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ASSESSMENT OF AIR POLLUTION TOLERANCE LEVELS OF SELECTED PLANTS AT TAMAKA INDUSTRIAL SITE OF KOLAR, KARNATAKA, INDIA

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ABSTRACT

Greenbelts realized as an eco-sustainable, eco-friendly, and cost-effective technology for long term solution to mitigate the air pollution at industrial sites as well as polluted urban areas. The present study was carried out to evaluate air pollution tolerance of 20 selected plant species located at Tamaka industrial site in Kolar district of Karnataka, India. Air pollution tolerance level of plants was determined based on air pollution tolerance index (APTI) using biochemical parameters such as ascorbic acid (A), total chlorophyll (T), relative water content (R), and leaf extract pH (P). APTI values >7, 6-4 and <3 were categorized as tolerant, moderately tolerant and sensitive, respectively. APTI value was determined for all the species for three seasons, winter, summer and rainy. Among the 20 species, 15 species were recorded under tolerant category, and five species under moderately tolerant category, and no species was recorded under sensitive category. One way ANOVA revealed that the APTI value of the selected species varied significantly among the three seasons ($F_{(2,57)}$ = 4.720, p<0.05). Present study provides first hand information on APTI of plants at Tamaka industrial site which can be useful for greenbelts development at the industrial sites of Kolar district of Karnataka, India.

KEY WORDS: Greenbelts, APTI, Tamaka, Industrial site, Air pollution, India

Anthropogenic activities have mostly negative impacts on environment. Fast growth of population, urbanization and industrialization are the major cause of air pollution (Vailshery et al., 2013). New Delhi, the capital city of India, has historically experienced severe pollution episodes from 2015, and many of Indian cities air quality index values are at warning signs of air pollution threat as per Central Pollution Control Board (CPCB) of India. Automobiles, generators and industries are the source of greenhouse gases and particulate matters (Adrees et al., 2016). Lack of emission control devices in various industries release air pollutants directly to atmosphere. Air Pollutants not only disturb atmospheric composition, but, also human beings, plants and animals in surroundings (Jahan et al., 2016). Plants leaf surface act as sink of air pollutants. The plant leaves provide large space for dust absorption that lead to absorsion of air pollutants (Escobedo et al., 2008), and thereby reduce atmospheric pollution. However, due to long period of pollution, plants are severely affected in the urban and industrial sites (Panda and Rai, 2015). Air pollutants damage the functional ecology of plants in terms of processes such as photosynthesis, respiration and transpiration processes. It is reported that there exists direct effects of industrial pollution on significant changes in plant biochemistry (Panda and Rai 2015). The effects of air pollutants are high in sensitive plants and low in tolerant ones (Govindaraju et al., 2012).

Only a few studies carried out on air pollution tolerance levels of plants worldwide, and it is scantly particularly for industrial areas. Keeping this in view, the present study was aimed to evaluate air pollution tolerance index (APTI) of 20 selected plant species located at Tamaka industrial site of Kolar district of Karnataka, India, and to identify the most tolerant and sensitive species.

MATERIALS AND METHODS

The present study was carried out in Tamaka industrial site (TIS), located in Kolar district of Karnataka state of India (Figure 1). Kolar district lies between the latitude 12° 45′ 54″ to 13°35′ 47″ N and longitude 77° 50′ 29″ to 78° 35′ 18″ E and covers an area of about 4,012 km^2. Climate data available for the past eight years (2009-2016) for Kolar, revealed that the mean monthly maximum and minimum temperature is 31° C and 20° C, respectively (Figure 2). Mean annual rainfall and rainy days is 1212 mm and 201 days, respectively.

