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CALCULATION THE AIR POLLUTION TOLERANCE INDEX OF *EUCALYPTUS* PLANT IN BAGHDAD CITY

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ABSTACT
Air pollution from various sources is one of the most serious environmental problems, especially after pollutants are deposited on the surface of the soil and leaves of the plants and then transferred to the rest of the plant and entering food chains. The present study was conducted to determine the effects of air pollution on different biochemical parameters in *Eucalyptus* sp. and calculation the Air Pollution Tolerance Index. The selected plant leaves were collected from five sites, four of them within the city of Baghdad, namely Al-Jadriya, Al-Andlous, Al-Doura and close to the private generators to represent the urban areas and Abu Ghraib site to represent the rural area. The leaves were taken on a seasonal basis for the period from October 2016 to June 2017. Eleven biochemical parameters namely total chlorophyll, ascorbic acid, leaf extract pH, relative water content, total nitrogen, total protein content, total sugar content, proline, electrical conductivity, cadmium and lead. Higher reduction of total chlorophyll content recorded in private generator site (6.195 mg/g). Ascorbic acid content, relative water content and pH recorded maximum reduction in *Eucalyptus* leaves (0.335 mg/g, 58.193 %, 5.540) respectively. In addition, values of air pollution index (APTI) of the *Eucalyptus* plant were calculated in order to determine the sensitivity of these plants to air pollution. Higher value of APTI (6.434) was recorded in Al-Doura site, while lowest value of APTI (5.343) was recorded in Abu-Ghraib site.

KEYWORDS: Physiological, APTI, Chlorophyll, Bio indicator, and Private Generator.

INTRODUCTION
Air pollution is a basic problem in today's world and exposure to ambient air pollution has been linked to a number of different health outcomes[1]. Rapid industrialization and vehicular traffic especially in the urban areas lead to the deterioration of air quality by adding toxic gases and other substances to the atmosphere. All combustion releases gases and particulate matter into the air which includes SOx, NOx, CO, H_2S and particle matter as well as smaller quantities of toxic metals, organic molecules and radioactive isotopes[2-4]. There are many sources of air pollution that include natural sources (volcanoes, fires and sea spray) and anthropogenic sources (municipal incinerators, emission from personal generators, automobiles, metal smelters and power plant emissions (fuel combustion)[5]. The ambient environment of an urban area may be contaminated with several pollutants such as SO_2, CO, NOx, H_2S and heavy metals and the plants growing there would be exposed not only to one but to many pollutants and their different conditions[6,7]. The responses of plants to pollutants may provide a simple method of monitoring air pollutants as well as providing the pollution abatement measures. Cultivation of tolerant tree species may have a marked effect on varied aspects of the quality of the urban environment and the cleanliness of life in a city[8]. Thus , the need for monitoring the responses of plants to air pollution has been increased more than ever , especially in urban areas. Four physiological and biochemical parameters which are relative water content, leaf pH, ascorbic acid, and total chlorophyll were used to compute the APTI values[9]. Hence, the current study was conducted to find out the pollution tolerance level of *Eucalyptus* sp. plant growing in polluted and non-polluted areas of Baghdad city.

Study area
This study was carried out on *Eucalyptus* plant during 2016-2017. Five main sites were selected located inside Baghdad city in Al-Rusafa and Al-Karkh district. Those sites are Al-Jadriya as roadsides, Al-Andlous as commercial site, Al-Doura as industrial site, private generator (polluted sites) and Abu-Ghraib as control (non-polluted site) to investigate the effect of air pollution. Mature green leaves were selected for sampling and were kept in clean plastic bags. Then plant samples will be transported to the laboratory for testing. Samples of plant were collected seasonally for measuring the levels of air pollutants.

MATERIALS & METHODS
Total chlorophyll content
This was carried out according to the method described by [10]. 3 g of fresh leaves were blended and then extracted with 10ml of 80% acetone and left for 15minutes for thorough extraction. The liquid portion was decanted into another test-tube and centrifuged at 2,500 rpm for 3 minutes. The supernatant was then collected and the absorbance taken at 645 nm and 663 nm using a spectrophotometer.

