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Impacts of ambient air quality of an industrial region on a member of asteraceae and its potentials as a phytomonitor.

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Abstract

The highly industrialized and densely populated city of Tarapur provides ideal conditions for the study of the effects of urban stresses on plants. *Tithonia diversifolia* a member of Asteraceae was exposed to five different sites during the dry season of 2011. The transplants were exposed for thirty days. The above grounds phytomass dry weight, shoot length, total chlorophyll content and dust fall were recorded. The readings were compared with a control which was a relatively clean area. The decrease in all the parameters was observed when compared to control. There was a marked seasonal variation in all the parameters. Shoot length and chlorophyll content are more reliable parameters for air quality indication and in identifying *Tithonia diversifolia* as important indicator species. Urban air quality affects the health of humans, animals, and plants equally. Hence it becomes necessary to monitor the air quality for taking the abatement measures and understanding the effect of air pollutants on living organisms.

Keywords: Air pollution, phytomonitoring, tithonia, parameters.

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Introduction

Suspended Particulate Matter (SPM) or dust is one of the major air pollutants present in the environment. The dust load in an urban and industrial area is rising gradually due to more and more industrialization, construction, transportation, metal refining, and residential activities. There is a cumulatively high deposition of particulate matter on soil and leaf surfaces in urban and/or industrial areas [1]. The phytotoxic effects of dust originating from the urban and industrial area have been studied by numerous researchers.

Vegetation helps in reducing dust concentrations in surroundings by acting as a sink for air pollutants. The foliar surface of plants is an important receptor of atmospheric pollutants hence it is very crucial to select suitable plant species for urban environment [2].

Particulate pollutants are capable of causing many hazardous effects on plants like stomatal clogging, decreased photosynthetic activity, the death of tissues and leaf fall [3]. Air pollution effects are broadly classified into acute effects leading to severe foliar injury and chronic effects resulting due to long exposures at low concentrations and culminating in an invisible injury such as reduction in growth, emaciation and ultimately total dieback of the plant organs [4].

Maharashtra occupies an important position in the manufacturing sector of India with the industrial zone of Mumbai-Pune-Thane belt contributing to about 60% of State's output. This state has the maximum number of registered vehicles and also consumes the maximum amount of fossil fuels in the country, which are the main reasons considered for air pollution [5]. Tarapur industrial area located in Palghar Taluka of Thane District is one of the critically polluted areas of India and hence it was chosen for the current study in order to understand its ambient air quality.

In this work, an attempt was made to study the effect of environmental stresses like SPM or dust on Tithonia diversifolia (Hemsl.) A. Gray plant kept at various locations around Tarapur industrial area at morphological level by analyzing above ground phytomass and Shoot length and at biochemical level by analyzing Total chlorophyll content.

Materials and Method

Experimental plant

Tithonia diversifolia, Hemsl. an ornamental species from the Asteraceae family was chosen for this study. A perennial herb reaching to a height of 1-3 m, it has broadly ovate leaves sometimes 3-5 lobed with crenate margin. Leaves and petioles are pubescent and the inflorescence is Sunflower like.

Preparation of set

Seeds of *Tithonia diversifolia* were bought from a local seed dealer and sown in garden pots. Seeds obtained from this generation were used for the experiment. Plants were grown in polythene bags containing soil and farmyard compost in 3:1 ratio. Three plants were grown in each bag and 4 bags were prepared. This constituted one set. The plants were transported to the sites selected in the 3-4 leaf stage.

Study area

In the current study sites were selected which were located in and around industrial areas, close to a vehicular pollution source and in residential areas. 4 sets each, with each set consisting of three transplants of *Tithonia* saplings, were placed at five different sites in the year 2011-2012 around the industrial area of Tarapur. The description of experimental sites is given in (Table 1 and Figure 1).

