Terrestrial Plants as Indicator of Pollution in Basrah, Iraq

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Abstract

Conocarpus erectus, *Ziziphus jujube*, *Phoenix dactylifera* L., *Tamarix aphylla* and *Albizia lebbeck* were chosen in four different areas of Basrah (southern Iraq) and for different times during 2015 to test their tolerance to air pollution, leaves used to estimate the physiological evidence which showed that the low and highest values in December and May respectively, pH values were 4.55-8.67 in *Albizia lebbeck* and *Tamarix aphylla* respectively, and values of ascorbic acid 0.08-10.33 mg/g in *Ziziphus jujube* and *Albizia lebbeck* respectively, content aqueous leaves were 55.96-98.76% in *Albizia lebbeck* and *Ziziphus jujube* respectively, total chlorophyll recorded were 0.01-0.13 mg/g in *Phoenix dactylifera* and *Albizia lebbeck* respectively, while the lowest and highest values of air pollution index were (6.42-14.18) in *Albizia lebbeck* during December and May straight as well. The rise in temperature had a role in raising the sensitivity of plants to air pollutants, and the data showed the variance of values, which is due to the variation of air pollution.

Key words: pH, Ascorbic acid, Relative water, Chlorophyll, Air pollution.

Introduction:

The steady increase in the population, as well as the increase in factories and the resulting combustion and development in other areas, a large number of vehicles and cars on the roads, which increase the release of gases from car exhausts, as well as changing climatic conditions and the lack of falling rain, which increases the volatile dust in the atmosphere, all of this leads to an increase in air pollutants and their impact on living organisms, including plants on the side of roads or in gardens (DEFRA, 2019). The toxins in the atmosphere of cities affect human health and the ecosystem as they cause serious global air pollution problems, As polluted air increases respiratory diseases such as asthma and bronchitis, and also increases difficult diseases such as cancer (Azam *et al*., 2016). Several studies have shown the importance of using plants as a vital guide for monitoring air pollution because of its ability to accumulate pollutants in their live tissues. (Arora and Choyal, 2014).

The researchers Uka1 *et al*., (2019) had shown in their study, all four tree species had a mean APTI estimation of more than 17, thus, which are open-minded to vehicular contamination. The open-minded reaction to vehicular contamination in the investigation zone was as per the following:
Terminalia catappa>*Ficus platyphylla*>*Mangifera indica* and *Polyalthia longifolia*. A significant decrease in acidity and total chlorophyll, ascorbic acid, and also plant's relative water content and yield of wheat and mustard plants which cultivated in contaminated sites (Joshi Chauhan *et al*., 2009).

Kwak *et al*., (2020) explained that carbon absorption potential was just seen in *Taxus cuspidata* and *Zelkova serrata* as an outcome of no stomatal drowsiness, given the total tree upgraded SO2 take-up under abundance SO2 introduction. So as to diminish air quality injury brought about via air contaminations, cuspidate were assessed to be poor and poor entertainers, and the examination recommends that reconciliation of both APTI and API dependent on stomatal assimilation transition is expected to choose differ trees species in green space arranging/development to control vaporous air contamination. A study was conducted in which samples of 18 ornamental plant species were collected in two locations in Rasht, northern Iran. They were then subject to leaf relative water content, total chlorophyll content, leaf extract pH and ascorbic acid content to determine their index of air pollution tolerance. The outcomes showed that the species contrasted in resistance at various locales. The *Yucca filamentosa* and *Berberis thunbergii* were recognized as air contamination tolerant species among the 18 species considered, so they are suggested for use in parks (Ghfari *et al*., 2020).

The study looked at the tolerance of four plants present around a petrochemical plant in southwestern Iran to pollutants in the atmosphere and compared them to non-polluted areas, and the results showed that with an increase in the value of APTI, this indicates an increased tolerance of species to pollution-induced stress. (Seyyednjad *et al.*, 2011).

