The Effect of Air Pollution on some Biochemical Parameters of Leaves of Three Tree Species Growing in the Industrial Area in Jeddah, Saudi Arabia

Shaheen, A. M., Al-Toukhy, A. A. and Hajar, A. S.

Biological Sciences Department, Faculty of Science, King Abdulaziz University, Saudi Arabia.

Abstract. The effect of industrial emissions on the levels of certain biochemical measurements in leaves of Camphor (*Cinnamomum camphora*), Henna (*Lawsonia inermis*), and Bougainvillea (*Bougainvillea spectabilis*) trees growing in the industrial zone in Jeddah - Saudi Arabia and Hada Al-Shame area (control) was done. Overall results showed that the content of chlorophyll a and b, total chlorophyll, carotenoids and protein in the plant leaf of the trees growing in the industrial zone were less comparing with the leaves of the trees growing in the control area.

Introduction

Chlorophyll measurement is an important tool to evaluate the effects of air pollutants on plants (Joshi *et al.*, 2009), since it plays an important role in plant metabolism and the reduction in of it corresponds directly to plant growth. Abbasi, *et al.*, (2004) and Tripathi, *et al.* (2009) reported that chlorophyll content of plants varies from species to species; age of the leaf and also with the pollution level as well as with other biotic and a biotic conditions. Agbaire and Esiefarienrhe, (2009) indicated that whereas certain pollutants increase the total chlorophyll content, others decrease it. Chauhan and Joshi (2010) reported that wheat and mustard plants grown at polluted sites showed significant reduction in total chlorophyll and carotenoid.

Joshi and Swami (2007) and Seyyednejad and Koochak (2011) reported significant reduction in carotenoid content of different plants grown at polluted sites. Several researchers have reported reduced carotenoid

content under air pollution (Joshi *et al.*, 2009; Tiwari *et al.*, 2006). Saquib *et al.* (2010) reported that the root biomass and chlorophyll a showed maximum reduction than any other selected parameters studied in the stressed area. Prasad and Rao (1981) found decrease in protein and carbohydrate content in petroleum-coke treated plants. Williams and Banerjee (1995) found considerable reduction in chlorophyll and protein content in leaves of *Mangifera indica* and *Shorea robusta* affected by the pollution in the industrial area. Verma and Singh (2006) noticed marked alterations in photosynthetic pigments and protein content in foliar tissues as affected by pollution. Also, Trivedi and Singh (1995) noticed significant reduction in protein content in a few plants as a result of fly ash particulates.

The aim of this investigation was to determine the effect of industrial emissions on the levels of some biochemical parameters in leaves of three plant species growing under industrial area (polluted) with those growing in unpolluted areas. The chosen parameters were

chlorophyll *a*, chlorophyll *b*, total chlorophyll, carotenoids and protein.

Materials and Methods

Study area

This study was conducted at Jeddah city industrial area, which is situated between 21°24'37"N latitude and 39°14'30"E longitude and the control area (the Agricultural Research Station, Hada Al-Sham, King Abdulaziz University at a distance of 120 km north-east of Jeddah) which situated between 21°47'50"N latitude and 39°43'33"E longitude in the West of Saudi Arabia.

Plant Materials

Three plant species with the same age, namely Bougainvillea (*Bougainvillea spectabilis*), Camphor (*Cinnamomum camphora*) and Henna (*Lawsonia inermis*) were selected for this study, as they were common in Jeddah industrial area (polluted) and the control area (unpolluted).

Chlorophyll (a+b) and carotenoids content measurements:

Samples (four discs each) were taken from fully expanded leaves of each plant and were extracted with acetone 80% in a water bath at 80°C. Full extraction of chlorophyll and carotenoids was achieved when the sample was discolored. Four replicates were prepared per plant species. Absorbance was read in a spectronic 20+spectrophotometer at wavelength 645 and 663 nm and read against an 80% acetone solvent blank. That was done according to the method described by Arnon (1949) and Lichtenthaler (1987).

