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RESEARCH ARTICLE

ASSESSMENT OF AIR POLLUTION TOLERANCE INDEX (APTI) OF DIFFERENT PLANTS OCCURRED IN BEIT HANOUN INDUSTRIAL AREA, NORTH GAZA STRIP, PALESTINE

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ABSTRACT

Air pollution is a major problem facing by the scientists internationally, particularly in industrial areas of the developing countries. Different studies related to air pollution, have been carried out at several areas of the world, but this is the first investigation, which examined the air pollution tolerance index of some natural plant species in Palestine. Identification of plant species for their tolerance or sensitivity range to air pollutants is significant because the tolerant plant species can used for controlling air pollution in industrial locations. Furthermore, the sensitive plant species can used as biological indicators for air pollution. Therefore, in the present study air pollution tolerance index (APTI) was estimated for different plant species inhabiting six locations namely Hamooda, Abosaphea, Mansoer, Spong, Medicine factory and Al show a station of the industrial area of BeitHanoun, Gaza Strip, Palestine. Samples of leaves of 23 plant species were selected from the six sites of the industrial area. The plant species *Solanum elaeagnifolium* cav., *Malva parviflora* L, *Polygonum equisetiforme Sm., Marrubium vulgare L., Verbascum sinuatum L.* were recorded at all sites of the study area. The four biochemical and physiological factors, relative water content, ascorbic acid content, total leaf chlorophyll, and leaf extract pH were used to evaluate the air pollution tolerance index (APTI) values of plant species. The results revealed a more credible result could be achieved when utilizing the above-mentioned four parameters than those of a single biochemical parameter. Based on APTI, *Polygonum equisetiforme* was found, at all locations of the study area, to be more tolerant compared to the remaining plant species, followed by *Nicotiana glauca*, *Solanum elaeagnifolium* and *Silybum marianum* successively considered as the most tolerant plant species in the study area. Lower APTI values were found with other plant species suchas Marrubium vulgare followed by *Marticaria recutita* and then *Chenopodium vulvaria,* which are considered as the most sensitive plant species. In conclusion, the air pollution tolerance index (APTI) values of the 23 studied plant species are less than 16, therefore all plant species are considered as sensitive to air pollutants and can be used as biological indicator for further monitoring of air quality.

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INTRODUCTION

Air pollution is a basic problem appearing fundamentally from manufacturing (Odilora *et al.,* 2006). The regression of characteristics of air quality is a serious environmental problem that affects a lot of industrial locations and civilized regions and peripheral areas worldwide (Kuddus *et al.,* 2011). Air pollution can be assigned by determining the variation in any aerial ingredient of the plant from the value that would have occurred without human activity (Tripathi and Gautam, 2007). Several strategies have been suggested for controlling air pollution. Plant species supply one of the perfect natural method of purifying the atmosphere by providing a lot of leaf surface for aggregation and absorption of air pollutants (Lui and Ding, 2008; Escobedo *et al.,* 2008; Das, 2010; Yannawar and Arjum, 2014). Air pollution influences on the vegetation such as the growth becomes stunted, biochemical synthesis modified and productivity is decreased (Chakraborty *et al.,* 2009). Plant species are very significant for preserving of biological and ecological balance by effectively participating in the gases an nutrients cycle, but air pollution may immediately impacts plants through leaves or soil acidification (Agbaire, 2009; Kumar and Nandini, 2013). Lakshmi *et al.* (2008) mentioned that plant species could act assensitive biological indicators of air pollution. They considered plant species as an important tool for recognizing the reaction to air pollution at biochemical level by analyzing the potential