A study tested all the trees in the three industrial areas south of Bengaluru to know their tolerance to air pollutants and the result was a different response, plants growing in a polluted environment had a higher's APTI value than the plants growing in a less polluted environment, as their study showed *Ficus religiosa*, *Azadirachta indica* and *Pongamia pinnata* L. are the most tolerant air pollution (Begume and Harikrishna, 2016). Also Viradia *et al*., (2020) studied plants in two industrial areas, Samrat and Metoda and noticed the difference of plants in their APTI values and emphasized the cultivation of plants tolerating air pollutants (have high APTI value) can be fused into greenbelts to help the natural approach and the executives rehearse in urban modern regions.

The sensitivity and reaction of plants to air pollutants are changeable. The plants are sensitive and the response behave as the biological, physiological, furthermore, the biochemical record can use, as pointers to air poisons and is the chance of the synergistic activity of toxins (Lakshmi *et al*., 2009).

It is a recognized fact that plants play an important position in cleaning the atmosphere by absorbing certain toxic air pollutant gases and some particulate matter through the leaves. Vegetation has a huge surface area and their leaves purpose as an efficient pollutant trapping device (Sirajuddin *et al*., 2012).

The study conducted to assess the APTI of selected plant species in four regions in Basra (southern Iraq) to determine the degree of air pollution.

Materials and Methods:

Study area:

Basrah is the southern governorate of Iraq and surrounded by Iran, Kuwait, and Saudi-Arabia. Basrah governorate has a hot weather (NCCI, 2015). Four different locations were selected according to their degree of contamination (Fig.1) and their description which was shown in Table (1).

Table 1. Description of study locations

Site	Latitude (N)	Longitude (E)	Classification
Al-Magedah	30.607578	47.754439	Trucks, Residential, Rural area
Karmat Ali	30.565341	47.752529	Rally vehicle zone
Khora	30.500336	47.837882	Co-dominantly commercial and traffic zone
Befor bridge of Zubair	30.451789	47.771349	Rally vehicle, Trucks zone

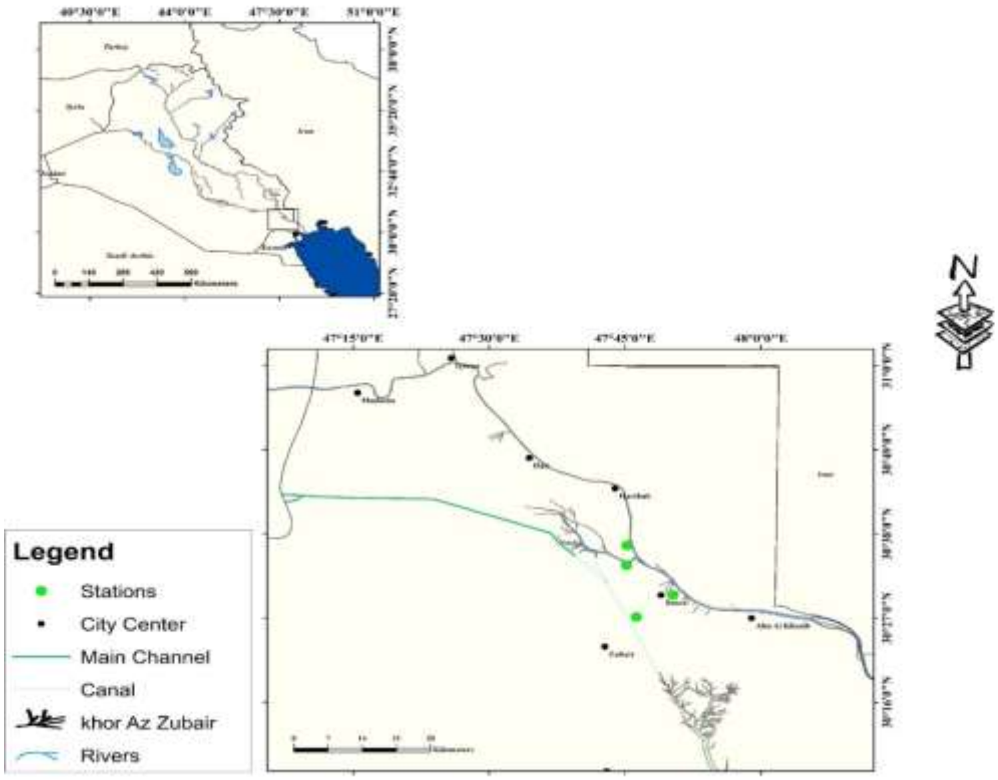

Fig. 1. Map of Iraq shows the study area in Basrah city

The highest and lowest temperatures for the air, as well as the relative humidity and the amount of rain to Basrah city, are included in Table (2), which was recorded by the Iraqi Meteorological and Seismological Authority at Basra International Airport.