Table 1. *Sites in Tarapur chosen for phytomonitoring of air quality using Tithonia diversifolia from October 2011- May 2012.*

No.	Site name	Description of site
1.	Pam-Tembhi (Control)	Village area, away from vehicular and industrial pollution
2.	Boisar railway station	Next to the railway station, near vehicle parking
3.	Chitralay market	Commercial complex, opposite to residential area
4.	Tarapur Atomic Power Station (T.A.P.S) residential colony	Clean environmenthe t, interior of Residential area
5.	Petrol pump	Along heavy vehicular traffic road, industrial area

Tithonia transplants were exposed to air pollutant and dust for a period of 30 days and they were replaced every month with new plant sets. After the exposure period, they were brought back to the laboratory and analyzed for dust fall, Morphological parameters like above ground phytomass and shoot length and Biochemical parameters like Total chlorophyll content which were compared with a control set for their reliability in monitoring air quality.

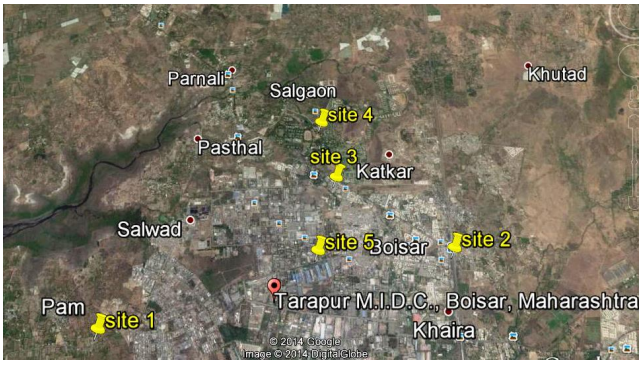

Figure 1. *Location of study sites selected for Pilot study of phytomonitoring using Tithonia diversifolia from October 2011- May 2012.*

Dust fall

Dust from the leaves of each plant sample was washed with water using spray bottles and foliar dust was collected in plastic beakers. Dust was carefully collected on pre-weighed Whatman's filter paper (pore size 110 mm). Dust fall was measured in gms/m² [6].

Morphological parameter

1. Above ground phytomass: The shoot of each plant was harvested at ground level and dried in an oven at 70 ± 1. The value for dry matter has been expressed as dry weight per plant

2. Shoot length: The length of each shoot was measured and later calculated with the control to give percentage reduction

Biochemical parameter

Total chlorophyll content: 1 gm fresh leaf sample was crushed in 20 ml of pre-chilled 80% acetone and filtered. The filtrate was centrifuged at 5,000 rpm for 5 min and later the supernatant was collected and O.D was taken at 663 and 645 nm [7].

Statistical analysis: A control was maintained, which was in a village away from any source of pollution. It was a garden area receiving full sunlight. A two-tailed students 't' test was carried out at confidence level $P<0.05$ for each parameter of concerned plant species. This was done in comparison to the control site for each period. Further statistical studies were carried out using the correlation coefficient in relation to all the parameters considered for the study. Box plots and histograms were also prepared using Excel and SPSS software.

Correlation analysis

Two morphological parameters i.e. above ground phytomass along with shoot length and one biochemical parameter viz. total chlorophyll content of Tithonia were used for phytomonitoring studies. However, in order to understand the effect of particulate matter like dust on the growth and physiological functions of Tithonia, a correlation analysis was carried out.

Results and Discussion

Out of the 4 bags of Tithonia kept at different sites in Tarapur industrial area, 1 bag was considered for dust fall measurement and other 3 bags were considered for above ground phytomass, shoot length and total chlorophyll content respectively. Mature and fully expanded leaves present on 3rd and 4th internode were selected for dust fall estimation.

Dust fall

Foliar dust was collected in two dry seasons i.e. winter of the year 2011 followed by summer of the year 2012 and was expressed in gm/m² (Table 2). Dust fall values of plants kept at experimental sites were compared with control plant sets which were placed away from vehicular and industrial pollution. Almost all sites showed significantly more dust fall as compared to the control set (Table 2).

