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Comparative assessment of air pollution tolerance index (APTI) in the industrial (Rourkela) and non industrial area (Aizawl) of India: An eco-management approach

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Science for phyto-technologies has got immense application in air pollution science. The present study focuses on the determination of air pollution tolerance indices (APTI) from six common road side plant species growing along industrial (Rourkela) and non industrial area (Aizawl), India. The APTI was determined by synthesizing the four different physiological and biochemical parameters, that is, leaf relative water content (RWC), ascorbic acid content (AA), total leaf chlorophyll (TCh) and pH of leaf extract. The plant species selected for the study were *Ficus bengalensis*, *Mangifera indica*, *Bougainvillea spectabilis, Psidium guajava, Hibiscus rosa-sinensis* and *Lantana camara.* Reduction in total chlorophyll content and pH was found in the leaf samples of all selected plants collected from Industrial site (Rourkela) when compared with samples from non industrial site (Aizawl) whereas APTI, ascorbic acid and RWC were found to be higher in the plant samples of Industrial site (Rourkela) as compared to non industrial site (Aizawl). On the basis of APTI, *F. bengalensis* was found to be tolerant (8.64) in industrial site (Rourkela) and *M. indica* (7.95) in non industrial site (Aizawl). Plant species such as *M. indica* and *B. spectabilis*, showing minimum difference in their APTI values may be considered as tolerant for both (industrial and non industrial) sites.

Key words: Air pollution tolerance indices (APTI), biochemical parameters, *Ficus bengalensis*, roadside plants.

INTRODUCTION

Air pollution has become a major problem arising mainly from industrialization and urbanization during the last few decades. Particulate matter is of great concern in relation to their adverse impact on human health and vegetation (Rai, 2013). The particulates and gaseous pollutants, alone and in combination can cause serious setbacks to the overall physiology of plants (Ashenden and Williams, 1980; Mejstrik, 1980; Anda, 1986; Das and Prasad, 2010). Trees experience the greatest exposure and influenced greatly by pollutant concentration due to their perennial habit (Raina and Sharma, 2003; Chauhan, 2010). Regional impact of air pollution on local plant species is one of the major ecological issues. The climate condition, the physico-chemical properties of air pollutants and their residence time in the atmosphere have impact on surrounding plants (Wagh et al., 2006). The most obvious damage occurs in the leaves which include chlorosis, necrosis and epinasty (Prasad and Choudhury, 1992).

The responses of plants to pollutants may provide a

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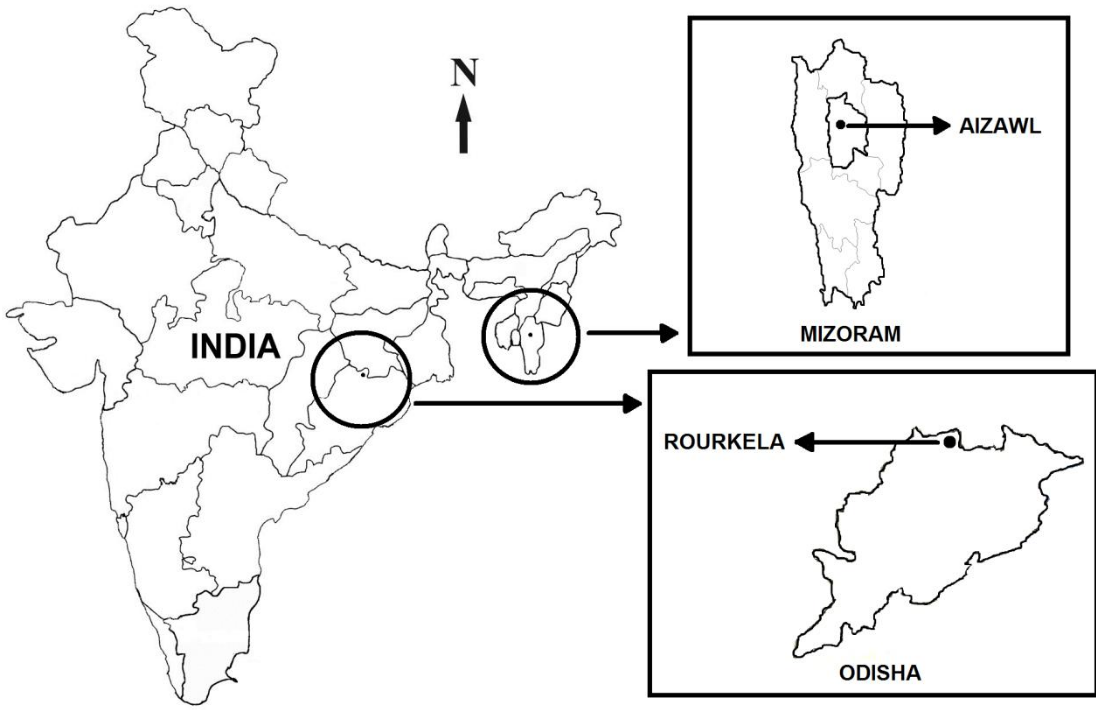