Table 2. Air temperature and rainfall through the sampling season

Months of Year	Temperature Minim C°	Temperature Maximum C°	Rainfall mm/ h	Days of Rainfall	Humidity %
January	-2.8 – 15.9	14.1 – 25.4	3.40	3	20 – 100
February	2.7 – 20.1	11.8 – 30.1	9.60	6	14 – 100
March	3.5 – 20.0	21.8 – 33.8	21.5	6	5 – 97
April	13.0 - 26.5	26.8 – 41.6	0.40	1	0 – 70
May	22.8 – 33.8	37.0 – 48.9	0.30	2	4 – 72
June	24.8 – 31.6	42.3 – 50.6	0.00	0	3 – 82
July	22.7 – 33.0	45.0 – 52.2	0.00	0	4 – 77
August	26.4 – 32.1	46.5 – 50.7	0.00	0	3 – 77
September	20.6 – 30.9	41.3 – 47.5	0.00	0	6 – 82
October	16.6 – 29.7	29.4 – 46.0	13.0	4	6 – 93
November	7.7 – 21.6	21.0 – 31.2	1.50	2	19 – 88
December	0.6 – 18.7	12.2 – 30.0	43.0	7	20 – 100

Leaves samples collection:

Terrestrial plants that were chosen near the roadside are presented in Table (3), in the study unpolluted area to compare with the chosen sites was not identified due to the difficulty in obtaining an unpolluted site. Three replicates of completely ripe leaves for each species were taken in the morning (9-10:30 am) during May, September, and December 2015.

Table 3. Plant species selected for phytochemical estimation

Common Name		Family
Erectus	*Conocarpus erectus*	Combretaceae
jujube (E)	Ziziphus *jujube*	Rhamnaceae
Palm	*Phoenix dactylifera* L	Palmae
Aphylla	*Tamarix aphylla*	Tamaricaceae
Lebbeck	*Albizia lebbeck*	Fabaceae

Parameters Studied:

Leaves extracts pH:

Fresh leaves(40 g) crashed and add 40 ml of ionic distilled water, then mash the mixture, then, clarify the extract and use a calibrated pH scale to measure the acid number of the clarified solution.

Relative water content (RWC):

Liu and Ding (2008) method was used to determine the relative value of the water content. The new leaves collected and submerged in water in a container for 8 hours, then removed from the water, wiped the leaves, and weighed before drying at 105 ° C for 4 hours. Then weigh it after drying. The equation below is used to calculate the percentage of RWC:

$$RWC\ (\%) = \frac{\text{Initial weigh - Dry weigh}}{\text{Saturated weight - Dry weight}} \times 100$$

Ascorbic acid content

Optical absorption spectrometer used to measure the leaf content of ascorbic acid according to Kuddus (2011), the concentration of ascorbic acid record according to the following equation:

$$\text{Ascorbic acid(mg/g)} = \frac{[E0-(Es-Et)]\times V}{W\times V1\times 1000}$$

Where,

W = Weight of fresh leaves .

V1 = Volume of the supernatant .

V = Total volume of the mixture.

The value of [Eo – (Es – Et)] is calculated by the standard curve.

Chlorophyll Content(TC):

The chlorophyll was determined using the method as shown by Singh *et al*., (1991). Then use the equation below to calculate the total chlorophyll(TC).

$$\mathbf{TC(mg/g)=\{(20.2\times A645)+(8.02\times A663)\}\times V/1000\times W}$$

Where: A645 = Absorbance at 645 nm,

A663 = Absorbance at 663nm,

V = Total volume of the extract

Air pollution tolerance index (APTI):

Air contamination degree of the plants was calculated by utilizing the equation developed by Singh and Rao, (1983) :

APTI = APTI = [{A (T+ P)} + R/10]

Where: A=[ascorbic acid content in leaf (mg/g)]; T=[total chlorophyll content in leave (mg/g)]; P=[leaf extract pH] and R=[Water content percentage of the leaf].