From the Box and Whisker's plot (Figure 2), it is clear that the overall average dust fall values were highest in the month of December and January whereas dust fall values were lowest in the month of April and October. However, a gradual increase in dust fall value was seen in the month of May. This might due to the presence of trichomes on *T. diversifolia* leaf that

retained dust even in May when a dust storm is a common occurrence in the pre-monsoon period. Site Petrol pump and Site Boisar railway station showed high dust fall values followed by Site Chitralaya market. This might be due to their proximity to industrial and vehicular sources and continuous movement of vehicular traffic. While Site T.A.P.S. residential colony had the lowest dust fall nearing to the control values as it is situated far away from pollution sources (Figure 3).

Above ground phytomass

As compared to control, plants growing at all sites showed a significant difference in their phytomass values (Table 3). Highest phytomass was recorded at T.A.P.S colony in the month of May while the lowest phytomass was recorded at site Petrol pump site in the month of December.

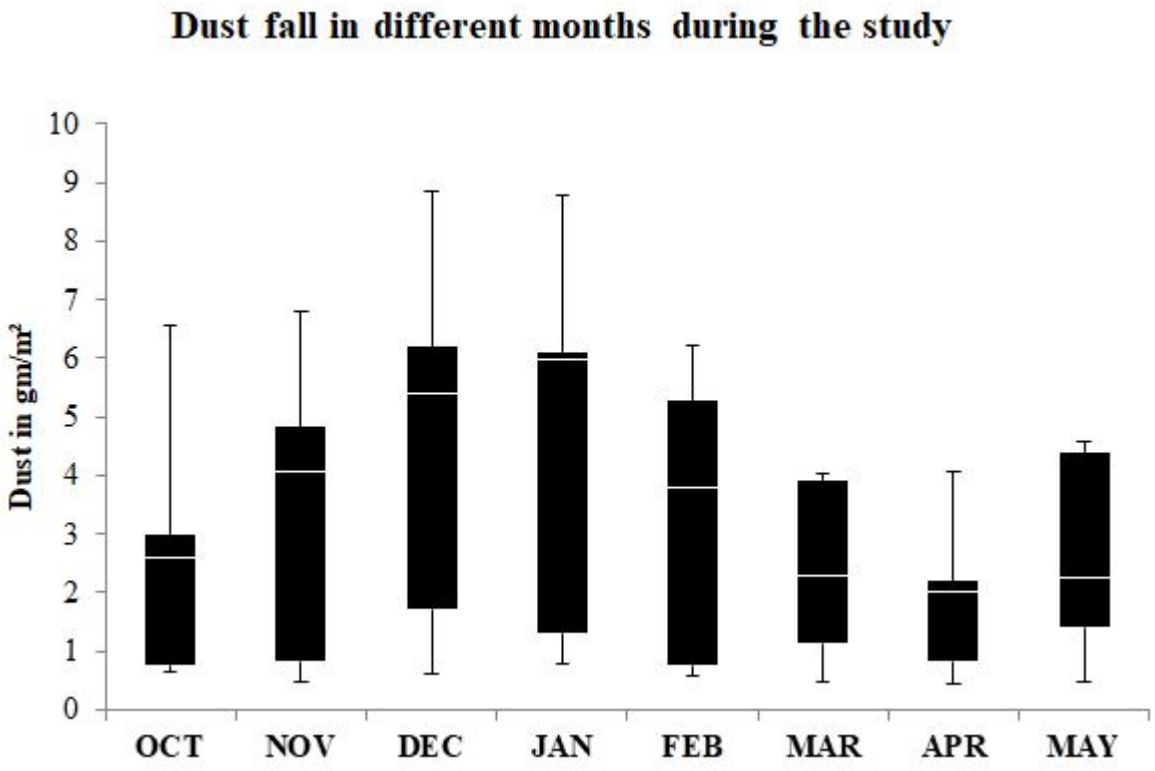

Figure 2. *Box plots of foliar dust fall in different months on Tithonia.*

Table 2. *Dust fall (gm/m²) on Tithonia diversifolia kept at different sites in Tarapur industrial area from October 2011-May 2012. (Mean of 3 readings ± S.E).*

