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A Comparative Analysis of Biochemical Indicators for air pollution in three Species Tree Planted Within the Greenbelt Project in Karbala province, Iraq

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Abstract: This study was undertaken to represent the December 2023 (Winter) and July 2024 (Summer) within the administrative confines of Karbala governorate, as part of the Southern Greenbelt Project. Three segments of the green belt were chosen to exemplify the environmental diversity of the area. The research report examined three extensively cultivated plant species in the study area: olive (*Olea europaea*), eucalyptus (*Eucalyptus camaldulensis*), and date palm (*Phoenix dactylifera*), to evaluate their efficacy in tolerating air pollution. Plants underwent APTI analysis using four biochemical parameters: total chlorophyll concentration, pH, relative water content (RWC), and ascorbic acid levels. This research aims to evaluate the tree species planted in the Southern Green Belt Project and to compare their effectiveness in mitigating air pollution, assessing their appropriateness for greenbelt initiatives. The aim of the research is to examine the efficacy of these plants in tolerating air pollutants. The findings indicated a substantial disparity between the locations and the seasons. The Air Pollution Tolerance Index for the eucalyptus plant had the highest APTI value, followed by the olive and palm species. The December 2023 yields superior outcomes compared to July 2024 for all plants. The distinction among plants based on the intensity of pollution to which they are subjected and the varying temperatures between seasons.

Keywords: Air pollution tolerance index (APTI), Air Pollution, Greenbelt, Environmental pollution, Karbala.

Introduction

The increase in population, urban expansion, unprecedented rise in the number of cars, transportation vehicles, factories, and the growing demand for energy production in all its forms have directly and which led to the release of millions of tons of pollutants and harmful gases into the air every day. Additionally, the increase in the concentration of carbon dioxide (CO_2) in the atmosphere has contributed to the global rise in temperatures, causing dry lands to expand at the expense of wet areas. This has led to an escalation in dust storms over the past years (Kim *et al*., 2015; Alhesnawi *et al*., 2018). Air pollution is the most critical issue being discussed globally on a daily basis due to the significant challenges it poses, as it threatens all forms of life (Mohsen Kizar *et al*., 2022). Indeed, the increase of green areas and extension of afforestation is considered one of the most effective means of combating or at best ameliorating this threat. Besides, trees contribute much to absorbing carbon dioxide from the atmosphere, which in turn leads to global warming and increased temperature and fluctuation in climates of the whole world (Manisalidis *et al*., 2020). The use of trees and shrubs in urban and road-side planting is one of the most effective methods for cleaning air pollution. Trees purify the atmosphere by absorption and trapping gaseous pollutants and fine particles (Sahu & Kumar Sahu, 2015). They provide a large surface area of leaves where atmospheric pollutants such as dust and gases are intercepted, absorbed, and accumulated, resulting in a reduction in air pollution (Zhang *et al*., 2020). The holy city of Karbala is one of the most affected by dust and desertification throughout the year due to its proximity to the western plateau, as well as an increase in industrial mining activities along with the rapid rise in the number of cars and urban expansion at the expense of wetland areas (Alhesnawi *et al*., 2019).

The goal of this research was to get rid of this problem that Choosing the right plant species to plant in the Green Belt Project and find sustainable solutions in the Holy City of Karbala by comparing the most commonly cultivated trees in green spaces within the city and evaluating their efficiency in tolerating pollutants through analyzing and comparing their biochemical characteristics.

Materials & Methods

Study Area

The Holy Province of Karbala is situated in Iraq, it has a desert environment, characterized by summer temperatures over 45°C and moderate winters. The yearly precipitation varies from 150 to 300 mm Table (1).

Table (1): Climatic data for the study area during the sampling period.