Statistical analysis:

Information was examined by a single direction investigation of fluctuation (ANOVA) utilizing the Statistical Program for Social Sciences (SPSS 20) for windows.

Results and Discussion:

Leaf extract pH:

The present study recorded values of leaf extract pH, which ranged from 4.55 in *Albizia lebbeckplant* to 8.67 in the *Tamarix aphylla* in December and September respectively (Fig.2). The values characterized by differences between the locations and plants as well, especially noting their change in May as the temperature rises, which may be due to the high percentage of pollutants in the Summer. The exposure to air oxide pollutants, such as nitrogen oxides and sulfur, affects the degree of acid content (Bharti *et al*., 2018; Rathore *et al*., 2018).

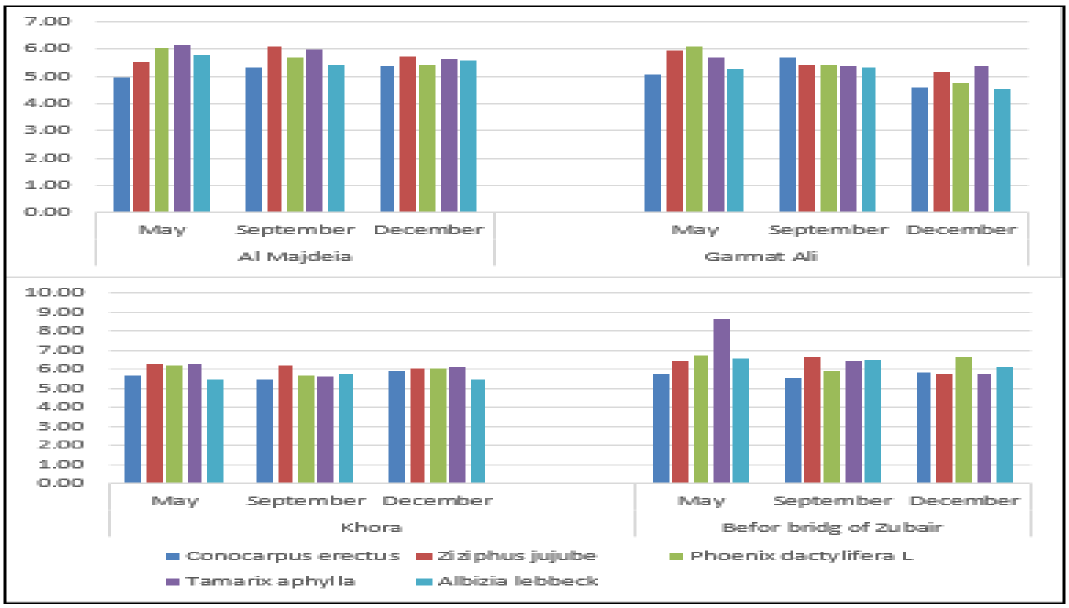

Fig. 2. Leaf extract pH of plants samples in study locations

Total chlorophyll content (TCC) mg/g:

Albizia lebbeck has the highest value of total chlorophyll content (TCC) during the study periods, (0.13 mg/g) while the lowest value was 0.1 mg/g in *Phoenix dactylifera* L. in May month (Fig. 3), but the significant differences were low in plant content of TCC. Chlorophyll is an important component of photosynthesis, it may be caused by varying concentrations due to the leaf's age and air pollution levels, or on the other hand dust collection is more which can cause dust molecule disintegration in cell sap and effected the pH (Lohe *et al*., 2015).