Figure 1. Study area- Aizawl, Mizoram (NE India) and Rourkela, Odhisa, India.

simple method of monitoring air pollutants as well as providing the pollution abatement measures. Plantation 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 (Bamniya et al., 2011).

Air pollution tolerance index (APTI) is an inherent quality of plants to encounter air pollution stress which is presently of prime concern particularly in industrial and non-industrial areas. Therefore, APTI of the plants needs to be monitored and checked for the predominant species that are present in the polluted and non-polluted areas. In the present study, APTI of common growing roadside plants in industrial and non-industrial site have been investigated.

The present study was conducted in Industrial area (Rourkela) and non-industrial area (Aizawl). The study was carried out on six common roadside plant species growing along Industrial (Rourkela) and non- industrial (Aizawl) sites during winter season (Nov 2011 to Feb 2012).

Rourkela, known as the industrial capital of Odisha is located at 84° 53' E longitude and 22° 12' N latitude in Sundargarh district of Odisha at an elevation of about 219 m above the mean sea level (ASL) (Figure 1). The climate of Rourkela is characterized as tropical monsoon climate, with minimum temperature in December and maximum in May. Rourkela city is famous for its steel industries under steel Authority of India Ltd and is known as steel city. A number of other industries are also present such as cement factory, fertilizer, sponge iron industries, thermal power plants making Rourkela as an industrial site for the present study.

Aizawl (21°58'- 21°85' N and 90°30'- 90°60'E), the capital of the state, Mizoram, is 1132 m ASL and comes under an Indo Burma hotspot region (Rai, 2009) (Figure 1). The altitude in Aizawl district varies from 800 to 1200 m. The climate of the area is typically monsoonic. The annual average rainfall is amounting to ca 2350 mm. The area experiences distinct seasons. The ambient air temperature normally ranges from 20 to 30°C in summer and 11 to 21°C in winter (Laltlanchhuanga, 2006). In Aizawl, there is less traffic intensity and no industries present as compared to Rourkela so it is considered as non industrial site.

The present study deals with bio monitoring potential of six common plant species (*Ficus bengalensis*, *Mangifera indica*, *Bougainvillea spectabilis, Psidium guajava, Hibiscus rosa-sinensis* and *Lantana camara*), along the roadside of industrial and non-industrial site, exposed to air pollution.

METHODOLOGY

The plants selected for the study where those common to both sites. The fresh leaf samples (in three replicates of selected plants) were collected in early morning from height of 1 to 2 m from ground level of both sites. Selected plants were on the edge of the road almost with similar topography or condition and leaf samples were immediately brought to the laboratory in polythene bag, kept in ice box for further analysis of various biochemical parameters such as

Table 1. The biochemical characteristics and the APTI for plants from Industrial site (Rourkela) and Non Industrial site (Aizawl).