No.	Site Name	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1.	Control	0.64 ± 0.14	0.48 ± 0.01	0.62 ± 0.14	0.77 ± 0.14	0.59 ± 0.13	0.46 ± 0.01	0.43 ± 0.01	0.49 ± 0.11
2.	Boisar railway station	*2.58 ± 0.12	*4.06 ± 0.14	5.39 ± 0.16	*6.13 ± 0.35	6.21 ± 0.14	*4.04 ± 0.29	*2.01 ± 0.21	*4.41 ± 0.34
3.	Chitralay market	*2.99 ± 0.09	*4.86 ± 0.24	6.22 ± 0.17	5.97 ± 0.17	*3.78 ± 0.41	*2.30 ± 0.14	*2.21 ± 0.11	*2.27 ± 0.04
4.	T.A.P.S. residential colony	0.75 ± 0.18	0.83 ± 0.17	*1.71 ± 0.27	1.28 ± 0.21	0.74 ± 0.04	1.11 ± 0.26	0.83 ± 0.01	1.39 ± 0.26
5.	Petrol pump	6.57 ± 0.09	*6.80 ± 1.14	*8.86 ± 0.49	*8.77 ± 0.3	5.31 ± 0.16	*3.93 ± 0.09	*4.08 ± 0.19	4.57 ± 0.1
*= significant at p<0.05									

Shoot length

Maximum shoot length of Tithonia was recorded at Petrol Pump followed by Boisar Railway Station and T.A.P.S Residential Colony. Whereas lowest shoot length was observed in plants kept at Site Boisar Railway Station (Table 4).

Total Chlorophyll

Low total chlorophyll content was seen in plants kept at the sites Petrol pump, Chitralay market and Boisar railway station as compared to the control site (Table 5).

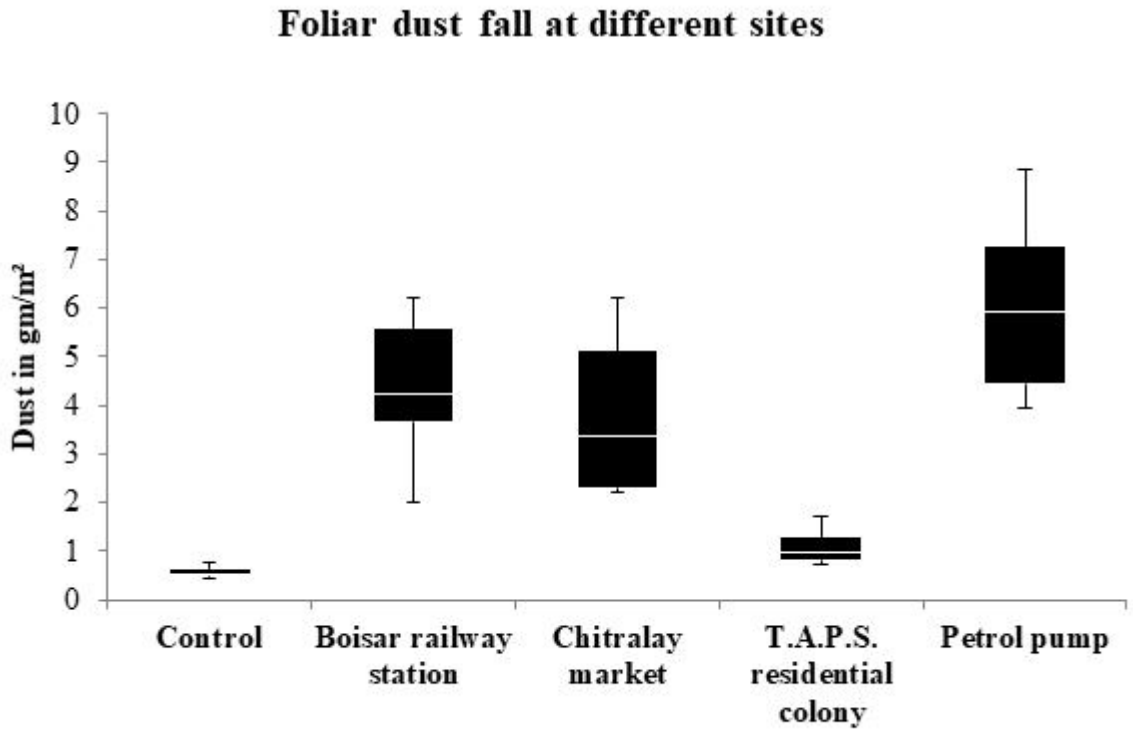

Figure 3. *Box plots of foliar dust fall at different sites during the study period on Tithonia.*