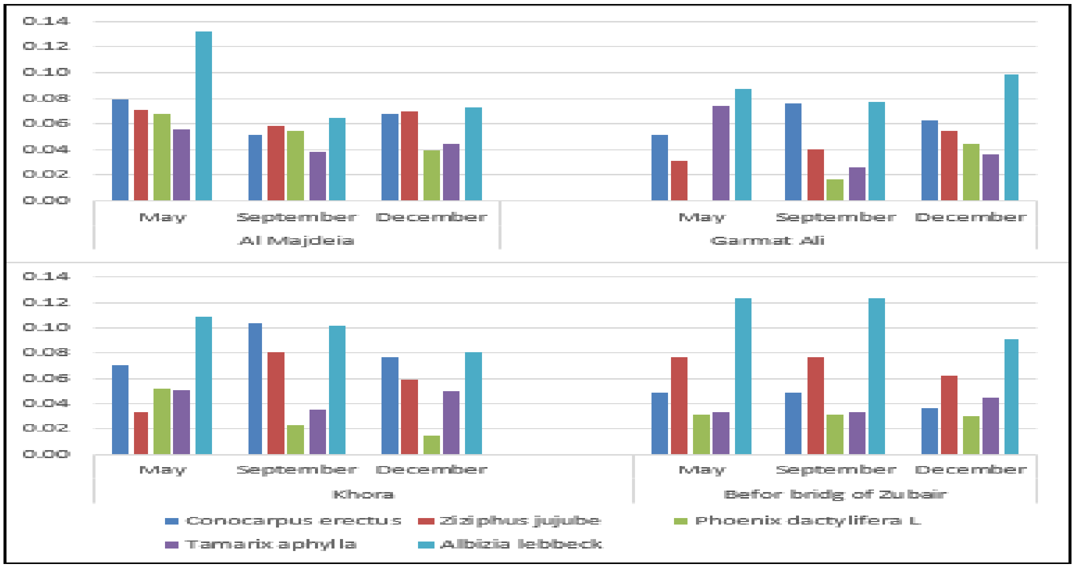

Fig. 3. Total chlorophyll of plants in study locations

Ascorbic Acid Content (AAC) mg/g:

The concentrations of Ascorbic Acid are increased in May month (Fig.4). Plants did not show many differences with their content of ascorbic acid, and also between study sites, except it was clear between the months of research work, we can note the significantly increased in concentrations in May. The highest concentration was 10.33 mg/g in *Albizia lebbeck*.

Because of the resistance component of the individual plant, and expanded degree of ascorbic corrosive substance helps contamination resilience. At the biochemical level, oxidation of sulfhydryl and unsaturated fat twofold securities by ozone builds film porousness, brings down foliar sugar and polysaccharide levels, and upsets layer bound photosynthetic frameworks. Any adjustments in their digestion would influence the ascorbic corrosive focus (Sadia *et al*. 2019).

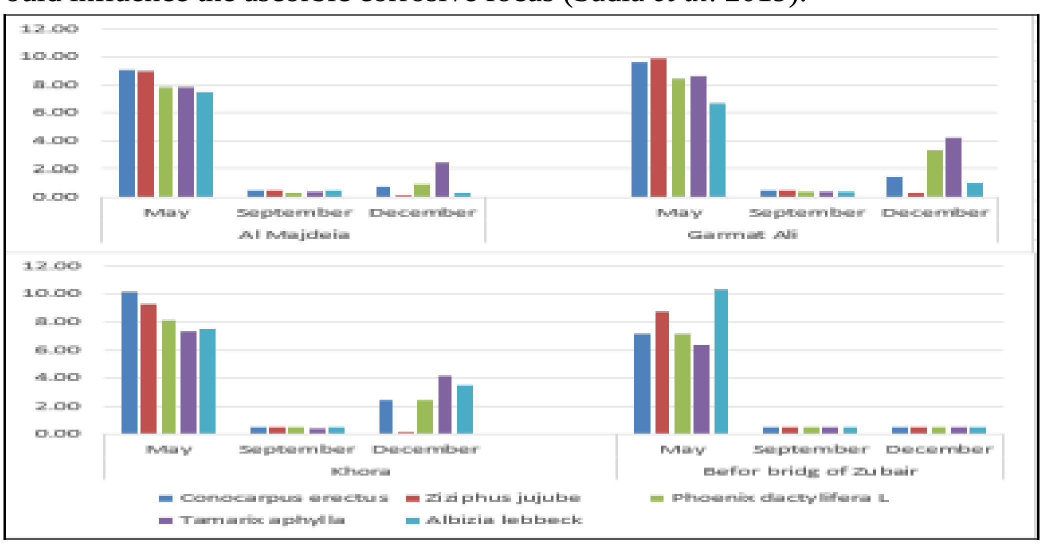

Fig. 4. Ascorbic acid of plants in study locations

Relative water content (RWC)%:

In this study the plants showed variable content of relative water. The RWC percentage was ranged from 56.25% in *Albizia lebbeck* in Al Majdeia to 98.76% in *Ziziphus jujube* in Garmat Ali in the same month(May). Some significant differences are observed between plants as well as between study months. The increased of (RWC%) of the plant makes it more resistant to external pollutants (Aghaiee *et al*., 2019).