Chl. a = 12.7 DX 663 – 2.69 DX 645 X vmg mg/g
Chl. b = 22.9 DX 645 – 4.68 DX663 X vmg mg/g
T. chl. = 20.2 DX 645 + 8.02 DX 663 X vmg mg/g

Relative water content

According to the method described by [11], leaf relative water content was determined and calculated with the formula.

$$R = \frac{F - D}{D} * 100$$

FW = Fresh weight
DW = Dry weight

Leaves extract pH and Ascorbic acid

Leaf extract pH was estimated by [2]. Ascorbic acid (AA) content was analyzed by [12].

Biochemical analysis

Total sugar content was estimated by[13]; Electrical conductivity [14]; total nitrogen content and protein content were estimated by[15]; determination of elements like potassium, cadmium, lead were measured by XRF analysis [16].

APTI (Air Pollution Tolerance Index) determination

The calculations of air pollution tolerance index for the selected plants were made by the method described by [17]. The formula of APTI is given as :
APTI = (A (T+P) + R)/10
Where:
A = Ascorbic acid content (mg/g)
T = Total chlorophyll (mg/g)
P = pH of leaf extract
R = Relative water content of leaf (%)

Statistical analysis

In order to evaluate the parameters for *Eucalyptus* plant, using analysis of variance, F-test and t-test; experiments in this study were set up as in complete randomized design for each parameter in five locations (Al-Jadriya, Al-Andlous, Al-Doura, Abu-Ghraib and private generator) and were replicated 4 times for each parameter. To explain the differences between means, using least significant differences (LSD) at p ≤0.05, and expressed that as (mean ± SEM). SPSS program 2010 and excel application were used to find the result and draw the figures with some effects [18,19].

RESULTS

The data in table 1 are representing the biochemical parameters in *Eucalyptus* plant. Higher percentage of total protein and nitrogen was recorded in private generator site, while the lowest percentage was recorded in Al-Jadriya site. Total sugar content, proline and electrical conductivity were increased in private generator site. Whereas cadmium and lead values were higher at Al-Andlous site as shown in table 1.

TABLE 1: Biochemical parameters of *Eucalyptus* sp. in different sites at Baghdad city

Parameters / Locations	Total protein content %	Total nitrogen content %	Total sugar content %	Proline content µ mole/g	EC µS/cm	Cadmium ppm	Lead ppm
Al-Jadriya	10.370 ± 1.079 c	1.660 ± 0.172 c	11.280 ± 1.370 b	3.048 ± 0.517 b	1304.500 ± 68.333 c	1.575 ± 0.025 bc	2.525 ± 0.368 b
Al-Andlous	11.263 ± 1.046 bc	1.803 ± 0.168 bc	15.928 ± 2.441 ab	2.485 ± 0.499 b	1785.000 ± 79.060 a	1.675 ± 0.025 a	3.400 ± 0.129 a
Al-Doura	11.165 ± 0.485 bc	1.788 ± 0.078 bc	14.075 ± 0.277 b	3.243 ± 0.291 b	1301.500 ± 51.750 c	1.600 ± 0.041 abc	2.725 ± 0.085 b
Abu-Ghraib	13.950 ± 0.605 ab	2.233 ± 0.194 ab	15.673 ± 2.556 ab	3.035 ± 0.468 b	1727.250 ± 58.356 a	1.375 ± 0.013 c	1.625 ± 0.100 c
Private generator	15.605 ± 1.705 a	2.498 ± 0.157 a	20.475 ± 1.131 a	5.655 ± 0.453 a	1527.000 ± 37.875 b	1.650 ± 0.029 ab	1.900 ± 0.041 c

Small letters indicate to comparison in column, similar letters are non-significantly differences between means at (p ≤0.05), Using (LSD test).