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synergistic effects of pollutants. Previous researches have determined the effect of air pollution on different biochemical parameters such as ascorbic acid, leaf extract pH, chlorophyll content and relative water content (Rao, 1979; Klumpp *et al.,* 2000; Flowers *et al.,* 2007; Hoque *et al.,* 2007). Assessment of a single mentioned parameter does not provide a pure image of pollution, and using separate parameter gave conflicting outcome for the same plant (Han *et al.,* 1995). So, a formulae has been adopted based on four biochemical parameters to obtain an experimental value referred to as the air pollution tolerance index (APTI) of different plant species according to previous studies (Singh and Rao, 1983; Lakshmi *et al.,* 2008; Yan-Ju and Hui, 2008; Choudhury and Banerjee, 2009). The air pollution tolerance index has been applied to grade plant species in terms of sensitivity or tolerance to air pollution and has been used by scientists to choose plant species that are tolerant against air pollution (Singh and Rao, 1983; Raza and Murthy, 1988; Yan-Ju and Hui, 2008).The aim of this study is to assess the air pollution tolerance index (APTI) values of twenty-three plant species collected from different six locations of the BeitHanoun Industrial Area, North Gaza Strip, Palestine. The investigation will also determine the tolerance and sensitivity of the examined plant species. The importance of this study lies in being the first of its kind in the Gaza Strip and its results will lead us to save some of the most sensitive plant species of air pollution by trying to plant them in less polluted areas.

MATERIALS AND METHODS

Area of the study

The present study was carried out, between spring and summer seasons of 2012/2013, in the industrial area of BeitHanoun city, located in the northern part of GazaStrip, Palestine.

Leaf sample collection

Samples of leaves were collected from 23 plant species of the six various locations of the study area. *Solanum elaeagnifolium* cav., *Malva parviflora* L., *Polygonum equisetiforme Sm., Marrubium vulgare L.,* and *Verbascum sinuatum L.* were the only five plant species commonly presented at all locations of the study area. The sampling area at the present study was divided into six locations, to be representative of the vegetation. The six locations are Hamooda station, Abusaphea, Mansoer factory, Spong factory, Medicine factory and Al Shaowa station. Three replicates of fresh leaf samples were selected from each plant species and taken to the laboratory for analysis. The fully leaves from all the locations were transported in bags to the laboratory. The fresh leaf weight was measured immediately upon getting to the laboratory. The leaf samples were washed out thoroughly with distilled water. Samples were preserved in a refrigerator for other analysis. Scientific and common name of plant species and their family of the tested plant are summarized in Table (1).

Analysis of biochemical parameters

Air pollution tolerance index (APTI) of the wild plant species frequently grown in the industrial area, BeitHanoun city were estimated. The leaf samples were analyzed for relative leaf water content (RWC), total chlorophyll content (TCH), leaf extract pH and ascorbic acid (A.A) at all the previous mentioned plant species at the different locations of the study area.

Table 1. The plant species growing in the six various sites of the study area

S.No.	Scientific Name	Family
1	*Alhagi graecorum Boiss*	Fabaceae
2	*Arisarum annua l.*	Amaranthaceae
3	*Carthamus tenuis* (Boiss.&Blanche) Bornm	Asteraceae
4	*Centaurea hyalolepis* Boiss.	Asteraceae
5	*Chenopodium vulvaria L.*	Chenopodiaceae
6	*Conyza bonariensis* (L.) Cronquist	Asteraceae
7	*Datura innoxia miller*	Solanaceae
8	*Diplotaxis erucoides (L.) DC*	Brassicaceae
9	*Emex spinosa (L.)Campd.*	Polygonaceae
10	*Malva parviflora* L.	Malvaceae
11	*Marrubium vulgare* L.	Labiate
12	*Matricaria recutita L*	Asteraceae
13	*Mercurialis annua* L	Euphorbiaceae
14	*Nicotiana glauca* Graham	Solanaceae
15	*Silybum marianum (L.)Gaerth.*	Asteraceae
16	*Polygonum equisetiforme* Sm.	Polygonaceae
17	*Ricinus communis* L.	Euphorbiaceae
18	*Sinapis alba L*	Brassicaceae
19	*Solanum elaeagnifolium* cav.	Solanaceae
20	*Urtica dioica L.*	Urticaceae
21	*Verbascum sinuatum* L	Scrophulariaceae
22	*Verbesina encelioides* (Cav.)	Asteraceae
23	*Withania somifera(L.)Duna L*	Solanaceae

Relative leaf water content (RWC)

According to the methods described by (Singh, 1977; Sivakumaran and Hall, 1978), leaf RWC determination was calculated by:

$$RWC = \frac{FW - DW}{TW - DW} \times 100$$

Where: FW = Fresh weight, DW = dry weight, TW = turgid weight.