Months	Minimum Temperature (C°)	Maximum Temperature (C°)	Average Temperature (C°)	Relative Humidity (%)	Amount of Precipitation (mm)	Average Wind Speed (m/s)
December 2023	8.1	20.6	13.9	62	9.9	5.43
January 2024	6.42	19.79	12.81	59.6	1.1	5.4
February 2024	7.64	19.29	13.42	65.8	41.5	5.59
March 2024	9.16	24.06	16.51	50.6	10.9	6.73
April 2024	16.92	33.67	25.29	35.4	6.7	7.85
May 2024	19.85	35.45	27.84	33.5	29.7	7.39
June 2024	27.39	45.43	36.65	32.35	0	7.17
July 2024	27.94	44.89	36.77	16.72	0	8.22

The Southern Green Belt (study area) is situated within the administrative limits of the central district's municipality, encircling the city from the south and extending into portions of the east and west. It is around 100 meters in width and 23.5 kilometers in length, encompassing an area of 2,350,000 square meters (Fig.1). This research included four areas, chosen based on adjacent land usage. Two sites represent an urban area: "Sector 1" and "Sector 6," measuring 2.29 km and 3.89 km in length, respectively. The third site, "Sector 4," denotes the industrial region, with a length of 3.33 km (Fig. 2). in the 2006 master plan and is split into seven administrative sectors. The region is thickly populated with vegetation, mostly date palms, olive trees, and eucalyptus.

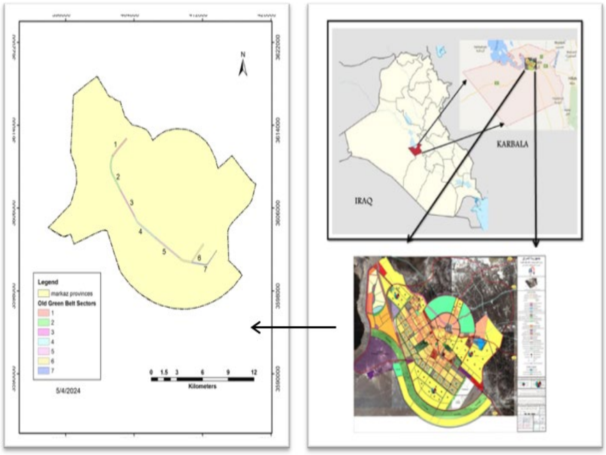

Fig. (1): A map of the administrative boundaries of Karbala Province, the central district, and the Southern Green Belt Project in the Holy Province of Karbala (the study area).

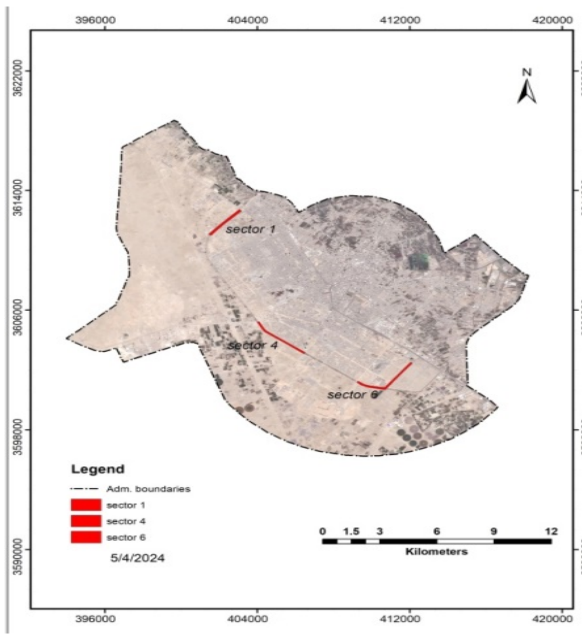

Fig. (2): The location of the Southern Green Belt with the study sectors (1, 4, 6) marked.

Certain areas of the green belt provide open recreational spaces for the city's inhabitants. The samples gathered in December 2023 and July 2024. The chosen plants were of comparable age (15-18 years) and as uniform as feasible, with exposure to sunshine and without any previous trimming. During the research season, completely developed leaves were meticulously picked at a height of

The last location is the Al-Ataba Nursery, regarded as the reference site, situated in a rural region spanning 2.7 km. It received formal approval

roughly 1.5-2 meters, picking them randomly for each species. The leaves were thereafter packed in plastic containers and transferred to the laboratory for the requisite examinations.

Estimation of the plant's biochemical characteristics

Relative water content (RWC%)

The relative water content was calculated according to (Sivakumaran and Hall, 1978).

$$RWC\% = \frac{FW-DW}{TW-DW} \times 100 \quad \ldots \quad (1)$$

Where: FW = fresh weight, measured immediately after dust removal from the leaves; TW = turgor weight of leaves, determined after soaking the leaves in distilled water for 12 hours; and DW = dry weight, acquired by drying the leaves in an oven at 65-70°C until a consistent weight is reached.