Table 3. *Above ground phytomass (dry weight in gm) of Tithonia diversifolia kept at different sites in Tarapur industrial area from October 2011- May 2012. (Mean of 12 samples ± S.E)*= significant at students t-test P<0.05.*

No	Site Name	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1.	Control	2.29 ± 0.44	1.68 ± 0.33	0.92 ± 0.26	0.88 ± 0.26	1.18 ± 0.21	1.49 ± 0.22	2.94 ± 0.66	3.01 ± 0.5
2.	Boisar railway station	*1.33 ± 0.2	*1.07 ± 0.22	*0.9 ± 0.1	0.84 ± 0.14	*1.12 ± 0.19	*1.38 ± 0.23	*1.37 ± 0.22	*1.54 ± 0.25
3.	Chitralay market	*1.15 ± 0.22	*0.84 ± 0.14	*0.81 ± 0.07	*0.79 ± 0.07	*0.86 ± 0.16	*1.32 ± 0.2	*1.57 ± 0.36	*1.88 ± 0.49
4.	T.A.P.S residential colony	*1.8 ± 0.32	*1.39 ± 0.25	0.79 ± 0.13	*0.8 ± 0.09	1.24 ± 0.33	1.89 ± 0.35	2.76 ± 0.48	2.95 ± 0.49
5.	Petrol pump	*1.22 ± 0.24	*1.13 ± 0.18	*0.30 ± 0.03	*0.49 ± 0.04	*0.98 ± 0.17	*1.27 ± 0.19	*1.36 ± 0.29	3.71 ± 0.7
*=significant at students t-test P<0.05									

Correlation statistics

The correlation study revealed that dust fall was in negative correlation with morphological parameters like above ground phytomass and shoot length along with biochemical parameter like ascorbic acid content, protein content and total chlorophyll content of *Tithonia* considered for investigation (Table 6).

Table 4. *Shoot Length (cms) of Tithonia diversifolia kept at different sites in Tarapur industrial area from October 2011- May 2012. (Mean of 12 samples ± S.E).*

No.	Site Name	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1.	Control	37.58 ± 1.72	21.16 ± 1.75	21.83 ± 1.66	19.04 ± 0.80	28.07 ± 1.82	32.75 ± 2.46	35.92 ± 3.26	36.5 ± 2.61
2.	Boisar railway station	32.5 ± 4.65	19.8 ± 3.07	14.75 ± 1.67	*12.60 ± 1.96	9.52 ± 1.47	26.57 ± 4.07	*26.78 ± 3.95	*28.56 ± 3.91
3.	Chitralay market	*29.40 ± 4.47	23.53 ± 3.36	17.2 ± 1.44	14 ± 1.17	*14.43 ± 1.92	26 ± 3.45	30.11 ± 4.38	33.39 ± 5.00
4.	T.A.P.S residential colony	*29.84 ± 4.53	23.1 ± 3.52	*15.58 ± 2.35	20.75 ± 2.39	16.34 ± 2.36	*26.20 ± 3.92	30.22 ± 4.60	33.76 ± 4.90
5.	Petrol pump	23.42 ± 3.43	*17.13 ± 2.24	16 ± 1.33	15.4 ± 1.28	*19.60 ± 2.79	*17.93 ± 2.36	*25.66 ± 3.83	34.8 ± 5.26

*= significant at P<0.05

Table 5. *Total Chlorophyll Content of Tithonia diversifolia leaves in mg/gm fresh weight from different sites in Tarapur industrial area studied during October 2011- May 2012 (Readings are Means of 3 sample readings ± S.E).*