TABLE 2: Air Pollution Tolerance Index (APTI) of *Eucalyptus* sp. in different sites at Baghdad city. Results of *Eucalyptus* samples (mean ± SE)

Parameters / Locations	Ascorbic acid mg/g	Total chlorophyll content mg/g	pH	Relative water content %	APTI
Al-Jadriya	0.445 ± 0.015ab	9.005 ± 0.571 a	6.183 ± 0.099ab	51.743 ± 2.421 b	5.841
Al-Andlous	0.478 ± 0.010 a	7.983 ± 0.403 a	6.440 ± 0.057 a	48.263 ± 2.066 b	5.503
Al-Doura	0.408 ± 0.016 b	8.993 ± 0.378 a	6.405 ± 0.100ab	58.193 ± 0.419 a	6.434
Abu-Ghraib	0.335 ± 0.030 c	9.063 ± 0.267 a	6.163 ± 0.101 b	48.418 ± 2.358 b	5.343
Private generator	0.440 ± 0.034ab	6.195 ± 0.343 b	5.540 ± 0.082 c	48.978 ± 0.807 b	5.413

Small letters indicate to comparison in column, similar letters are non-significantly differences between means at (p ≤0.05), Using (LSD test).

Four physiological parameters were selected to generate Air Pollution Tolerance Index as illustrated in table 2. High level of total chlorophyll content was observed in control site (Abu-Ghraib), while the lowest level of total chlorophyll was scored in private generator site. The mean concentration of ascorbic acid content recorded highest level in Al-Andlous site, while the lowest level in Abu-Ghraib site. Highest level of pH was scored in Al-Andlous site whereas the lowest level was scored in private generator site. Relative water content was recorded highest level in Al-Doura site, the lowest level was recorded in Al-Andlous site. High air pollution tolerance value was recorded in Al-Doura site and lowest value of air pollution tolerance index was recorded in Abu-Ghraib site.

DISCUSSION

Nitrogen is an essential plant nutrient and many terrestrial ecosystems are adapted to conditions of low nitrogen availability, a situation that often leads to plant communities with high species diversity[20]. Proteins are large molecules consist of a number of smaller molecules called amino acids which are made up of both an amino group and a carboxyl group. Unlike animals, plants can synthesize amino acids which are needed for protein synthesis and ultimately plant growth and development. Proteins are important compounds that participate in biological and metabolic processes, includung catalyzing chemical reactions (enzymes), transporter proteins and synthetic proteins[21]. The current results recorded reduction in total protein levels, while the results showed increasing in total nitrogen levels in *Eucalyptus* sp. Reduction of protein may be an enhance in the activity of the degradative enzyme like proteases which catalyses the breakdown of polypeptides into amino acids to resist the stress induced by pollution[22]. Whereas proline is amino acid known to occur widely in higher plants and normally accumulates in large quantities in response to environmental stresses[23]. Under normal conditions, the biosynthesis of proline takes place in the cytosol whereas under stress condition proline production can also be possible in chloroplasts[24,25]. The present work demonstrated that under air pollution conditions, proline level of polluted leaves has significantly increased ($P <0.05$). The study of[26] indicated that the scavenging reaction of ROS with other amino acids, such as tryptophan, tyrosine, histidine *etc*. are more effective compared with proline and proline is of special interest because of its extensive accumulation in plants during environmental stress. According to[27,28] reported that sugars produced during photosynthesis are the substrates of carbon and energy metabolism and are used in the biosynthesis of polysaccharides like starch and cellulose in plants. Also, soluble sugar is an important constituent and source of energy for all living organisms.

The results of this study demonstrated that levels of sugar were differing in all sites of Baghdad city. Soluble sugar accumulates under salt stress as seen in table 1. This agrees with the study of [29].