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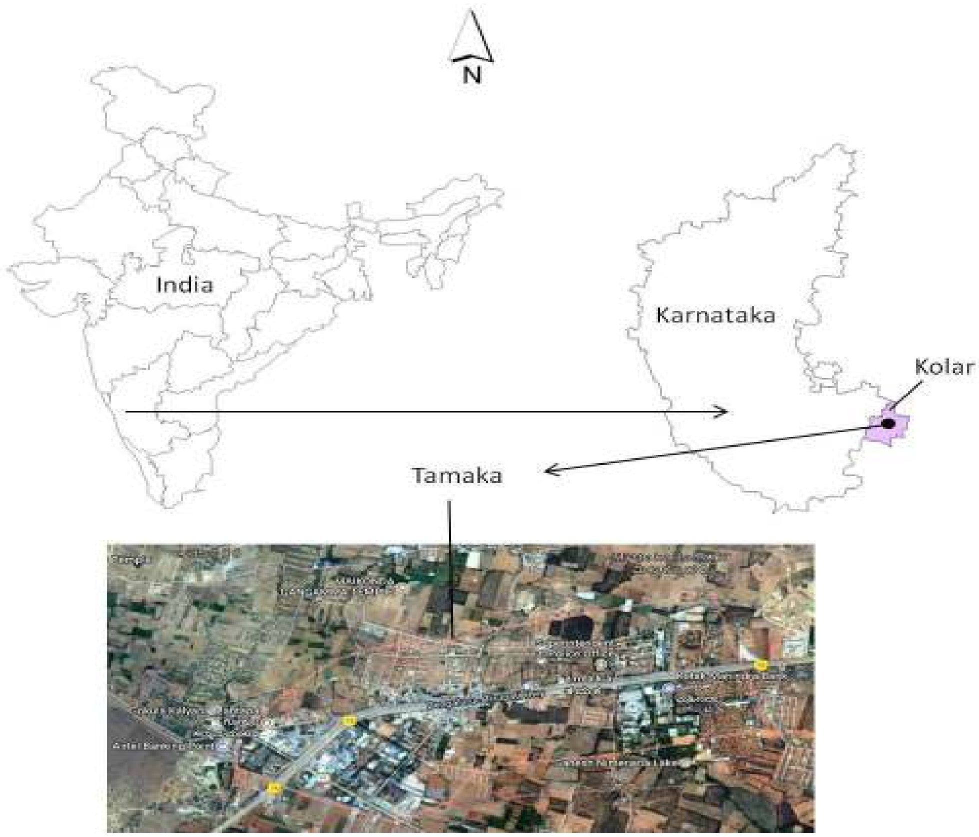

Figure 1. Location of Tamaka industrial site in Kolar district of Karnataka State, India

