µgm^{-3})			
Site	**S**	**A**	**W**	**SP**	**S**	**A**	**W**	**SP**	**S**	**A**	**W**	**SP**
P1	1.9	1.5	1.2	2.4	3.6	2.1	2.2	2.9	291.5	259.9	337	550.7
P2	2	1.8	2.1	3.7	1.8	2.4	4.4	0.34	665.8	705.8	673.5	664.3
P3	1.4	1.3	1	1.9	0.6	1.9	3.7	1.6	461.7	421.4	501.1	699.4
P4	1.8	1.3	0.6	1.1	2.2	1.8	4.4	2.3	320	364.6	350.1	426.1
Average	1.78	1.48	1.23	2.28	2.05	2.05	3.68	1.79	434.8	437.9	465.4	585.1
C	0.04	0.03	0.04	0.05	0.04	0.04	0.05	0.07	195.5	180	200	235
CPCB standard (24hr)	0.1				0.25				350			

Where: P = polluted sites (P1=Karda city, P2 = Al-Sader city, P3 = Al-Shula city, P4 = Mansour city), 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 the vibration and distribution of four biochemical and physiological parameters values calculated during this study : total chlorophyll content, ascorbic acid content, pH and relative water content of plant leaves of the studied species at the four pollution sites and control sites .

Table 3 explains the average of biochemical and physiological parameters concentration, total chlorophyll content recorded the highest value in *A. lebbeck* 0.248±0.019 mg/g followed by *Z. spina-Christi*, 0.237±0.034 mg/g followed by *E. camaldulensis* 0.229±0.033 mg/g and then *O. europaea* 0.104±0.015 mg/g in polluted sites. While the total chlorophyll content in the same species in the control site was 0.192 ± 0.067, 0.188 ± 0.059, 0.175 ± 0.042 and 0.048 ± 0.025 mg/g in *Z. spina-Christi*, *A. lebbeck*, *E. camaldulensis*, and *O. europaea* respectively.

The highest ascorbic acid content average was in *A. lebbeck* 97.46 ± 14.76 mg/100g followed by *E. camaldulensis* 38.54 ± 5.27 mg /100g followed by *Z. spina-Christi* 12.97 ± 11.39 mg/100g and finally *O. europaea* 3.45 ± 0.35 mg/100g at the contaminated sites. In the control site, the highest value of ascorbic acid content was also in *A. lebbeck*, which was 122.33±21.05 mg/100g followed by *Z. spina-Christi* 29.53±14.20 mg /100g and finely *E. camaldulensis* and *O. europaea* 8.18 ± 2.50 and 2.08 ± 0.09 mg /100 g respectively.

For the pH, *A. lebbeck* also recorded the highest pH average was 6.55 ± 0.18 followed by *Z. spina-Christi* 6.33±0.08 and *E. camaldulensis* and *O. europaea* 5.72±0.15 and 5.25 ± 0.22 respectively in contaminated sites. For control site, the results were the same previous serial but at lower values 6.34±0.12, 6.29±0.19, 5.12±0.28 and 5.10±0.23 in

A. lebbeck, *Z. spina-Christi*, *E. camaldulensis* and *O. europaea* plants, respectively.

The highest relative water content average was 84.90±2.97% in *A. lebbeck* followed by *Z. spina-Christi* and *E. camaldulensis* 82.44±2.86 and 82.32 ± 5.41% respectively. and *O. europaea* recorded the lowest value 75.80±3.13% in polluted sites . In the control site *E. camaldulensis* had the highest value 94.75±4.81% followed by *A. lebbeck* 90.85±4.28%, followed by *Z. spina-Christi*, 81.65±2.78%, and *O. europaea* 74.95±4.33%.

The highest APTI average was 74.74 ± 11.59 in *A. lebbeck* followed by *E. camaldulensis* 31.16 ± 3.29 and *Z. spina-Christi* 16.76±10.29 respectively. *O. europaea* recorded the lowest value 9.43 ± 0.19 in polluted sites. In the control site *A. lebbeck* had highest value 88.94 ± 10.70 followed by *Z. spina-Christi* 27.31 ± 6.39 , followed by *E. camaldulensis*, 13.81±1.09 and *O. europaea* 8.57±0.12.