Cadmium is released into the atmosphere by natural and anthropogenic means. It does not have any known useful biological functions and therefore not considered an essential metal[30]. The results of the present study revealed that cadmium concentrations in all sites were above the permissible limits (0.02 ppm) according to WHO[31]. In this study, higher cadmium content at Al-Jadriya site and Al-Andlous site might result from the frequent human activity in the dense commercial and residential areas, such as heavy traffic flow[32,33]. Lead was one of the first metals used by human, which have unique properties like softness, malleability, low melting point, and resistance to corrosion which make it one of the most widely used metals, and one of the oldest known occupational and environmental poisons[34]. Lead enters food chains mostly from plants, which often accumulate heavy metals to concentrations exceeding their levels in the soil by many times. Table 1 showed that concentration of lead in Al-Jadriya, Al-Andlous and Al-Doura sites were above permissible limits (2 ppm) according to WHO[31]. The air quality in the investigated area is affected mainly by the level of road traffic and industrial activities[35]. It is well known that chlorophyll is found in the chloroplasts of green plants and is called a photoreceptor [36]. Basically, chlorophyll measurement is an important tool to evaluate the effects of air pollutants on plants as it plays an important role in plant metabolism and any reduction in chlorophyll content corresponds directly to plant growth. In the present study, total chlorophyll levels for *Eucalyptus* plant ranged from 6.195 – 9.063 mg/g. While certain pollutants increase the total chlorophyll content [37], other decreases it. It is revealed from statistical analysis that chlorophyll level in *Eucalyptus* sp. decreases in private generator site and increases in control site. The reason for the low concentration of chlorophyll is due to vehicular emissions that have a profound impact on the concentration of chlorophyll, photosynthetic activity and chlorophyll content, because chlorophyll is the principal photoreceptor in photosynthesis, the light-driven process in which carbon dioxide is fixed to produce carbohydrates and oxygen. Work of [36] demonstrated that when plants are exposed to the environmental pollution above the normal physiologically acceptable range, photosynthesis gets inactivated. Ascorbic acid is a crucial antioxidant against various biotic and abiotic stresses and a strong reducing agent [38]. It plays an important role in pollution tolerance and protects the plant against oxidative damage by maintaining the stability of cell membrane during pollution stress and scavenges cytotoxic free radicals. Under experimental condition, ascorbic acid concentration from the urban sites gave highest levels than the control site. This agrees with the work of [39-43] observed that when exposed to air-borne pollutants, most plants experience physiological changes. pH is a biochemical parameter that acts as an indicator for sensitivity to air pollution[44]. pH plays a significant role in the physiological processes of plants. Mostly enzymes involved in the biological activities of the organism acquire different ranges of pH for their effective functions. The pH of leaf extract was found to be reduced in *Eucalyptus* sp. plant. The present study found that low pH had a good correlation with sensitivity to air pollution and also reduces photosynthetic activities in plants. Therefore, the photosynthetic efficiency is strongly dependent on leaf pH. The relative water content helps the plant to maintain its physiological balance under environmental stress condition when exposed to air pollution[45]. This is the reason for plant samples from the urban sites were quite higher compared to those of the control site. Water is crucial prerequisite for plant life. Due to unfavorable environmental conditions plants are subjected to various a biotic and biotic stresses affecting their growth, metabolism and yield[46]. So, this four physiological and biochemical parameters namely total chlorophyll, ascorbic acid, pH and relative water content were selected to compute Air Pollution Tolerance Index of *Eucalyptus* plant at Baghdad city.

From the results mentioned above, computed APTI levels revealed that *Eucalyptus* plant samples in all sites had

APTI level < 10 (*i.e.* APTI sensitive category). Levels of the study sites samples were higher than those of the control site. This is in agreement with the report of [47,48]. They reported an increase of APTI levels of plants at the urban site when compared with those at the control site. This may be due to constant exposure of these plants to increase of APTI levels of plants at the urban site when compared with those at the control site. This may be due to constant exposure of these plants to emissions of gaseous and particulate matter from industries operating where they were collected, as well as emissions from vehicle exhaust.

CONCLUSION

From the entire results obtained from the current study, *Eucalyptus* sp. respond differently to air pollution. Hence, the present study suggests that the morphological and biochemical traits of selected roadside plant have potential to serve as excellent quantitative and qualitative indicators of pollution level.

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