No.	Site Name	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1.	Control	0.23 ± 0.04	0.19 ± 0.03	0.21 ± 0.04	0.14	0.22 ± 0.02	0.2 ± 0.01	0.25 ± 0.04	0.38 ± 0.06
2.	Boisar railway station	0.15 ± 0.05	0.17 ± 0.04	0.09 ± 0.03	*0.08 ± 0.02	*0.05 ± 0.02	*0.10 ± 0.02	*0.08 ± 0.02	*0.13 ± 0.01
3.	Chitralay market	0.11 ± 0.04	*0.06 ± 0.02	-	-	*0.13 ± 0.04	*0.09 ± 0.03	0.16 ± 0.02	*0.19 ± 0.05
4.	T.A.P.S residential colony	*0.23 ± 0.01	0.27 ± 0.09	0.16 ± 0.05	*0.07 ± 0.02	*0.11 ± 0.03	0.17 ± 0.02	0.13 ± 0.02	*0.18 ± 0.03

* =Significant at P<0.05

– =sample inadequate

Table 6. *Correlation coefficient parameter studied for the year 2011-2012.*

	Dust fall	Above phytomass ground	Shoot length	Total chlorophyl
Dust fall	1	-0.471	-0.568	-0.78

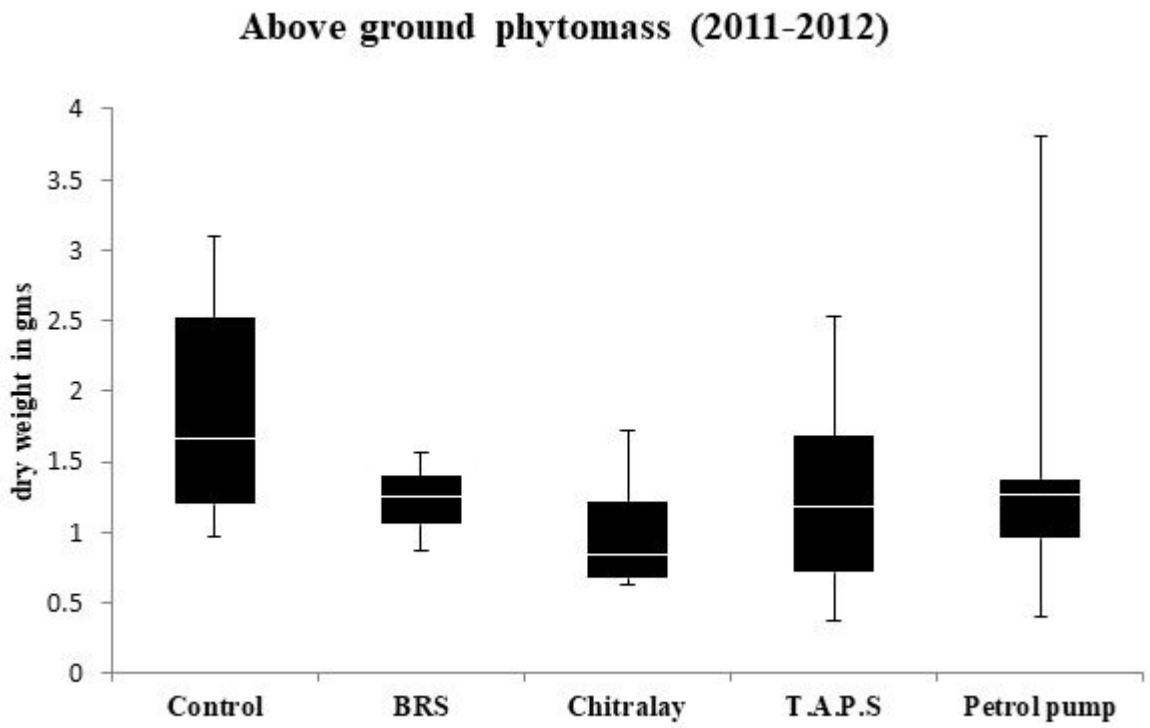

Figure 4. *Box plot for above ground phytomass of Tithonia diversifolia at different sites.*

Conclusion

In urban areas, there is a great variation in air quality due to changing traffic patterns and constant emissions of air pollutants from the factories. Under these conditions, [6] suggested that growth indicated by phytomass of Helianthus annus var. japonica belonging to the same family as Tithonia proved to be a reliable photo monitor of air quality. Shoot phytomass, ascorbic acid and protein content of plants are consistent in responding to the effects of air pollution [8].