Total chlorophyll content (TCH)

The total chlorophyll content was estimated by using the following formula (Singh *et al*. (1991):

$$\text{Total chlorophyll (mg/g)} = (20.2 \times A_{645} + 8.02 \times A_{663}) \times \frac{V}{1000 \times W}$$

Where: A645 = Absorbance at 645 nm, A663 = Absorbance at 663 nm, V = Total volume of extract, W = Weight of leaf material in gram.

Leaf extract pH

For determination of leaf pH, five grams (5 g) of the fresh leaf samples was well homogenized with 10 ml deionized water, left for a while and filtered. The pH of leaf extracted was calculated after calibrating pH meter with buffer solution of pH 4 and pH 9 (Agbaire, 2009).

Ascorbic acid (AA) content analysis

The ascorbic acid content was measured using the method of Keller and Schwager (1977). A half-gram of fresh sample of leaves was homogenized with 20 ml of oxalic acid extract solution. Sample of ascorbic acid concentration is measured on the standard curve of the corresponding dates. Finally, ascorbic acid is estimated by using the following equation.

$$\text{Ascorbic acid (mg/g)} = \frac{[Eo - (Es - Et)] \times V}{W \times V_1 \times 1000}$$

Where: W = Weight of the fresh leaf taken, V1 = Volume of the supernatant taken, V = Total volume of the mixture, Value of [Eo – (Es – Et)] is estimated by the standard curve.

Air pollution tolerance index (APTI) determination

The air pollution tolerance index (APTI) of 23 common plant species were estimated following the method of Singh and Rao (1983) and Escobedo *et al.,* (2008). The formula of APTI is given as:

$$\text{APTI} = \frac{[A\,(T + P)] + R}{10}$$

Where: A = Ascorbic acid content (mg/g), T = total chlorophyll (mg/g dry wt.), P = pH of leaf extract, R = relative water content of leaf percentage.

RESULTS

In this investigation, changes in biochemical parameters such as relative leaf water content (RWC), total chlorophyll content (TCH), leaf extract pH and ascorbic acid (AA) were measured for calculation of Air pollution tolerance index (APTI) for 23 plant species in six locations of the industrial area of BeitHanoun city, located in northern part of Gaza Strip, Palestine and the data is presented in (Tables 3-8). Plants which have high APTI values are considered tolerant to pollution and the plants which have low values are sensitive. According to APTI values, the plant species were divided as four groups depended on the response to pollution (Table 2) (Kalyani and singaracharya, 1995, Lakshmi *et al.,* 2008).

Table 2. Air pollution tolerance index value and plant response to pollution

Response	APTI value
Tolerant	30 to100
Intermediate	29 to17
Sensitive	16 to 1
Very sensitive	<1
Response	APTI value

The air pollution tolerance index (APTI) value and the four biochemical parameters of 12 different plant species growing commonly in Hamooda station of the industrial area of BeitHanoun city are given in table 3. At Hamooda station the APTI values ranged between 9.32-4.40, the maximum air pollution tolerance index value was found in *Solanum elaeagnifolium* cav. (9.32), *Polygonum equisetiforme* Sm. (9.32), *Ricinus communis* L. (8.50), and minimum were in *Marrubium vulgare* L. (4.40) and *Centaurea hyalolepis* Boiss. (5.70). As shown in table 3, the study showed that the highest ascorbic acid concentration was recorded in *Sinapis alba* Land the least concentration was found in *Chenopodium vulvaria* L. The relative water content ranged between (31.79% to 75.00%). It was the highest in *Polygonum equisetiforme* Sm. (75.00%) and least in *Marrubium vulgare* L. (31.79%). The pH of leaf extract in the experimental site was found to be greatest in *Verbesina encelioides* (Cav.) *(*9.0) and least in *Ricinus communis* L. (5.91) (Table 3).