Determination leaf nitrogen and protein

Leaf nitrogen and protein contents were determined as described by Andreas and

Gunter (1994). Nitrogen content was estimated from the nitrogen content of the leaves (%) by a Kjeldahl automatic Automatic kjeldhel According to A.O.A.C. (2006). The Protein concentration was done by multiplying the percentage of nitrogen $\times$ coefficient of a protein (6.25) for protein concentration, according to A.O.A.C. (2006).

Experimental Design

A completely randomized design with 4 replications were used to study each plant species separately where the industrial zone of Jeddah (polluted area) and the Hada Al-Shame (control area) were the treatments.

Statistical Analysis

Statistical analysis of the obtained data were statistically analyzed through analysis of variance and mean separation procedures after the assumption of the analysis of variance were tested and applied according to El-Nakhlawy (2010) using SAS (2006).

Results and Discussion

Nitrogen and protein contents in the plant species

Bougainvillea trees

Analysis of variance

Analysis of variance of the protein and nitrogen contents in the plant leaves under the effects of the industrial pollutants and the control area (Table 1) showed significant effects at $p \leq 0.05$ for the protein and nitrogen contents in the plant leaves of Bougainvillea trees, no significant in the plant leaves of Camphor and significant effects at $p \leq 0.01$ in the plant leaves of Henna.

Table (1). Analysis of variance of protein, nitrogen contents in plant leaves and nitrogen content in soil in the industrial zone and control area.

S.O.V.	df	MS	
		Bougainvillea	
		Protein in plant leaves	Nitrogen in plant leaves
Locations	1	8.7780*	0.2244*
Error	6	0.971	0.0249
		Camphor	
		Protein in plant leaves	Nitrogen in plant leaves
Locations	1	0.775 ^{NS}	0.0200 ^{NS}
Error	6	0.294	0.0075
		Henna	
		Protein in plant leaves	Nitrogen in plant leaves
Locations	1	110.558**	2.83**
Error	6	1.32	0.034

^{NS}: not significant at $p \leq 0.05$.

*, **: significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

Comparison between the means

Bougainvillea trees

As shown in Table (2) the Bougainvillea plant leaves in the industrial zone had protein and nitrogen contents less than in the plant leaves of Hada Al-Sham (control) with no significant values. Protein contents were 17.297 and 19.392% in the industrial zone and the control, respectively.

Camphor trees

As shown in Table (2) the Camphor plant leaves in the industrial zone had protein and nitrogen contents less than in the plant leaves

of Hada Al-Sham (control) with no significant values. Protein contents were 7.425 and 8.047% in the industrial zone and the control, respectively.

Henna trees

As shown in Table (2) the plant leaves in the industrial zone had protein and nitrogen contents less than in the plant leaves of Hada Al-Sham (control) with significant values. Protein and N contents in the control area are around twice them under the industrial area.

Table (2). Means of protein, nitrogen in plant and nitrogen in soil under the three species in the industrial zone and control area.

Locations	Means (%)	
	Bougainvillea	
	Protein in plant	Nitrogen in plant
Industrial Zone	17.297 b*	2.767 b
Hada Al-Sham	19.392 a	3.102 a
	Camphor	
	Protein in plant	Nitrogen in plant
Industrial Zone	7.425 a	1.188 a
Hada Al-Sham	8.047 a	1.288 a
	Henna	
	Protein in plant	Nitrogen in plant
Industrial Zone	8.565 b	1.370 b
Hada Al-Sham	16.00 a	2.560 a

* Means followed by the same letter are not significantly different according to LSD at ($p \leq 0.05$).

Plant protein is an essential component for the plant growth. Significantly lower concentration of total proteins in leaves of all tree species was recorded in the industrial area as compared to the control area. This results are confirmed with the results of (Trivedi and Singh, 1995; Williams and Banerjee, 1995 and Verma and Singh, 2006).

A decrease in protein content under heavy metal stress has been reported in other plant species such as *Lupinus albus* (Costa and Spitz, 1997) and *L. minor*. (Mohan and Hosetti, 1997).