A significant decrease in phytomass of Tithonia diversifolia was observed by Joshi NC [9] while studying the air quality in different parts of Mumbai city. This feature was observed in T. diversifolia kept at various sites (Figure 4).

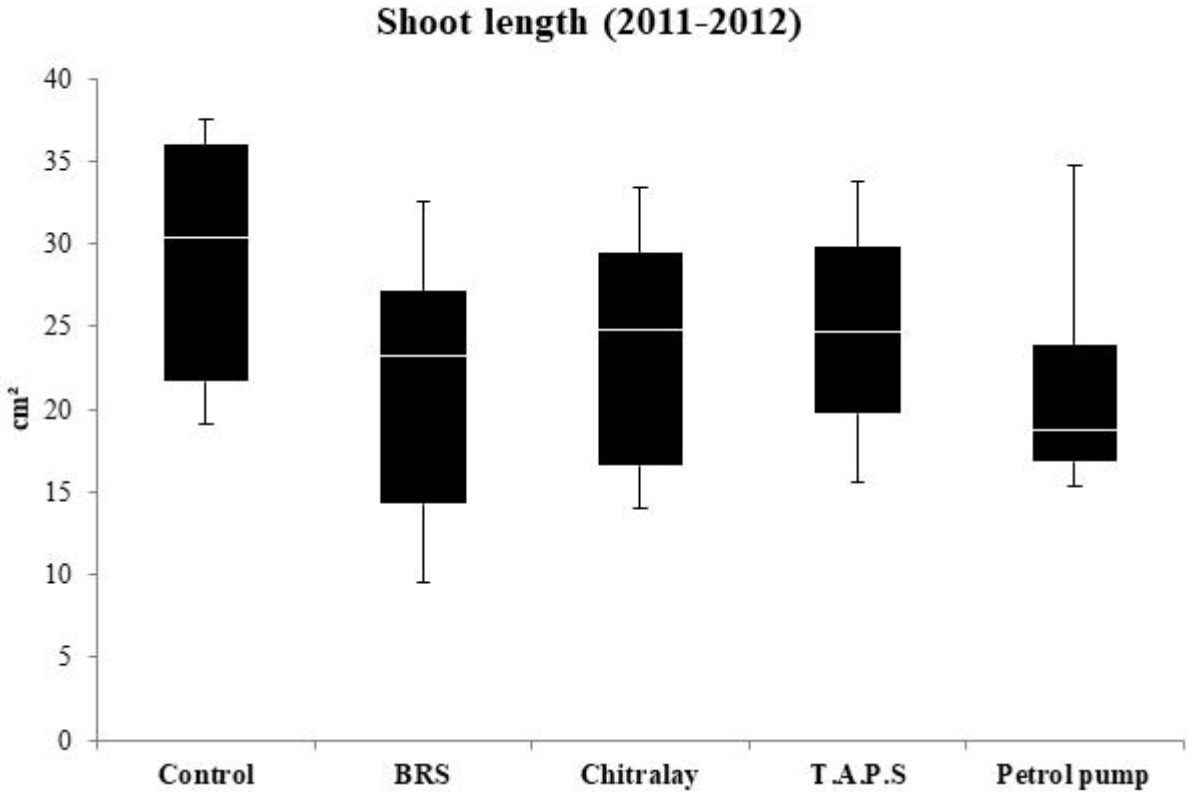

Figure 5. Box plot for shoot length of Tithonia diversifolia at different sites.