Table 4 shows the significant relationship degree among all biochemical parameters and APTI of all plant species studied. Where these four parameters had positive correlation with each other and with the values of the air pollution tolerance index.

Table 2. Temporal and Spatial distribution of Biochemical and physiological parameters of four selected trees during study period

Parameters \ Sites		P1				P2				P3				P4				C			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Tchl. mg/g	**S**	0.03	0.18	0.19	0.12	0.04	0.11	0.20	0.16	0.04	0.11	0.16	0.19	0.04	0.12	0.11	0.23	0.02	0.11	0.13	0.13
	A	0.09	0.24	0.17	0.25	0.11	0.16	0.22	0.17	0.08	0.16	0.29	0.25	0.10	0.29	0.17	0.19	0.04	0.17	0.16	0.16
	W	0.14	0.27	0.36	0.34	0.20	0.33	0.32	0.24	0.17	0.28	0.37	0.32	0.19	0.38	0.37	0.31	0.08	0.26	0.27	0.23
	SP	0.08	0.33	0.25	0.20	0.08	0.24	0.28	0.16	0.11	0.27	0.26	0.28	0.16	0.31	0.25	0.25	0.05	0.23	0.20	0.17
A.A mg/100g	**S**	2.5	2.1	47	27	4.1	10.2	117	28.4	3.6	9.4	122	11.8	4.5	4.3	98.2	17.8	2.2	14.8	121	4.5
	A	3	4.9	130	31.1	3.7	37.4	144	38	4	20.4	126	47.6	3	6	86.4	58.6	2.1	39.1	153	9.2
	W	3.1	3.2	80.1	35	4.2	14.6	54	57	3	5.2	83.8	27.6	3.1	12.5	126	44.1	2	20.2	108	8.6
	SP	3.2	4.2	45.3	38.2	2.8	55.8	114	58.8	4.2	7.5	90.2	62.4	3.2	9.8	95.7	33.2	2	44	108	10.1
pH	**S**	5.01	6.14	6.35	5.58	5.05	6.21	6.71	5.91	5.11	6.27	6.46	5.41	5.09	6.33	6.61	5.76	4.93	6.19	6.32	5.07
	A	4.95	5.99	6.63	5.85	5.17	6.36	6.32	4.99	4.82	5.93	6.13	5.17	5.11	6.28	6.41	5.33	4.87	6.09	6.17	4.77
	W	5.83	6.51	6.87	6.12	5.78	6.41	6.58	5.89	4.57	6.43	6.72	6.16	5.54	6.24	6.35	6.19	5.28	6.36	6.42	5.44
	SP	5.53	6.69	7.07	5.74	5.43	6.75	7.06	6.05	5.15	6.31	6.35	5.34	5.77	6.45	6.12	6.07	5.32	6.51	6.44	5.18
RWC %	**S**	73.3	73.1	74.7	89.5	76.4	92.6	93.2	83.6	72.4	75.5	81.9	76.8	79.5	86.2	89.1	93.2	74.6	79.7	90.7	98.7
	A	69.9	86.1	88.1	89.4	79.7	81.2	93.4	85.5	72.5	79.8	81.7	78.3	79.4	78.8	91.8	75.7	74.5	81.2	95	94.7
	W	83.2	92.7	88.7	87.1	74.3	83.5	86.4	78.8	76.4	92.6	90.1	87.1	77.3	75.4	81.4	86.3	76.9	85.7	92.7	97.6
	SP	83.7	91.4	86.3	82.8	60	76.8	77.5	77.8	73.8	69.1	69.9	58.1	80.9	84.1	84.1	87.1	73.8	80	85	88
APTI	**S**	8.6	8.6	38.5	24.2	9.7	15.6	90	25.3	9.1	13.4	87.2	14.3	9.9	11.3	75	19.7	8.6	17.3	86.8	12.2
	A	8.5	11.6	94.8	27.5	9.9	32.5	104	27.8	9.1	20.2	88.9	32.4	9.5	11.8	66.6	42.2	8.5	32	106	14
	W	10.2	11.4	66.8	31.3	9.9	38.8	69.5	43.5	9.1	12.8	68.1	26.3	9.5	15.8	92.4	37.2	8.8	21.9	81.4	14.8
	SP	10.1	12.1	41.6	30.9	7.6	46.4	90.7	44.5	9.5	11.9	66.4	40.7	9.6	15	76.3	29.5	8.6	27.3	88.9	13.8