Ascorbic acid content

One gram of each plant sample was weighed and placed in a 25 mL flask, then 10 mL of oxalic acid (0.05 M) was added. The samples were left in the shade overnight. Then, 2.5 mL of each sample was taken and mixed with 2.5 mL of oxalic acid (0.05 M), 0.5 mL of meta-phosphoric acid, 1 mL of sulfuric acid, and 2 mL of ammonium molybdate. The volume was then adjusted to 25 mL with distilled water. The samples were measured afterward in a spectrophotometer at 760-nm wavelength against the standard curve of ascorbic acid, which had been prepared in advance. The relation was drawn between the concentration of the acid and the absorbance values for each concentration, and this curve was used to calculate the concentration values for each sample (Hussain *et al*., 2010).

Total Chlorophyll Content (TCH)

The total chlorophyll content was determined by the method reported by (Singh *et al*. 1991). Crush with 20 ml of 80% acetone in a ceramic mortar. The absorbance was read in a spectrophotometer at 663 and 645 nm. The total chlorophyll content was computed from the following formula by (Aziz *et al*., 2019)

$$\text{Total Chlorophyll (mg/g)} = \frac{20.2(A645)+8.02(A663)\times V}{1000\times W} \quad \dots \quad (2)$$

Where A645 = Absorbance of the fraction at 645 nm, A663 = Absorbance at 663 nm of the fraction, V = Final volume in milliliters and W = Final weight of leaf (g).

Experiment design and statistical analysis

The results were statistically analyzed, and the means were compared by factorial experiment (3×2×4) was conducted using a (Nested) design within a randomized complete block design (RCBD) with three replicates. The first factor included four selected blocks (blocks 1, 4, 6, and a control site) out of ten available at the experimental site. The second factor consisted of two seasons (summer and winter), and the third factor involved three plant species (olive, palm, and eucalyptus). The data were analyzed using GenStat 12 software, and mean differences were compared using Duncan's multiple range test at a significance level of 0.05 (Nahum *et al*, 2018).

Air pollution tolerance index (APTI)

To determine the tolerance index values for the plant species described above, the method followed by Patel & Nirmal Kumar (2018) was employed, using the following equation:

$$APTI = \frac{AA(TCH+P)+RWC\%}{10} \quad \dots \quad (3)$$

Where: AA is ascorbic acid (mg g^{-1}), TCH = total chlorophyll content (mg g^{-1}), P = the pH level, and RWC% is relative water content. According to Padmavathi (2013), plants are classed based on their APTI values, as shown in Table (2).

Table (2): Classification of APTI Values for Plants (Padmavathi, 2013).

APTI	Value	Response
A	<11	Sensitive
B	16-12	Intermediate
C	17≥	Tolerant

Results & Discussion

Total Chlorophyll Content

Table (3) shows significant differences in the results between the plants according to the species locations and between the summer and winter. The olive plant recorded the lowest total chlorophyll concentration of 1.55 mg g^{-1} in sector 4 during winter, while the highest concentration was 2.69 mg g^{-1} in the nursery during summer. In terms of location, the highest concentration was 2.52 mg g^{-1} in the nursery, and the lowest was 1.65 mg g^{-1} in sector 1. For the date palm, the lowest concentration was 1.80 mg g^{-1} in sector 4 during winter, and the highest concentration was 2.77 mg g^{-1} in the nursery during summer. The effect of location showed the highest concentration of 2.72 mg g^{-1} in the nursery and the lowest concentration of 1.83 mg g^{-1} in sector 4. In the case of eucalyptus, the highest concentration was 3.51 mg g^{-1} in the nursery in the summer season, while the minimum concentration during this season was 1.57 mg g^{-1} in sector 4. Among the locations, the highest concentration was in the nursery, amounting to 2.79 mg g^{-1}, while the lowest, 1.67 mg g^{-1}, was realized in sector 4.