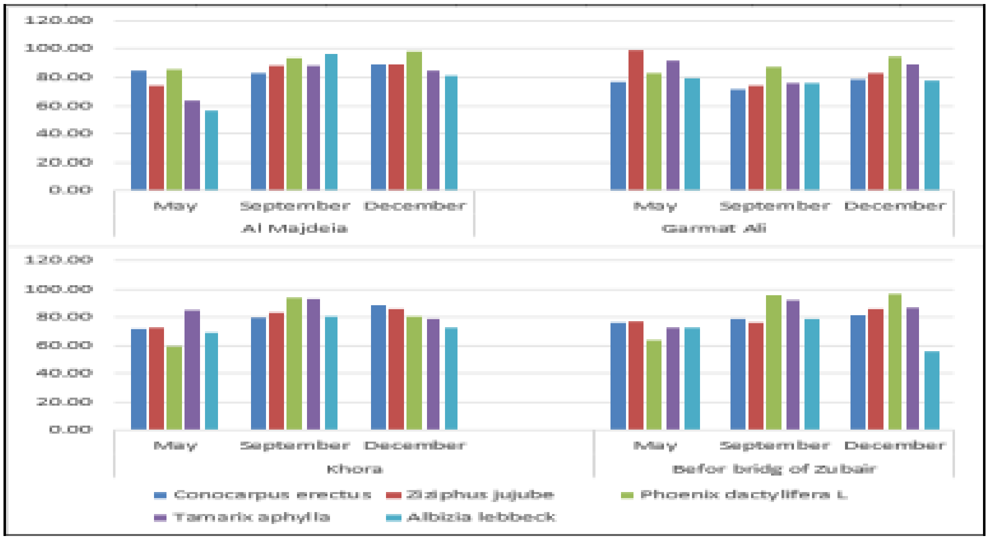

Fig. 5. Relative water content of plants in study locations

Air pollution tolerance index (APTI):

The study showed varied values of APTI between plants as well as between months of study. All APTI values in fig.(6) were showed greater in May month compared to September and December. *Ziziphus jujube* recorded higher value (15.83) while the lowest value in *Albizia lebbeck*. In general in spite of the positive correlation between ATPI and AAC in May month, but we did not notice this direct relationship with the other two months. Therefore, the response to environmental pollution by plants be varying and their tolerance to air pollution is linked by the ability to the adaptation to the different air pollutants.