Plant species	Rourkela					Aizawl				
	pH	Ascorbic acid	RWC	Chlorophyll	APTI	pH	Ascorbic acid	RWC	Chlorophyll	APTI
Ficus bengalensis	6.42±0.016	0.53±0.03	83.01±2.38	0.1±0.01	8.64	7.44±0.30	0.2 ±0.01	61.45±1.18	0.48±0.02	6.3
Psidium guajava	5.56±0.41	0.47±0.02	86.95±1.68	0.92±0.01	9	6.31±0.07	0.28±0.02	57.68±2.47	1.85±0.03	6
Bougainvillea spectabilis	6.84±0.17	0.2±0.02	75.6±3.84	1.45±0.05	7.72	7.1±0.02	0.1±0.01	68.42±12.4	2.99±0.09	6.94
Mangifera indica	5.88±0.03	0.25±0.02	88.09±1.63	1.1±0.01	8.98	7.07±0.16	0.16±0.02	78.03±4.86	2.41±0.01	7.95
Lantana camara	6.96±0.07	0.28±0.01	78.94±4.30	1.05±0.02	8.11	8.2±0.31	0.19±0.02	57.66±3.76	1.88±0.03	5.95
Hibiscus rosa-sinensis	5.39±0.10	0.45±4.71	90.26±0.63	1.98±0.04	9.35	6.86±0.22	0.24±0.01	72.02±5.85	2.94±0.02	7.43

Statistical analyses were performed with SPSS 11.2 software.

leaf extract pH (Singh and Rao, 1983), relative water content (RWC)RWC (Sen and Bhandari, 1978), total chlorophyll (Arnon, 1949), ascorbic acid (Keller and Schwager, 1977). The APTI was determined by calculating these biochemical parameters, proposed by Singh and Rao (1983). The APTI was calculated using the formula:

$$APTI = \frac{A(T+P)+R}{10}$$

Where, A = Ascorbic acid (mgg^{-1}); T = total chlorophyll (mggm^{-1} - f .w);P = pH of the leaf extract; R = Relative water content of leaf (%).

RESULTS AND DISCUSSION

The biochemical characteristics and the APTI for plants from industrial site (Rourkela) and non industrial site (Aizawl) are shown in Table 1. It is observed that all the plant species collected from industrial site (Rourkela) exhibited a pH towards acidic side, ranging from 5.0 to 7.0 whereas for non industrial site (Aizawl) plant species collected showed neutral to slightly alkaline pH range, that is, 6.0 to 9.0. The acidic nature may be due to the presence of SO_x, NO_x or other acidic pollutants from the industrial emission in the ambient air causing a change in pH of the leaf sap towards acidic (Swami et al., 2004). Low leaf pH extract showed good correlation with sensitivity to air pollution and also reduce photosynthetic process in plants (Yan-Ju and Hui, 2008; Thakar and Mishra, 2010). A pH on higher site improves tolerance against air pollution (Agarwal, 1986; Shannigrahi et al., 2011).

RWC of all the plant species collected from industrial site (Rourkela) were higher as compared to non-industrial site (Aizawl). Highest RWC in industrial site (Rourkela) was seen in *Hibiscus rosasinensis* and lowest in *B. spectabilis* (Table 1). In non-industrial site (Aizawl), the RWC of leaves of the plant species varied from maximum of 78.03% in *Mangifera indica* to a minimum of 57.66% in *Lantana camara.* High water content within a plant body will help to maintain its physiological balance under stress condition such as exposure to air pollution when the transpiration rates are usually high which may lead to desiccation. Therefore, maintenance of RWC by the plant may decide the relative tolerance of plants towards air pollution (Verma, 2003). The higher the RWC in a particular species, the greater is its drought tolerance capacity (Dedio, 1975). Thus, the higher RWC in industrial site sample may be responsible for normal functioning of biological processes in plants (Meerabai et al., 2012).