Where : **P** = Polluted sites (**P1**=Karda city, **P2** = Al-Sader city ,**P3** = Al-Shula city ,**P4** = Mansour city) ,**C** = Control site (Baghdad tourist island) , **1**= *Olea europaea* , **2** = *Ziziphus spina-Christi* , **3** = *Albizia lebbeck* , **4** = *Eucalyptus camaldulensis* , **Tchl** = total chlorophyll , **A.A** = ascorbic acid , **RWC** = relative water content , **APTI** = air pollution tolerance index . **S** = summer , **A** = autumn , **W** = winter , **SP** = spring .

Table 3. Biochemical and physiological parameters and tolerance index average values of four selected plants (all values are mean ± S.E) during study periods

Parameters	Plant species							
	O. europaea		***Z. spina-Christi***		***A. lebbeck***		***E. camaldulensis***	
	P	**C**	**P**	**C**	**P**	**C**	**P**	**C**
Tchl(mg/g)	0.104 ± 0.015	0.048 ± 0.025	0.237 ± 0.034	0.192 ± 0.067	0.248 ± 0.019	0.188 ± 0.059	0.229 ± 0.033	0.175 ± 0.042
A.A(mg/100g)	3.45 ± 0.35	2.08 ± 0.09	12.97 ± 11.39	29.53 ± 14.20	97.46 ± 14.76	122.33 ± 21.05	38.54 ± 5.27	8.18 ± 2.50
pH	5.25 ± 0.22	5.10 ± 0.23	6.33 ± 0.08	6.29 ± 0.19	6.55 ± 0.18	6.34 ± 0.12	5.72 ± 0.15	5.12 ± 0.28
RWC(%)	75.80 ± 3.13	74.95 ± 4.33	82.44 ± 2.86	81.65 ± 2.78	84.90 ± 2.97	90.85 ± 4.28	82.32 ± 5.41	94.75 ± 4.81
APTI	9.43 ± 0.19	8.57 ± 0.12	16.76 ± 10.29	27.31 ± 6.39	74.74 ± 11.59	88.94 ± 10.70	31.16 ± 3.29	13.81 ± 1.09

Where: Tchl = total chlorophyll . A.A = ascorbic acid, RWC = relative water content, APTI = air pollution tolerance index, P = polluted sites, C = control site .

Table 4. Correlation coefficient of biochemical parameters and APTI of analyzed plant leaf samples during study period.

Parameters	APTI	RWC	pH	A.A
Tchl	0.612062	0.979006**	0.866437*	0.616634
A.A	0.998728**	0.761471*	0.6687	
pH	0.688619	0.899884*		
RWC	0.759252*			

*: Significantly different at $p < 0.05$. **: Significantly different at $p < 0.01$.