The date palm had the highest total chlorophyll concentration, at 2.26 mg g^{-1}, followed by eucalyptus, at 2.12 mg g^{-1}, then olive, at 2.05 mg g^{-1}. In the case of seasons, all the plants studied had a mean total chlorophyll concentration higher in summer than in winter. The results reflect a decline in the total chlorophyll content of plants in sector 4 and the residential area; therefore, the highest recorded concentrations were obtained in the nursery. All these could also be attributed to the levels of pollution at the sites. Certain researchers propose that reduced total chlorophyll content can be used as an indicator for air pollution (Ninave *et al*., 2001; Ram *et al*., 2015). This is evidenced by previous chloroplasts, and activates the enzymes responsible for degrading chlorophyll (Indira *et al*., 2015). studies, which have shown high pollutant and heavy metal concentrations in industrial areas, busy streets, and city centers; these are reported to be statistically different in the study sites. When the leaf surface is covered, this may sometimes cause yellowing of leaves and tissue damage (Kirichenko *et al*., 2017). Thus, pollutants inhibit chlorophyll synthesis due to accumulation of sulfur dioxide in the plant tissues induces damage to and degradation of chloroplast and activation of chlorophyll-degrading enzymes (Mehmood *et al*., 2024).

Table (3): Total chlorophyll concentration (mg g^{-1}) for the studied plants based on location and season.

Seasons	Olive (*Olea europaea*)		
Location	Location Averages	December 2023	July 2024
Sector 4	2.11 b	1.55 e	2.67 a
Sector 1	1.64 c	1.04 c	2.25 b
Sector 6	1.96 b	1.72 d	2.21 b
Nursery	2.52 a	2.36 b	2.69 a
Season Averages		1.66 b	2.45 a
plant species	2.05b		
	Date Palm (*Phoenix dactylifera*)		
Sector 4	1.83 d	1.80 d	1.86 d
Sector 1	2.19 c	2.22 c	2.17 c
Sector 6	2.30 b	2.21 c	2.40 b
Nursery	2.72 a	2.68 a	2.77 a
Season Averages		2.22 a	2.30 a
plant species	2.26a		
	Eucalyptus (*Eucalyptus camaldulensis*)		
Sector 4	1.67 c	1.77 de	1.57 f
Sector 1	2.37 b	1.81 d	2.93 b
Sector 6	1.69 c	1.73 de	1.65 ef
Nursery	2.79 a	2.07 c	3.51 a
Season Averages		1.84 b	2.41 a
plant species	2.12ab		

Numbers with the same letters do not have significant differences between them.

Ascorbic acid

Table (4) illustrates significant differences in the results between the plants locations seasons. The olive plant recorded the highest concentration of ascorbic acid at 5.55 mg g^{-1} in sector 4 during winter, while the lowest concentration was 2.61 mg g^{-1} in the nursery during summer. For the locations, the lowest concentration was 2.87 mg g^{-1} in the nursery, and the highest was 4.75 mg g^{-1} in sector 4. In the case of the date palm, the highest concentration was 5.12 mg g^{-1} in sector 4 during winter, and the lowest concentration was 1.12 mg g^{-1} in the nursery during summer. Regarding the effect of location, the lowest concentration was 1.35 mg g^{-1} in the nursery, while the highest concentration was

4.46 mg g^{-1} in sector 4. The eucalyptus plant had a lowest concentration of 2.56 mg g^{-1} in the nursery during the summer season, while the highest concentration was 5.83 mg g^{-1} in sector 6 during winter. For the location, the lowest concentration was 2.85 mg g^{-1} in the nursery, and the highest concentration was 5.14 mg g^{-1} in sector 4. The eucalyptus plant exhibited the highest concentration of ascorbic acid at 4.36 mg g^{-1}, followed by olive at 3.74 mg g^{-1} and date palm at 2.81 mg g^{-1}. For the seasons, the concentration of total chlorophyll averaged for all plants was greater in winter as compared to summer. Ascorbic acid is regarded as one of the most important antioxidants and is involved in building and protecting cell walls. It helps contribute to plants' resistance against the damaging influences of air pollution (Conklin, 2001). It also possesses an ability to prevent the formation of free radicals, which are known to chemically, biologically, and physiologically damage plants (Pathak *et al.*, 2011). This indicates that an elevated concentration of ascorbic acid in plants may indicate stress-related signs, and therefore such conditions may be aligned with pollution conditions, which were witnessed in sector 4 and sector 6, exhibiting the highest concentrations in all the plants, while the concentrations were lower in the nursery. The statistical results showed a significant difference among these values. Besides, the statistical analysis of winter and summer seasons showed a significant difference between them, with concentrations increasing in winter. This might be partly explained by the negative impact of low winter temperatures on processes in metabolism and acid synthesis within the plant resulting from lower daylight hours and reduced photosynthesis. Furthermore, increased humidity may alter the reactivity of dust particles settled on the leaves, amplifying their negative effects on the plant (Bharti *et al.*, 2018).