Total chlorophyll, chlorophyll a and chlorophyll b and carotenoid contents

Bougainvillea trees

Analysis of variance

Analysis of variance of chlorophyll a and chlorophyll b, total chlorophyll and carotenoid contents in the plant leaves under the effects of the industrial pollutants and the control area (Table 3) showed significant effects at $p \leq 0.05$ for these four characters except the chlorophyll b of *Bougainvillea* trees, which not significantly affected by the pollution sources.

Table (3). Analysis of variance of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents in leaves of *Bougainvillea* under the effects of the industrial zone and control area.

S.O.V.	d r	MS			
		chlorophyll a	chlorophyll b	total chlorophyll	carotenoid
Locations	1	0.272*	0.026 ^{NS}	0.4675*	0.0522*
Error	6	0.034	0.0155	0.0642	0.0062

^{NS}: not significant at $p \leq 0.05$.

*: significant at $p \leq 0.05$.

Comparison between the means

As shown in Table (4) the plant leaves in the industrial zone had chlorophyll a and total chlorophyll contents less than in the plant leaves of Hada Al-Sham (control) with significant values, while chlorophyll b was insignificant affected.

The carotenoid content in the plant leaves was around five times in the control than under the industrial pollutants, with values of 0.2483 and 0.0868 mg/100 g, respectively.

Table (4). Means of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid in plant leaves of *Bougainvillea* (*Bougainvillea spectabilis*) in the industrial zone and control area.

Location	Means (mg/100 g)			
	chlorophyll a	chlorophyll b	total chlorophyll	carotenoid
Industrial Zone	0.586 b*	0.298 a	0.885 b	0.0868 b
Hada Al-Sham	0.955 a	0.413 a	1.368 a	0.2483 a

* Means followed by the same letter are not significantly different according to LSD at ($p \leq 0.05$).

Camphor trees

Analysis of variance

Analysis of variance of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents in the plant leaves under the effects of the industrial pollutants and the control area (Table 5) showed no significant effects at $p \leq 0.05$ for the three chlorophyll characters, while carotenoid content significantly affected by the industrial pollution at $p \leq 0.01$.

Table (5). Analysis of variance of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid in plant leaves of *Camphor* in the industrial zone and control area.

S.O.V.	d f	MS			
		chlorophyll a	chlorophyll b	total chlorophyll	carotenoid
Locations	1	0.1559 ^{NS}	0.0105 ^{NS}	0.2475 ^{NS}	0.0929**
Error	6	0.0611	0.0122	0.1131	0.0063

^{NS}: not significant at $p \leq 0.05$.

** : significant at $p \leq 0.01$.

Comparison between the means

As shown in Table (6) the plant leaves in the industrial zone had chlorophyll a, chlorophyll b and total chlorophyll contents without significant differences than the control

area, but carotenoid content was around four times in the control than under the industrial pollutants.

Table (6). Means of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents in plant leaves of Camphor in the industrial zone and control area.

Location	Means (mg/100 g)			
	chlorophyll a	chlorophyll b	total chlorophyll	carotenoid
Industrial Zone	0.304 a *	0.1010 a	0.405 a	0.0695 b
Hada Al-Sham	0.583 a	0.1735 a	0.757 a	0.2850 a

* Means followed by the same letter are not significantly different according to LSD at ($p \leq 0.05$).

Henna trees

Analysis of variance

Analysis of variance of chlorophyll a and chlorophyll b, total chlorophyll and carotenoid contents in the plant leaves under the effects of the industrial pollutants and the control area (Table 7) showed significant effects at $p \leq 0.01$ for chlorophyll a, chlorophyll b and total chlorophyll in the plant leaves of Henna trees, while carotenoid content in the plant leaves was not significantly affected by the industrial pollution at $p \leq 0.05$.

Table (7). Analysis of variance of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents in plant leaves of Henna in the industrial zone and control area.

S.O.V.	df	MS			
		chlorophyll a	chlorophyll b	total chlorophyll	carotenoid
Locations	1	3.329**	0.055**	0.653**	0.286 ^{NS}
Error	6	0.010	0.005	0.026	0.058

^{NS}: not significant at $p \leq 0.05$.