Table 3. Air pollution tolerance index (APTI) of different plants growing in Hamooda station. (Values are the mean of three individual experiments)

S.No.	Plant Species	PH	TCH	A.A	RWC	APTI
1	*Solanum elaeagnifolium* cav.	6.96	1.10	2.91	69.70	9.32
2	*Malva parviflora* L.	6.7	0.43	1.096	68.89	7.67
3	*Polygonum equisetiforme* Sm.	7.1	0.19	2.49	75.00	9.32
4	*Verbesina encelioides* (Cav.)	9.0	0.34	1.011	73.77	8.32
5	*Ricinus communis* L.	5.91	2.04	1.39	73.97	8.50
6	*Matricaria recutita* L.	6.3	0.41	1.28	52.60	6.12
7	*Sinapis alba* L	6.46	0.26	3.01	50.48	7.07
8	*Centaurea hyalolepis* Boiss.	6.73	0.84	2.29	39.73	5.70
9	*Chenopodium vulvaria* L.	7.0	0.54	0.69	61.62	6.68
10	*Verbascum sinuatum* L	6.7	0.47	1.58	45.81	5.71
11	*Conyza bonariensis* (L.) Cronquist	6.12	0.57	1.99	51.55	6.48
12	*Marrubium vulgare* L.	6.7	0.42	1.72	31.79	4.40

At Abusaphea industrial site (Table 4), chlorophyll (TCH) concentration ranged between 0.26-1.0 mg/g of the green weight. The study showed that the highest A.A concentration was in *Solanum elaeagnifolium* (2.85) and the least concentration was found in *Alhagi graecorum Boiss.* (0.20). Relative water content ranged between (48.48% to 85.48%). The highest concentration was in *Alhagi graecorum Boiss* (85.48%) and the least concentration was found in *Verbesina encelioides (Cav.)* (48.48%).

Table 4. Air pollution tolerance index (APTI) of various plant species growing in Abusaphea station. (Values are the mean of three individual experiments)

S.No.	Plant Species	PH	TCH	A.A	RWC	APTI
1	*Solanum elaeagnifolium* cav.	7.4	0.51	2.85	68.03	9.1
2	*Malva parviflora* L.	6.8	0.37	0.91	59.97	6.6
3	*Polygonum equisetiforme Sm.*	6.85	0.26	2.52	70.97	8.9
4	*Verbesina encelioides (Cav.)*	8.85	0.86	0.65	48.48	5.5
5	*Ricinus communis* L.	6.45	0.65	0.68	63.16	6.8
6	*Matricaria recutita* L.	6.62	0.37	1.20	63.42	7.2
7	*Sinapis alba* L	6.6	1.00	2.18	66.38	8.3
8	*Chenopodium vulvaria* L.	7.2	0.58	1.14	68.42	7.7
9	*Datura innoxia miller*	6.43	0.83	1.68	61.13	7.3
10	*Nicotiana glauca* Graham	6.67	0.45	0.82	79.43	8.5
11	*Marrubium vulgare* L.	6.8	0.62	1.48	59.23	7.0
12	*Alhagi graecorum Boiss.*	6.7	0.77	0.20	85.48	8.7
13	*Verbascum sinuatum* L	7.0	0.90	1.60	55.00	6.8
14	*Mercurialis annua* L	6.65	0.30	1.39	58.55	6.8

The highest pH value was measured in *Verbesina encelioides* (Cav.) (8.85) and the least in *Verbascum sinuatum L* (6.43). The APTI value was ranging between (9.06 and 5.48). The maximum value was in *Solanum elaeagnifolium* cav. (9.06), *Polygonum equisetiforme* Sm. (8.89), *Alhagi graecorum Boiss.* (8.70) and *Nicotiana glauca* Graham*.* (8.53) and the minimum value were in *Verbesina encelioides* (Cav.) (5.48) and *Malva parviflora* L. (6.65) (Table 4). At Mansoer factory site (Table 5), the maximum APTI value was recorded in *Nicotiana glauca* Graham (9.01), *Verbesina encelioides* (Cav.) (8.73) and