Table (4): Concentration of ascorbic acid (mg g^{-1}) for the studied plants according to locations and seasons.

Seasons	Olive (*Olea europaea*)		
Location	Location Averages	December 2023	July 2024
Sector 4	4.75 a	5.55 a	3.95 b
Sector 1	3.54 b	3.92 b	3.16 d
Sector 6	3.82 b	4.11 b	3.53 c
Nursery	2.87 c	3.13 d	2.61 e
Season Averages		4.17 a	3.31 b
plant species	3.74b		
	Date Palm (*Phoenix dactylifera*)		
Sector 4	4.46 a	5.12 a	3.78 b
Sector 1	3.41 b	3.86 b	2.96 c
Sector 6	2.04 c	2.33 d	1.75 e
Nursery	1.35 d	1.85 e	1.12 f
Season Averages		3.22 a	2. 40 b
plant species	2.81c		
	Eucalyptus (*Eucalyptus camaldulensis*)		
Sector 4	5.14 a	5.45 b	4.83 c
Sector 1	5.00 a	5.33 b	4.67 c
Sector 6	4.47 b	5.83 a	3.11 d
Nursery	2.85 c	3.14 d	2.56 e
Season Averages		4.93 a	3.79 b
plant species	4.36a		

Numbers with the same letters do not have significant differences between them.

Table (5) indicate PH value in leaves of trees that exposed for the pollution regarding species, locations, and seasons. The lowest pH value of 5.38 was recorded for the olive plant in Sector 4 during the summer, while the highest value was 7.37 at the nursery site in winter (Table 4). In terms of location, the highest value was 6.98 at the nursery, and the lowest was 5.78 in Sector 4. Date of palm, the highest value recorded was 7.75 at the nursery in winter, while the lowest was 5.39 in Sector 4, also during winter. The highest value for the eucalyptus plant was 8.57 at the nursery in winter, while the lowest was 6.42 in Sector 4 during the summer. The maximum pH value recorded in the nursery was 8.91, while the minimum of 6.64 was recorded in Sector 4. Among the plants, the eucalyptus plant had a maximum pH of 8.57, followed by the date palm and olive with pH values of 6.62 and 6.44, respectively. In statistical analysis, highly significant differences were detected among the locations and between summer and winter seasons. Considering the data, it could be seen that the average pH value during winter was higher than in summer for all the plants. The low pH values in Sector 4 and the city center (Sector 1) and elevated values in the nursery site indicate the presence of acidic pollutants like nitrogen and sulfur oxides. These results are in agreement with similar studies, such as those by Salaa & Al-Kawaz (2017) and Nwadinigwe (2014). Acidity can also be enhanced because dust particles may contain oxides that can induce acidity in plants or because of the stomata closure due to dust accumulation. This result is in agreement with several other studies, such as Nwadinigwe *et al*. (2014), Rai (2013), and Maysoon & Luma (2017).

Table (5): The pH levels of the studied plants according to locations and seasons.

Seasons	Olive (*Olea europaea*)		
Location	Location Averages	December 2023	July 2024
Sector 4	5.78 c	6.42 b	5.38 c
Sector 1	6.55 b	6.62 b	6.49 b
Sector 6	6.34 b	6.55 b	6.13 b
Nursery	6.98 a	7.37 a	6.60 b
Season Averages		6.74 a	6.15 b
plant species	6.44b		
	Date Palm (*Phoenix dactylifera*)		
Sector 4	5.83 d	6.28 c	5.39 d
Sector 1	6.66 b	6.65 b	6.66 b
Sector 6	6.31 c	6.40 bc	6.22c
Nursery	7.68 a	7.62 a	7.75 a
Season Averages		6.74 a	6.50 b
plant species	6.62b		
	Eucalyptus (*Eucalyptus camaldulensis*)		
Sector 4	6.64 c	6.86 c	6.42 c
Sector 1	7.55 b	7.58 b	7.52 b
Sector 6	7.92 b	8.29 a	7.56 b
Nursery	8.91 a	8.57 a	7.81 b
Season Averages		7.82 a	7.32 b
plant species	7.57a		

Numbers with the same letters do not have significant differences between them.