** : significant at $p \leq 0.01$.

Comparison between the means

As shown in Table (8) the plant leaves in the industrial zone had chlorophyll a, chlorophyll b and total chlorophyll contents less than in the plant leaves of Hada Al-Sham (control) with significant values. The carotenoid content in the plant leaves was not

significant affected by the industrial pollutants, compared the control area.

Table (8). Means of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents in plant leaves of Henna in the industrial zone and control area.

Location	Means (mg/100 g)			
	chlorophyll a	chlorophyll b	total chlorophyll	carotenoid
Industrial Zone	0.389 b *	0.136 b	0.525 b	0.092 a
Hada Al-Sham	0.092 a	0.301 a	1.0970 a	0.470 a

* Means followed by the same letter are not significantly different according to LSD at ($p \leq 0.05$).

The results of this study of the three trees species showed that the composition of chlorophyll and carotenoid pigments in the plant leaf of the trees growing under the industrial pollutants were less comparing with the leaves of the trees growing in the control. These results are confirmed with the results of Mage *et al.* (1996) and Saquib *et al.* (2010).

The lower amount of chlorophyll a, chlorophyll b, total chlorophyll and carotenoids under polluted environment were also noted in several other studies (Singh *et al.* 1985; Singh *et al.* 1990; Malabari *et al.* 1991; Dhir *et al.* 1999; Nighat *et al.* 1999, 2000; Saquib, 2008; Iqbal *et al.* 2010; Chauhan and Joshi, 2010). Several researchers have reported reduced carotenoid content under air pollution (Joshi *et al.*, 2009; Tiwari *et al.*, 2006).

Conclusion

1. Protein contents of the plant leaves were 17.297%, 7.425% and 8.565% in Bougainvillea, Camphor and Henna, respectively under the industrial zone compared with 19.392%, 8.047% and 16.00%, respectively under the control area.
2. Chlorophyll b, total chlorophyll and carotenoid contents were higher under Hada Al-Sham than industrial conditions in Bougainvillea trees.

3. Only carotenoid content in the Camphor leaf was significantly higher under the control than the industrial conditions with around 4 times.
4. Chlorophyll a, b and total chlorophyll were significantly higher in the Henna leaf under the control than the industrial zones, while carotenoid content did not significantly affected by the locations
5. The reduction biochemical parameters in leaves of the three plant species studied at the industrial area clearly indicates the deleterious effect of air pollution on plant health.
6. Based on the above study, it is evident that Camphor (*Cinnamomum camphora*), Henna (*Lawsonia inermis*), and Bougainvillea (*Bougainvillea spectabilis*) trees can be used as a bio-indicator to monitor the air pollutants.

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تأثير تلوث الهواء على بعض الصفات الكيموحيوي لأوراق ثلاثة أنواع من الأشجار تنمو في المنطقة الصناعية بجدة، المملكة العربية السعودية

شاهين، أحمد محمد عبدالرحيم؛ والطوخي، عبدالمنعم عبدالمجيد؛ وآل حجر، عبدالرحمن سعيد

قسم علوم الأحياء، كلية العلوم، جامعة الملك عبدالعزيز، جدة، المملكة العربية السعودية

المستخلص. تم دراسة تأثير الانبعاثات الصناعية على مستويات بعض القياسات البيوكيميائية في أوراق أشجار الكافور (*Cinnamomum camphora*)، الحناء (*Lawsonia inermis*)، والجهنمية (*Bougainvillea spectabilis*) النامية في المنطقة الصناعية بمدينة جدة - المملكة العربية السعودية ومنطقة هذا الشام (مقارنة). بشكل عام أظهرت النتائج أن محتوى كلوروفيل أ وب، الكلوروفيل الكلي، الكاروتين والبروتين في أوراق نباتات الأنواع الثلاثة من الأشجار التي تنمو في المنطقة الصناعية كان أقل مقارنة مع أوراق الأشجار التي تنمو في منطقة المقارنة.

الكلمات المفتاحية: الكلوروفيل، الكاروتينات، البروتين، صبغات التمثيل الضوئي، تلوث الهواء، المناطق الصناعية.