Discussion:

Sulfur dioxide is a major air pollutant emitted from various natural or industrial sources. The annual global emission rate of this gas in the air is estimated at 114 million metric tons. Industrial sources contribute about 90% (18). This may support the current research results. The contaminated sites recorded a high concentration of this gas 2.28 ppmm^{-3} compared with the control site 0.05 ppmm^{-3}. Nitrogen dioxide is also a highly polluting gas to the air, due to vibration of its natural and industrial emissions sources. The annual global emission rate of active nitrogen oxides in the air is estimated at 230 million metric tons. Industrial sources contribute about 60% (18, 19). This may give evidence to exceed the nitrogen concentration value 3.68 ppmm^{-3} in polluted sites, the value of the control site is 0.07 ppmm^{-3}. The suspended particulate matter in the air is one of the most dangerous air pollutants due to the health and environmental problems caused by the diversity of natural and industrial sources as well as the diversity of nature and size (20). This was observed in the current research results, the highest average value of particulate was 585.1 µgm^{-3} in the contaminated sites, exceeding the control site value of 235µgm^{-3}. The increase in the average of air pollutants during the spring months may lead to an increase in population activity during this period, leading to an increase in the traffic density of the vehicles in the Baghdad City, which is accompanied by high emission levels for the exhausts as well as the presence of other constant pollution sources in those sites

Plants in urban environments have become very important because of their effective role in improving local and regional air quality (21) through the absorption and filtration of gaseous and particulate pollutants (22), as well as storing large quantities of pollutants, (23). Therefore, the regional air pollution damage in the local plant environment has become one of the major environmental issues. Trees are the largest and most affected by air pollutants due to their constant nature (24).

The plant's tolerability varies from one species to another, and it can be estimated at biochemical and physiological levels based on four parameters adopted in many studies (25, 26, 27). These parameters are the total chlorophyll content, ascorbic acid content, the pH values and the relative water content of plant leaves. It was found that different air pollutants directly and indirectly affect the overall metabolic activities within the plant before the appearance of its morphological impacts (28). Observed from the current research results in Table(3), all plant species studied in contaminated sites recorded high values for the four parameters compared with the samples taken from the control site, and it is possible to describe the degree and kind of tolerance of these plants based on these four parameters. The chlorophyll pigment is the essential light receptors in the photosynthesis activity, so the evaluation of its content within plant leaves is an important tool for assessing the degree and kind of effect of air pollutants in plants because it plays an important role in the overall metabolic activities within plants (29). The leaf chlorophyll content values have been widely adopted as evidence of contamination (30) in their study of the effect of air pollution on some biochemical traits in nineteen plant species such as *Acalypha indica*, *Euphorbia hirta*, *Ficus reliogiosa*, and others, in Hyderabad, the total chlorophyll content varied by plant species and the degree of the area contamination. Thus, plants that possess high chlorophyll value are described as air pollution tolerant.

Ascorbic acid in the plant is a natural antioxidant and plays an important and significant role in the plant's tolerance to air pollution by activating many of the protective physiological mechanisms in plants. Conklin (31) observed through their study the relationship between foliage damage and antioxidant change in red and Norway spruce when exposed to acidic mists that ascorbic acid is available in many parts of the plant, especially in the leaves and participate in the chloroplast and cell wall protection, and also observe its role in the photosynthesis activity, especially the carbon dioxide fixation as well as cellular division (32), it was observed through the present study results that all species recorded high ascorbic acid content values in polluted sites compared with control site. This agrees with Agarwal *et al.* (33) who studied the effect of sulfur dioxide in the content of ascorbic acid in some agricultural crops. The high content of ascorbic acid in plant leaves gives an indication of their resistance to sulfur dioxide, so the high levels of ascorbic acid content are an indicator of their tolerant against air pollution.

The results of this study indicate that pH values tend to be acidic, ranging from (5.25 - 6.55); this may be due to the presence of high concentration of SO_2 and NO_2 gases in the ambient air.This result agrees with (34), through their study of automobile exhausts contamination effects in *Shorea robusta* and *Malotus phillipensis* plants in Asarori, Dehradum, so the pH value was a vital biochemical indicator of air pollution (27,11) found through their study of analyzing the cost effectiveness of Santiago, Chile's policy of using urban forests to improve air quality that pH of the plant extract is accompanied with high conversion efficiency of hexose sugar to ascorbic acid and this agrees with the results of the current study as shown in Table (4) that the pH value is linked with the ascorbic acid values by positive correlation in all plants.