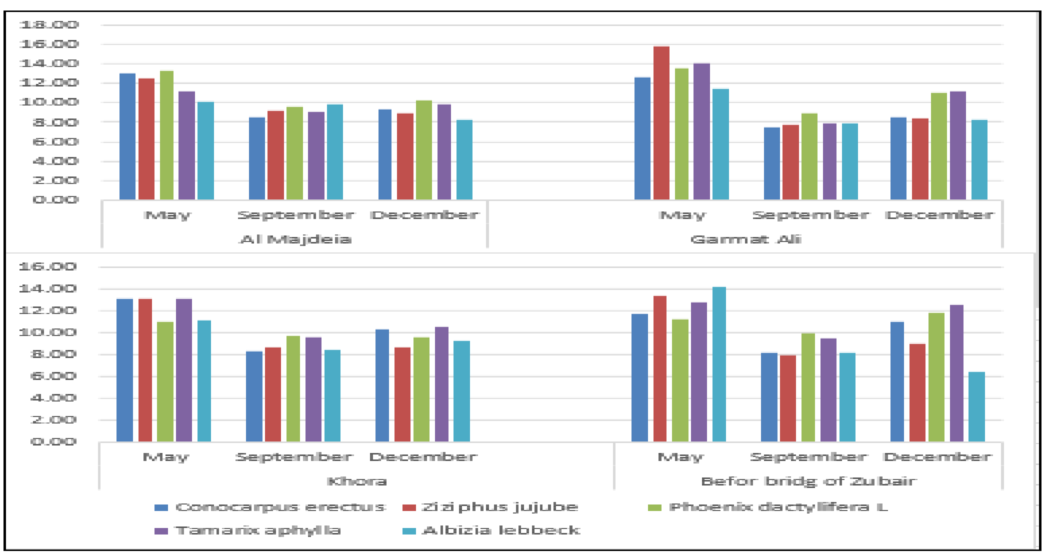

Fig. 6. Air pollution tolerance index of plants in study locations

The Tables (4-6) show the pairwise comparisons dependent APTI adjustment for multiple comparisons: Bonferroni, and the mean difference is significant at 0.05 level.

Table 4. Pairwise comparisons between study monthes dependent APTI means

Time		Mean Difference	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
May	September	3.891*	.373	.000	2.969	4.814
	December	2.935*	.373	.000	2.013	3.858
September	May	-3.891*	.373	.000	-4.814	-2.969
	December	-.956*	.366	.035	-1.862	-.050
December	May	-2.935*	.373	.000	-3.858	-2.013
	September	.956*	.366	.035	.050	1.862

*** The mean difference is significant at the .05 level. b. Adjustment for multiple comparisons: Bonferroni.**

Table 5. Pairwise comparisons between study locations dependent APTI means

Station		Mean Difference	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Al Majdia	Karmat Ali	-.145	.433	1.000	-1.333	1.044
	Al Khora	-.174	.433	1.000	-1.362	1.015
	B. b.of Z.	-.277	.433	1.000	-1.465	.911
Karmat Ali	Al Majdia	.145	.433	1.000	-1.044	1.333
	Al Khora	-.029	.433	1.000	-1.217	1.159
	B. b.of Z.	-.132	.433	1.000	-1.321	1.056
Al Khora	Al Majdia	.174	.433	1.000	-1.015	1.362
	Karmat Ali	.029	.433	1.000	-1.159	1.217
	B. b.of Z.	-.103	.433	1.000	-1.292	1.085
B. b.of Z.	Al Majdia	.277	.433	1.000	-.911	1.465
	Karmat Ali	.132	.433	1.000	-1.056	1.321
	Al Khora	.103	.433	1.000	-1.085	1.292

a. Adjustment for multiple comparisons: Bonferroni. B. b.of Z.(Befor bridg of Zubair).

Table 6. Pairwise comparisons between study plants dependent APTI means

Plant		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
C. erectus	*Z. jujube*	-0.108	0.484	1.000	-1.599	1.383
	P. dactylifera	-0.655	0.484	1.000	-2.145	0.836
	T. aphylla	-0.773	0.484	1.000	-2.264	0.717
	A. lebbeck	0.797	0.484	1.000	-0.693	2.288
Z. jujube	*C. erectus*	0.108	0.484	1.000	-1.383	1.599
	P. dactylifera	-0.547	0.484	1.000	-2.037	0.944
	T. aphylla	-0.666	0.484	1.000	-2.156	0.825
	A. lebbeck	0.905	0.484	1.000	-0.585	2.396
P. dactylifera	*C. erectus*	0.655	0.484	1.000	-0.836	2.145
	Z. jujube	0.547	0.484	1.000	-0.944	2.037
	T. aphylla	-0.119	0.484	1.000	-1.609	1.372
	A. lebbeck	1.452	0.484	0.063	-0.039	2.943
T. aphylla	*C. erectus*	0.773	0.484	1.000	-0.717	2.264
	Z. jujube	0.666	0.484	1.000	-0.825	2.156
	P. dactylifera	0.119	0.484	1.000	-1.372	1.609
	A. lebbeck	1.571	0.484	0.031	0.080	3.061
A. lebbeck	*C. erectus*	-0.797	0.484	1.000	-2.288	0.693
	Z. jujube	-0.905	0.484	1.000	-2.396	0.585
	P. dactylifera	-1.452	0.484	0.063	-2.943	0.039
	T. aphylla	-1.571	0.484	0.031	-3.061	-0.080

Based on observed means. The error term is Mean Square (Error) = 1.405.