Ascorbic acid is regarded as an antioxidant found in large amount in all growing plant parts and influence resistance to adverse environmental condition including air pollution (Keller and Schwager, 1977; Lima et al., 2000). The mean concentration of ascorbic acid in leaves of industrial and non-industrial sites is summarised in Table 1. The ascorbic acid content increased in the leaves of plants at industrial site (Rourkela) than those of the non-industrial site (Aizawl). Table 1 shows that in industrial site (Rourkela), the concentration of ascorbic acid ranged from 0.20 to 0.53 mgg^{-1} with *B. spectabilis* and *F. bengalensis* recording the lowest and highest value, respectively, where as in non-industrial site (Aizawl) ascorbic acid concentration was found to be lower with *B. spectabilis* (0.10 mggm^{-1}) while *P. guajava* recording highest (0.28 mggm^{-1}). Ascorbic acid, a stress reducing factor is generally higher in tolerant plant species. Tripathi and Gautam (2007) reported pollution load dependent increase in ascorbic acid content of all the plant species might be due to the increased rate of production of reactive oxygen species (ROS) during photo-oxidation process. In the present study, concentration of ascorbic acid is high in industrial sample supporting the studies of Meerabai et al. (2012) and Agbaire and Esief (2009).

Chlorophyll content of plant signifies its photosynthetic activity as well as the growth and development of biomass. Chlorophyll content of plant varies from species to species depending upon the age of leaf, pollution level as well as other biotic and abiotic condition (Katiyar and Dubey, 2001). The chlorophyll content was found to be low in the leaf samples collected from industrial site (Rourkela) as compared to the non-industrial site (Aizawl) for all the investigated plant species. The present study revealed that chlorophyll content in all the plants varied with the pollution status of the area. The higher the levels of pollutants, the lower the chlorophyll content as certain pollutants in totality reduce the total chlorophyll content (Allen et al., 1987). Rao and Leblanc (1966) have also reported reduction in chlorophyll content brought by acidic pollutants like SO_2 which causes phaeophytin formation by acidification of chlorophyll. Reduction in chlorophyll content in variety of crop plant due to NO_2, SO_2 and O_3 exposure have also been reported by Agrawal et al. (2003).

The APTI values calculated for each plant species at two sites are presented in Table 1. Table 1 clearly showed an increase in the APTI value of industrial site as compared to the non industrial site. The APTI of plant species from non industrial site ranged from 5.95 to 7.95 and the maximum was observed in case of *M. indica*. The APTI value showed an increase in case of plants from industrial site (Rourkela) ranging from 7.72 to 9.35 with maximum in *Hibiscus rosa-sinensis*. The APTI value estimated using the four biochemical parameters in plant leaves namely RWC, total chlorophyll content, pH and ascorbic acid value can be used as a predictor of air quality. Plants having higher index value are tolerant to air pollution while plants with lower index value show less tolerance (Singh and Rao, 1983). All the plants found in industrial site are indicative of higher pollution exposure as compared to non-industrial site. A plant species known to be sensitive or tolerant in one geographical area may behave differently in another area (Raza et al., 1985).

Dust pollution and chronic concentration of gaseous pollutants may affect the biochemical make up and tolerance capacity of plants to the air pollution. Industrial site (Rourkela) is in the grip of more serious air pollution problem due to heavy vehicular and industrial emission as compared to non industrial site (Aizawl) where there are no industries. It can be concluded that the entire result obtained from this study indicates that different plant respond differently to air pollution hence different indices obtained for both sites suggested that, plants growing in industrial site have higher APTI than those in non-industrial site. *F. bengalensis* (8.64) was found to be tolerant in industrial site (Rourkela) and *M. indica* (7.95) in non-industrial site (Aizawl), whereas, *M. indica* and *B. spectabilis* showed least decrease in their APTI value. They can be considered more tolerant species for both the sites.

Conclusion

Biomonitoring of air pollution and its impact on biochemical parameters is extremely relevant in air pollution science. The study clearly reflects that the tolerance of plants towards air pollution may be site-specific. An overview of the entire result obtained from this study reveals that industrial site (Rourkela) have higher APTI values as compared to non industrial site (Aizawl). Further, *M. indica* and *B. spectibilis* may be suitable for plantation at both the sites.

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