The plant body water content plays a role in maintaining its physiological balance under the air pollution pressure and the high water content gives evidence for plant pollution tolerance (35). Therefore, the relative water content of plant leaves is a suitable parameter for describing the plant water state because it is one of the external pressure physiological responses, especially with the high plant transpiration rate. High water contains an indicator of drought-resistant plants (36), depending on this explanation can be considered plants species in the current study are air pollution tolerance species because they recorded high values for relative water content ranged from (75.80 - 84.90%).

It is noted that when depend on a single parameter, it does not give enough description of the plant's air pollution tolerability. So when we depend on the ascorbic acid plant content, *A. lebbeck* in the current study can be described as a tolerant plant because it recorded a high value of 97.46 mg /100g and *O. europaea* plant as sensitive because it recorded value 3.45 mg /100 g, while the relative water content values of the current study all plants can be described tolerant plants because they recorded high and closure values. This was also reported by Racchi, Mickler *et al.* (8,37), when they studied *Ailanthus altissima*, they found that depending on one physiological parameter alone gives conflicting results for the same species; therefore, the using of all parameters gave a more accurate description of the degree and type of the plant's tolerability against air pollution. Therefore, the value of the air pollution tolerance index was used to describe many plants in several studies (30, 12, 16), Air Pollution Tolerance Index plays significant role to determine resistivity and susceptibility of plant species. Based on the APTI values the plants were conveniently grouped as follows: <1 Very sensitive, 1 to 16 Sensitive, 17 to 29 Intermediate, 30 to 100 Tolerant (38). We note from all the above that plants alter their physiological pathways when exposed with the air pollution problem. This agrees with Mandal (39) through their studying of physiological changes in certain test plants under automobile exhaust pollution.

Conclusion:

Possible conclusion from this study that plants have a high air pollution tolerance index value are described as tolerant species and thus they are huge sinks for pollutants and can be used in the build of greenbelt to remove or mitigate the air pollutants, while the plants that have low air pollution tolerance index values are described as sensitive species and used as bioindicators for air pollution monitoring.

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اختبار كفاءة بعض النباتات في تحمل ملوثات الهواء داخل مدينة بغداد. العراق

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الخلاصة :

صممت هذه الدراسة لمراقبة تلوث الهواء المحيط في عدة مواقع ضمن مدينة بغداد . العراق واخذت القراءات لمدة سنة واحدة من ايار2016 الى غاية نيسان 2017، اذ سجل اعلى تركيز لغاز ثاني اوكسيد الكبريت (SO_2) 2.28 جزءبالمليون/م^3 وغاز ثاني اوكسيد النتروجين(NO_2) 3.68 جزءبالمليون/م^3 والدقائقيات (SPM) 585.1 مايكروغرام /م^3، وشملت هذه الدراسة ايضا تقدير قيمة دليل التحمل لتلوث الهواء (APTI) في اربعة انواع من النباتات المزروعة في جانبي الطريق وهي الزيتون *Olea europaea* L و السدر *Ziziphus spina-Christi* (L.) Desf و الالبيزا *Albizia lebbeck* (L.) Benth و اليوكالبتوز *Eucalyptus camaldulensis* Dehnh عن طريق استعمال اربعة مقاييس حيوية كيميائية وفسيولوجية وهي محتوى الكلوروفيل الكلي total chlorophyll content و محتوى حامض الاسكوربكascorbic acid content والاس الهيدروجيني pH والمحتوى المائي النسبي relative water content للاوراق النباتية، اذ اظهرت النتائج ان اعتماد مجموعة مقاييس متنوعة يعطي نتائج اكثر ثقة من الاعتماد على مقياس واحد، كما وبينت المقاييس الاربعة المقاسة خلال هذه الدراسة ارتباطا معنويا مع بعضها البعض ومع قيم دليل التحمل لتلوث الهواء في النباتات المدروسة جميعها .

الكلمات المفتاحية: دليل تحمل تلوث الهواء، الكلوروفيل، الاس الهيدروجيني.