Polygonum equisetiforme Sm.(8.4) and the minimum values were in *Conyza bonariensis* (L.) Cronquist (5.56) and *Malva parviflora* L. (6.03). As shown in Table 5, *Solanum elaeagnifolium* car. had the highest concentration of ascorbic acid (AA) (3.02mg/g) and *Ricinus communis* L. showed the least concentration of AA (0.61mg/g). The pH was ranging between (6.44- 8.95). The highest was recorded in *Verbesina encelioides* (Cav.) (8.95) and the least was recorded in *Nicotiana glauca Graham* (6.44). Chlorophyll (TCh) concentration ranged between 0.22-1.86mg/g of the green weight. The relative water content ranged between (48.05% to 83.13%) with the highest value in *Nicotiana glauca Graham* (83.13).and the least value was found in *Marrubium vulgare L.* (48.05%) (Table 5). At Spong factory site of the industrial area, the concentration of the ascorbic acid (AA) ranged between 0.68 and 2.49 mg/g, chlorophyll (TCh) concentration ranged between 0.09-1.57 mg/g of the green weight. The study showed that the biggest concentration in the ascorbic acid was in *Polygonum equisetiforme* Sm. and the least concentration was found in *Carthamus tenuis (Boiss. & Blanche) Bornm.* The APTI values ranged between (8.54- 4.99), the maximum air pollution tolerance index value was found in the following plant species *Withania somifera (L.) Duna L.* (8.54), *Nicotiana glauca* Graham (8.20), *Polygonum equisetiforme* Sm. (8.11) *and Marrubium vulgare* L. (7.64) and the minimum values were in *Malva parviflora* L. (4.99) and *Verbesina encelioides* (Cav.) 6.38) (Table 6).

Table 5. Air pollution tolerance index (APTI) of different plants growing in Mansoer factory site. (Values are the mean of three individual experiments)

S.No.	Plant Species	PH	TCH	A.A	RWC	APTI
1	*Solanum elaeagnifolium* cav.	6.65	0.53	3.02	56.40	7.8
2	*Malva parviflora* L.	6.55	0.28	0.97	53.68	6.0
3	*Verbesina encelioides (Cav.)*	8.95	0.85	1.20	75.51	8.7
4	*Marrubium vulgare* L.	8.3	0.54	1.96	48.05	6.5
5	*Ricinus communis* L.	6.45	0.49	0.61	70.28	7.5
6	*Nicotiana glauca Graham*	6.44	0.22	1.04	83.13	9.0
7	*Arisarum annua* L.	6.7	1.86	1.54	56.35	7.0
8	*Conyza bonariensis (L.) Cronquist*	6.45	0.31	0.90	49.54	5.6
9	*Chenopodium vulvaria* L.	6.85	0.47	1.18	57.70	6.6
10	*Verbascum sinuatum* L	6.55	0.61	0.73	51.49	5.7
11	*Withania somifera(L.) Duna L*	7.3	0.42	1.21	59.20	6.9
12	*Polygonum equisetiforme Sm.*	6.85	0.26	2.20	68.00	8.4
13	*Carthamus tenuis (Boiss.&Blanche) Bornm*	6.7	0.39	1.61	53.84	6.5

Table 6. Air pollution tolerance index (APTI) of different plants growing in Spong factory site. (Values are the mean of three individual experiments)

S.No.	Plant Species	PH	TCH	A.A	RWC	APTI
1	*Solanum elaeagnifolium*cav.	7.55	0.20	1.63	56.47	6.9
2	*Malva parviflora* L.	7.2	0.22	0.72	44.53	5.0
3	*Verbesina encelioides(Cav.)*	9.2	0.82	1.43	49.46	6.4
4	*Marrubium vulgare* L.	7.8	0.76	1.72	61.65	7.6
5	*Withania somifera(L.)Duna* L	6.4	0.09	0.97	79.08	8.5
6	*Nicotiana glauca Graham*	6.0	1.57	0.72	76.50	8.2
7	*Alhagi graecorumBoiss.*	7.3	0.45	0.09	69.70	7.0
8	*Polygonum equisetiforme Sm.*	6.5	0.53	2.48	63.59	8.1
9	*Chenopodium vulvaria* L.	8.4	0.59	0.89	60.41	6.8
10	*Verbascum sinuatum* L	6.7	0.71	0.80	70.00	7.59
11	*Carthamus tenuis (Boiss. & Blanche) Bornm.*	6.5	0.87	0.68	65.86	7.1

At Medicine factory site of the industrial area, the concentration of the ascorbic acid (AA) ranged between 0.73 and 2.5 mg/g, chlorophyll (TCh) concentration ranged between 0.1- 1.67 mg/g. For the plant species, the study showed that the biggest concentration in the AA was in *Polygonum equisetiforme* Sm. and the least concentration was found in *Alhagi graecorum Boiss.* The highest value of RWC was in *Nicotiana glauca* Graham (87.44%) and the least value was found in *Verbascum sinuatum L.* (45.21% %).