Yannawar and Arjun (2014) divided the index value to (1-8) Sensitive, (8-10) Intermediate, and (10-above) tolerant (Table, 7) .

Gradation of APTI showed plants or trees with low APTI are sensitive to pollution, but whose value is more than 10, they are considered to be resistant to pollution and can be used as purifiers for air pollutants. Covariance in the plant's tolerance gradation is according to the sampling period which agrees with Liu and Ding (2008).

Table 7. Plants' tolerance gradation through the sampling seasons

Area	Plants	May	September	December
Al Majdia	*Conocarpus erectus*	T	I	I
	Ziziphus jujube	T	I	I
	Phoenix dactylifera L	T	I	T
	Tamarix aphylla	T	I	I
	Albizia lebbeck	T	I	I
Karmat Ali	*Conocarpus erectus*	T	S	I
	Ziziphus jujube	T	S	I
	Phoenix dactylifera L	T	I	T
	Tamarix aphylla	T	S	T
	Albizia lebbeck	T	S	I
Al Khora	*Conocarpus erectus*	T	I	T
	Ziziphus jujube	T	I	I
	Phoenix dactylifera L	T	I	I
	Tamarix aphylla	T	I	T
	Albizia lebbeck	T	I	I
Befor bridg of Zubair	*Conocarpus erectus*	T	I	T
	Ziziphus jujube	T	S	I
	Phoenix dactylifera L	T	I	T
	Tamarix aphylla	T	I	T
	Albizia lebbeck	T	I	S

In tolerance class of plants: tolerant (T); Intermediate tolerant (I); Sensitive (S).

Finally, it can be said that the resistance of plants to different pollutants depends on several physiological and chemical processes according to their formative nature, including the mechanical movement of stomata, enzymatic activities, how to remove toxins, genetic factors, and tree age. The trees used in the study can be planted in urban areas, especially near traffic intersections, to reduce air pollution, especially as the country now suffers from desertification and lack of green lands.

Conclusions:

It can be said that the cultivation of polluted and perennial plants across the country is important for reducing pollution which can solve many air quality issues related to a specific area. More extensive research in various polluted areas is required to effectively control particulate pollution in the atmosphere.

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النباتات الأرضية كمؤشر لتلوث الهواء في البصرة/العراق

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الملخص

اختيرت نباتات *Conocarpus erectus* و *Ziziphus jujuba* و *Phoenix dactylifera* L. و *Tamarix aphylla* و *Albizia lebbeck* في أربع مناطق مختلفة من البصرة (جنوب العراق) ولثلاث أوقات مختلفة خلال عام 2015 لاختبار مدى تحملها لتلوث الهواء، حيث جمعت عينات ورقية منها وباستخدام التحاليل المختبرية المتبعة، أظهرت النتائج أقل قيمة كانت في شهر كانون الأول بينما سجلت أعلى القيم في أيار، حيث تراوحت قيم الأس الحامضي 4.55 –8.67 في *Albizia lebbeck* و *Tamarix aphylla* على التوالي، وحامض الأسكوربيك 0.08 – 10.33 ملغ/غ في *Ziziphus jujube* و *Albizia lebbeck* على التوالي، المحتوى المائي للأوراق 55.96 – 98.76% في *Albizia lebbeck* و *Ziziphus jujube* على التوالي، الكلورفيل الكلي 0.01 – 0.13 ملغ/غ في *Phoenix dactylifera* و *Albizia lebbeck* على التوالي، كانت أقل وأعلى قيمة لدليل تلوث الهواء (6.42 – 14.18) في *Albizia lebbeck* خلال كانون أول وأيار على التوالي أيضاً. وكان لارتفاع درجة الحرارة دور في رفع حساسية النباتات لملوثات الهواء، وأظهرت البيانات تباين القيم والذي قد يكون بسبب تباين درجة التلوث الهوائي.

الكلمات المفتاحية: الأس الحامضي، حامض الأسكوربيك، المحتوى المائي، الكلورفيل الكلي، دليل تلوث الهواء.