Relative water content (RWC%)

Table (6) illustrates significant differences in the results The plants related to species locations and between the summer and winter seasons. The olive plant recorded the highest relative water content (%) at 89.50% in the nursery during winter, while the lowest percentage was 81.19% in sector 4 during winter as well. For locations, the highest percentage was 87.97% in the nursery, and the lowest was 81.78% in sector 4. In contrast, the palm plant exhibited the lowest percentage of 73.13% in sector 4 during summer and the highest percentage of 82.56% in the nursery during winter. The highest percentage for this location was 80.19% in the nursery, while the lowest was 77.19% in sector 4. The eucalyptus plant showed the highest percentage of 87.98% in the nursery during the summer, while the lowest percentage was 74.70% in sector 6 during the summer as well. For this plant, the highest percentage was 86.68% in the nursery and the lowest was 76.63% in sector 4. The olive plant exhibited the highest relative water content at 85.52%, followed by eucalyptus at 82.35%, and palm at 78.03%. Regarding the seasons, the relative water content during winter is higher than in summer for all plants. The decrease in relative water content in sector 4 and sector 1 compared to the nursery indicates that the plants may have experienced stress. Most physiological systems in plants rely on water, and when water levels go below normal thresholds, it directly impacts their capacity to endure stress situations. These findings align with many studies demonstrating reduced relative water content in contaminated regions (Gholami *et al*., 2016; Manjunath & Reddy, 2019; Qader & Shekha, 2023). This phenomenon can be ascribed to the substantial accumulation of dust on the leaves, which absorbs moisture from leaf tissues and induces stomatal closure, thereby diminishing transpiration, a process crucial for the ascent of water from the roots to the leaves (Taiz and Zeiger, 2010).

Table (6): Relative water content (RWC%) of the studied plants according to locations and seasons.

Seasons	Olive (*Olea europaea*)		
Location	Location Averages	December 2023	July 2024
Sector 4	81.78 c	81.19 f	82.38 ef
Sector 1	87.85 a	88.21 ab	87.49 bc
Sector 6	84.49 b	85.77 de	83.21 de
Nursery	87.97 a	89.50 a	86.45 cd
Season Averages		86.17 a	84.88 b
plant species	85.52 a		
	Date Palm (*Phoenix dactylifera*)		
Sector 4	77.19 b	81.26 ab	73.13 d
Sector 1	77.48 b	79.50 bc	75.04d
Sector 6	77.27 b	80.44 ab	74.53 d
Nursery	80.19 a	82.56 a	77.74 c
Season Averages		80.96 a	75.11 b
plant species	78.03 c		
	Eucalyptus (*Eucalyptus camaldulensis*)		
Sector 4	76.63 c	78.57 e	74.70 f
Sector 1	83.87 b	84.89 cd	82.86 d
Sector 6	82.22 b	87.54 ab	76.91 ef
Nursery	86.68 a	85.38 bc	87.98 a
Season Averages		84.09 a	80.61 b
plant species	82.35 b		

Numbers with the same letters do not have significant differences between them.

Air pollution tolerance index (APTI)

Table (7) illustrates significant differences in the results between locations and between Plants according to the species seasons. The olive plant recorded the highest value for the Air Pollution Tolerance Index (APTI) at 13.22 in Sector 4 during winter, while the lowest value was 8.85 in the nursery during summer. Regarding location, the lowest value was 10.19 in the nursery, and the highest value was 12.74 in Sector 4. For the date palm, the highest value was 12.77 in Sector 4 during winter, while the lowest value was 9.63 in the nursery during summer. In terms of location, the lowest value was 10.44 in the nursery, and the highest value was 12.25 in Sector 4.The eucalyptus plant showed the lowest value of 9.94 in the nursery during summer, while the highest value was 13.69 in Sector 6 during winter. For location, the lowest value was 10.38 in the nursery, and the highest value was 13.20 in Sector 4. With an Air Pollution Tolerance Index of 12.14, the eucalyptus plant was the most tolerant, then the date palm (11.35) and olive (11.38). The results indicate that during winter, the values for all plants were higher than those in summer, consistent with the findings of Padmavathi *et al*. (2013). Based on the classification used in our study (Table 1) , the species displayed similar assessments (moderate tolerance), despite the differences in biochemical indicator values (Table 7). The variations between the plants across different locations and seasons can be attributed to the influence of certain biochemical factors used to calculate index values, which vary from one site to another based on pollution intensity and temperature (Alhesnawi *et al*., 2019).