The APTI values ranged between (9.25- 5.32), the maximum air pollution tolerance index value was found in the following plant species *Alhagi graecorum Boiss.* (9.25), *Nicotiana glauca* Graham (9.10), *Polygonum equisetiforme* Sm. (8.77), *Solanum elaeagnifolium* cav. (7.78) and minimum were in *Verbascum sinuatum* L (5.32) and *Malva parviflora* L. (5.39) (Table 7).

Table 7. Air pollution tolerance index (APTI) of different plants growing in Medicine factory site. (Values are the mean of three individual experiments)

S.No.	Plant Species	PH	TCh	A.A	Rw	APTI
1	*Solanum elaeagnifolium* cav.	5.81	0.41	1.6155	67.78	7.78
2	*Malva parviflora* L.	7.3	0.29	0.7677	48.09	5.39
3	*Polygonum equisetiforme* Sm.	7.05	0.13	2.4960	69.81	8.77
4	*Verbesina encelioides*(Cav.)	8.7	0.37	1.3308	58.16	7.02
5	*Alhagi graecorumBoiss.*	6.25	0.62	0.7290	87.44	9.25
6	*Marrubium vulgare* L.	7.7	0.61	0.8596	52.62	5.98
7	*Nicotiana glauca* Graham	6.38	0.13	1.3898	81.97	9.10
8	*Carthamus tenuis* (Boiss.&Blanche) Bornm	6.45	1.67	1.3048	54.26	6.49
9	*Chenopodium vulvaria* L.	7.0	0.10	0.7754	54.47	6.00
10	*Verbascum sinuatum* L	6.25	0.71	1.1503	45.21	5.32
11	*Datura innoxia miller*	6.4	0.88	0.8005	62.93	6.88
12	*Conyza bonariensis* (L.) Cronquist	6.6	0.30	0.8709	60.67	6.67

Table 8. Air pollution tolerance index (APTI) of different plants growing in Al Shaowa station site. (Values are the mean of three individual experiments)

S.No.	Plant Species	PH	TCh	A.A	Rw	APTI
1	*Solanum elaeagnifolium*cav.	6.7	0.71	2.0398	65.87	8.10
2	*Malva parviflora* L.	6.5	0.21	1.4006	35.87	4.53
3	*Polygonum equisetiforme* Sm.	6.9	0.39	1.5735	59.96	7.14
4	*Verbesina encelioides* (Cav.)	8.5	0.73	1.5430	62.08	7.63
5	*Alhagi graecorum Boiss.*	6.5	0.16	0.3454	64.14	6.64
6	*Marrubium vulgare* L.	7.2	0.59	1.4208	52.42	6.35
7	*Nicotiana glauca* Graham	6.4	0.23	1.0945	79.88	8.71
8	*Carthamus tenuis* (Boiss.&Blanche) Bornm	7.7	0.33	1.0526	38.26	4.67
9	*Chenopodium vulvaria* L.	7.2	0.51	1.1678	65.81	7.48
10	*Verbascum sinuatum* L	7.27	0.57	0.8971	64.26	7.13

At Al Shaowa stationsite, the APTI values ranged between (8.71-4.53) the maximum air pollution tolerance index value was found in the following plant species *Nicotiana glauca* Graham. (8.71), *Solanum elaeagnifolium* cav. (8.10), *Verbesina encelioides* (Cav.) (7.63) and *Chenopodium vulvaria L.* (7.48) and minimum were in *Malva parviflora* L. (4.53) and *Carthamus tenuis* (Boiss & Blanche) Bornm (4.67) (Table 8). The concentration of (AA) ranged between 0.35and 2.04mg/g, chlorophyll (TCh) concentration ranged between 0.16- 0.73 mg/g of the green weight.