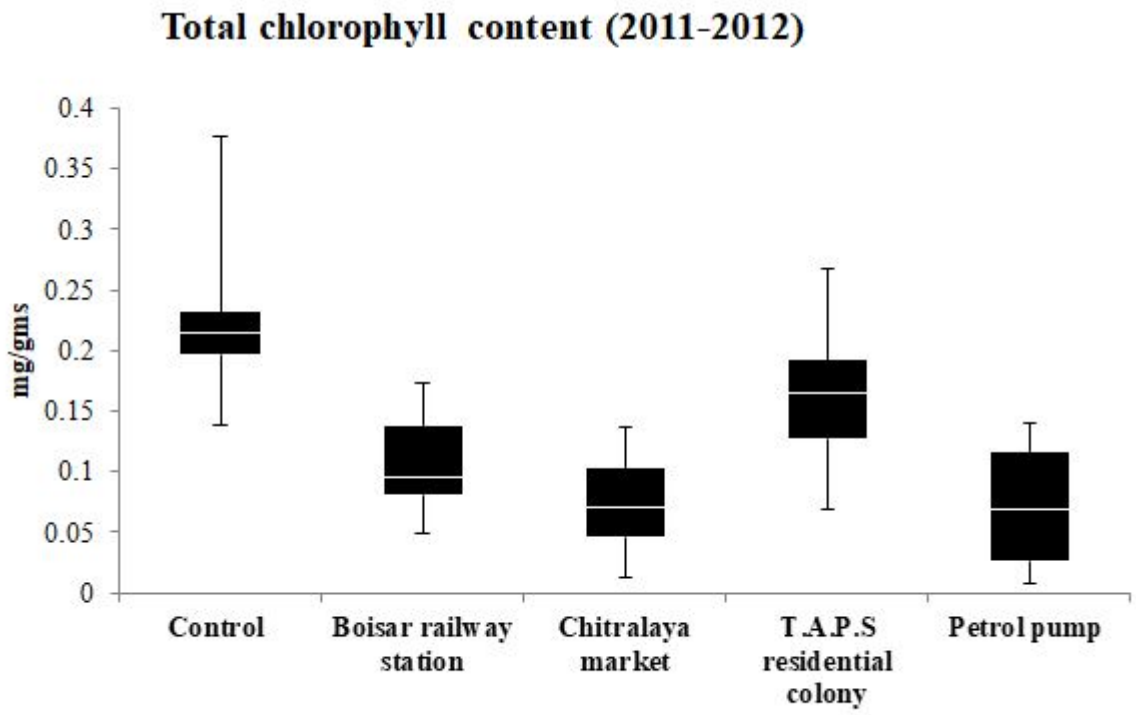

Figure 6. Box plots for total chlorophyll content in Tithonia diversifolia leaf from different sites.

All the morphological and biochemical parameters of Tithonia when taken into account showed consistently significant differences as compared to the values of control plants. Moreover, a significant reduction in the values of above ground phytomass, shoot length and total chlorophyll content was observed.

Dust fall was in weak negative correlation with above ground phytomass. Whereas showed a stronger negative correlation with shoot length and total chlorophyll content. This clearly indicates that the increase in dust fall values might have caused a decrease in shoot length, and total chlorophyll content of Tithonia. A decrease in phytomass values in comparison with the control is an estimation of ambient air quality, that reduction in the values of morphological parameters is a reflection of stress is well documented by several authors [10].

Reduction in plant length of Vitis vinifera L. due to decrease in phytomass, net primary production and chlorophyll content in response to roadside dust was observed by Leghari SK [11]. Prasad MNV, et al. [12] found that dust kiln caused a reduction in chlorophyll content, starch, protein, phytomass, and yield of Groundnuts (Arachis hypogaea L.). Due to dust, a significant reduction in chlorophyll content, photosynthesis, and growth in cotton was also reported by Ambrust DV [13]. This was also observed for Tithonia where an increase in the level of dust caused the reduction in growth i.e. to shoot length and chlorophyll content. Thus it can be stated that shoot length and chlorophyll content are more reliable parameters for air quality indication and in identifying Tithonia diversifolia as important indicator species (Figures 5 and 6).

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