Table (7): The value and classification of the Air Pollution Tolerance Index (APTI) for the studied plants based on locations and seasons.

Seasons	Olive (*Olea europaea*)		
Location	Location Averages	December 2023	July 2024
Sector 4	12.74 a	13.22 a	12.26 b
Sector 1	11.28 b	12.11 b	10.45 f
Sector 6	11.32 b	11.89 c	10.75 e
Nursery	10.19 c	11.53 d	8.85 g
Season Averages		12.18 a	10.57 b
Average tolerance	11.38		
	Date Palm (*Phoenix dactylifera*)		
Sector 4	12.25 a	12.77 a	11.73 c
Sector 1	11.01 a	11.58 c	10.44 e
Sector 6	11.70 b	12.13 b	11.27 d
Nursery	10.44 c	11.25 d	9.63 f
Season Averages		11.93a	10.76 b
Average tolerance	11.35		
	Eucalyptus (*Eucalyptus camaldulensis*)		
Sector 4	13.20 a	13.69 a	12.71 c
Sector 1	12.29 c	12.53 c	12.05 d
Sector 6	12.69 b	13.15 b	12.23 d
Nursery	10.38 d	10.82	9.94
Season Averages		12.54 a	11.73 b
Average tolerance	12.14		

Numbers with the same letters do not have significant differences between them.

Conclusions

The use of the Air Pollution Tolerance Index (APTI) can be considered an easy and cost-effective method for biomonitoring the severity of air pollution in urban areas. It relies on changes in the biochemical properties of plants exposed to pollution and serves as a straightforward and reliable means of comparing different plant species. Additionally, it is a non-destructive method that preserves the plants and can provide insights into the pollution levels over relatively large areas. This method can be implemented under field conditions without the need for expensive tools or devices.

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Contributions of authors

J.H.A.: Collection of specimens, Laboratory techniques, wrote and revised the manuscript.

S.N.J.: Suggestion the proposal of the article, revised the manuscript.

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Conflicts of interest

In accordance with the publishing policy requirements, the authors declare that there is no potential conflict of interest.

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تحليل مقارن للمؤشرات البيوكيميائية لتلوث الهواء في ثلاثة أنواع من الأشجار المزروعة ضمن مشروع الحزام الأخضر في كربلاء ، العراق

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المستخلص: أجريت هذه الدراسة خلال شهري ديسمبر 2023 (الشتاء) ويوليو 2024 (الصيف) ضمن الحدود الإدارية لمحافظة كربلاء، كجزء من مشروع الحزام الأخضر الجنوبي .تم اختيار ثلاثة أجزاء من الحزام الأخضر لتوضيح التنوع البيئي للمنطقة. كما تم اختبار ثلاثة أنواع من النباتات المزروعة على نطاق واسع في منطقة الدراسة: الزيتون (*Olea europaea*) اليوكالبتوس (*Eucalyptus camaldulensis*) ونخيل التمر (*Phoenix dactylifera*) ، لتقييم فعاليتها في تحمل تلوث الهواء . خضعت النباتات لتحليل APTI باستخدام أربعة معايير كيموحيوية: تركيز الكلوروفيل الكلي، ودرجة الحموضة، ومحتوى الماء النسبي، وتركيز حامض السكوربيك، وأشارت النتائج إلى وجود تباين كبير بين المواقع والفصول، حيث سجل مؤشر تحمل تلوث الهواء لنبات اليوكالبتوس أعلى قيمة لمؤشر تحمل تلوث الهواء، يليه الزيتون والنخيل .ويحقق شهر ديسمبر 2023 نتائج أفضل مقارنة بشهر يوليو 2024 لجميع النباتات .ويعتمد التمييز بين النباتات على شدة التلوث الذي تتعرض له ودرجات الحرارة المتفاوتة بين المواسم.

الكلمات المفتاحية: مؤشر تحمل تلوث الهواء(APTI) ، تلوث الهواء، الحزام الأخضر، التلوث البيئي، كربلاء.