For the plant species, the study appeared that the biggest concentration in the ascorbic acid was in *Solanum elaeagnifolium* car. and the least concentration was found in *Alhagi graecorum Boiss.* Relative water content ranged between 35.87% to 79.88%that the highest value was in *Nicotiana glauca* Graham (79.88%) and the least value was found in *Malva parviflora* L.(35.87%). pH was recorded in experimental site ranged between(6.4-8.5), the highest value was in *Verbesina encelioides* (Cav.) (8.5) and the least was in *Nicotiana glauca* Graham (6.4)(Table 8).

DISCUSSION

Vegetation naturally develop special responses to particular level of air pollution. The plant species can absorb pollutants through leaves providing various physiological, morphological and biochemical benefits (Singh andVerma, 2007). Sensitive plant are proposed as biological indicators (Tripathi *et al.,* 1999; Raina and Sharma, 2006). The sensitive plant species can determine the locations of air pollution and tolerant plants help in reducing air pollution (Subrahmanyam *et al.,* 1985; Seyyednjad *et al.,* 2011). Various plant species have an important variation in their sensitivity to air pollution (Singh and Rao, 1983) and evaluation of plant species with respect to their sensitivity or tolerance rang to air pollution could be fundamental. The difference four physiological factors such as leaf relative water content (RWC), ascorbic acid content (AA), total leaf chlorophyll (TCh) and pH of leaf extract of plant species leaves can be utilized to indicate the air pollution before exhibiting physiological visible damage in the leaves (Mandal and Mukherji, 2000; Agrawal, 2003; Joshi and Swami, 2007). The evaluation of those four physiological factors revealed that an important incompatible and unstable results just as mentioned by Han *et al*. (1995). Depending on its concentration, ascorbic acid has a reducing power and it affects numerous physiological mechanisms such as cell wall synthesis, cell division and photosynthetic carbon fixation (Conklin, 2001; Raza and Murthy, 1988; Agbaire and Esiefarienrhe, 2009). The chlorophyll contents may be increased because of the effect of some air pollutants (Allen *et al.,* 1987) and it is considered the biological indicator of plant productivity (Raza and Murthy 1988). The total chlorophyll is also associated to ascorbic acid productivity (Lakshmi *et al.,* 2008). Scholz and Reck (1977) has mentioned that pH as a biological indicator for sensitivity to air pollution. In the present study, from the tables 3-8 it was evident that the plant species of six sites of the industrial area of BeitHanoun city, Gaza Strip, Palestine showed different values of air pollution tolerance index (APTI), and an overview of the study results clarified that various plant species responded differently to air pollutants in different locations of the industrial area (Table 3-8).

The results showed that *Polygonum equisetiforme* have the highest APTI value at all sites of the industrial area followed by *Nicotiana glauca* followed by *Solanum elaeagnifolium* followed by *Silybum marianum*, and is considered as the most tolerant plant species of the study area. The APTI values for the remaining plant species are lower as *Marrubium vulgare* followed *Marticaria recutita* followed by *Chenopodium vulvaria* and considered as more sensitive plant species. The results also revealed that, the air pollution tolerance index (APTI) values of the 23 plant species are less than 16, therefore all plant species are considered as sensitive to air pollutants and can be used as biological indicator for air pollution (Kalyani and singaracharya 1995; Suvarna Lakshmi 2008).

Conclusion

In conclusion, air pollution tolerance index (APTI) assessment for plant species, growing in various locations of industrial area, is of significance because of the increased and severe threat on environment due to air pollution. It is worth noting that various plant species react differently to air pollution depended on the different ecological conditions of the study sites. Plant species have the possibility to utilize as an important qualitative biological indicator of air pollution. Therefore, this study was advantageous for monitoring of air quality and in identification of sensitive and tolerant appropriate plant species which could be cultivated for controlling the air pollution or used as biological indicators and this may become an important mechanism for reducing of air pollution at the urban environment. Based on the role of the plant species as bio-monitoring, *Marrubium vulgare, Marticaria recutita, Chenopodium vulvaria, Conyza bonariensis and Carthamus tenuis*are plants recorded at the study area and can be utilized as biological monitors of air quality.

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