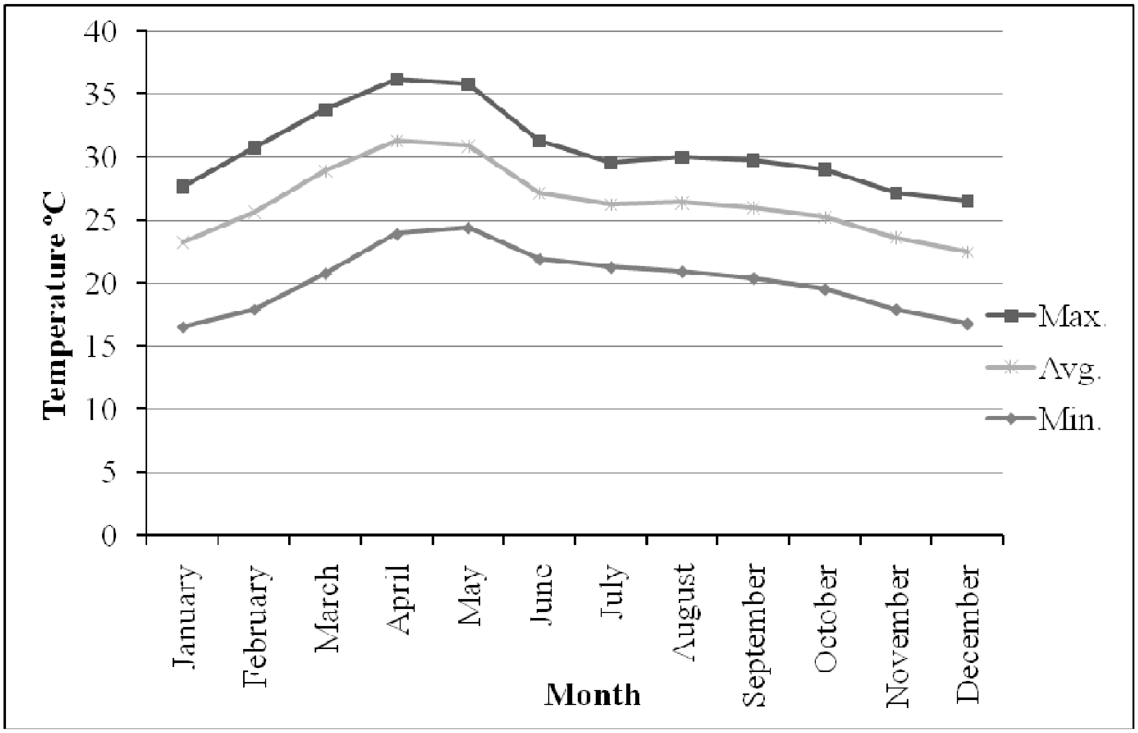

Figure 2. Mean monthly temperature for the study area during 2009 - 2016

Twenty tree species located at TIS were selected for the present study (Table 1). Plant sampling was carried out during early morning 6.00 am to 9.00 am for three seasons, winter, summer and rainy during 2015. Matured fresh leaves were collected in polythene bags and transferred immediately to laboratory, for determination of APTI following Singh and Rao (1983), based on biochemical parameters such as ascorbic acid, total chlorophyll, pH and relative water content. The APTI was computed as APTI = $[A\ (T+P)\ +R]/10$, where A is ascorbic acid, T is total chlorophyll, P is pH and R is relative water content. Three replicates were used for each plant species.

Air pollution tolerance and sensitivity of selected species were determined based on the APTI value. APTI values were categorized into three levels, 1) tolerant (if the APTI value is >7), 2) moderately tolerant (if the APTI value is between 6 to 4), and 3) sensitive (if the APTI value is <3).

One way ANOVA was carried out to check significance of APTI values among the different seasons. Correlation analysis was done to check relationships between APTI values with the biochemical parameters.

RESULTS AND DISCUSSION

APTI can alone be considered as a criterion for selection of air pollution tolerant plant species for development of greenbelts (Singh et al. 1991). The results of present study revealed that the APTI values of the 20 species ranged from 4.98 to 8.93 (Table 1). The maximum value was recorded for *Terminalia catappa* (8.93±1.48), followed by *Polyalthia longifolia* (8.65±1.00), *Anthocephalus cadamba* (8.35±1.63), *Grevillea robusta* (8.30±0.52) and *Peltophorum pterocarpum* (8.29±1.38), while the lowest APTI (4.98±1.22) was recorded for *Pongamia pinnata* (Table 1). Pandey et al., (2015) investigated APTI values of 29 plant species of Varanasi city, and recorded maximum value for *Ficus benghalensis* (26.01), followed by *Cassia fistula* (24.52), *Ficus religiosa* (23.35), *Polyalthia longifolia* (22.88), *Drypetes roxburghii* (22.88) and *Zizyphus jujuba* (22.11), and the lowest was reported for *Madhuca indica* (11.01).

Table 1. APTI values and air pollution tolerance level for the 20 study species at Tamaka industrial site.

		APTI value	

Sl. no.	Name of the plant species	Winter	Summer	Rainy	Average	Tolerance level
1	*Anthocephalus cadamba* Miq.	9.09	6.48	9.47	8.35±1.63	Tolerant
2	*Azadirachta indica* A.Juss.	5.14	7.91	8.50	7.19±1.80	Tolerant
3	*Bauhinia variegata* L.	7.48	7.66	7.89	7.68±0.21	Tolerant
4	*Dalbergia melanoxylon* Guill. & Perr.	5.76	7.26	7.49	6.84±0.94	Moderately Tolerant
5	*Ficus benghalensis* L.	8.66	6.88	8.85	8.13±1.09	Tolerant
6	*Grevillea robusta* A.Cunn.	7.72	8.48	8.71	8.30±0.52	Tolerant
7	*Markhamia platycalyx* Sprague	6.78	6.18	6.66	6.54±0.32	Moderately Tolerant
8	*Millingtonia hortensis* L.f.	7.51	7.52	7.75	7.59±0.14	Tolerant
9	*Morus nigra* L.	8.83	7.22	8.31	8.12±0.82	Tolerant
10	*Muntingia calabura* L.	5.30	8.92	9.00	7.74±2.12	Tolerant
11	*Peltophorum pterocarpum* Backer ex K.Heyne	6.70	8.96	9.19	8.29±1.38	Tolerant
12	*Polyalthia longifolia* (Sonn.) Hook.f. & Thomson	7.91	9.79	8.25	8.65±1.00	Tolerant
13	*Pongamia pinnata* (L.) Merr.	4.30	4.25	6.39	4.98±1.22	Moderately Tolerant
14	*Samanea saman* (Jacq.) Merr.	3.37	6.78	6.90	5.68±2.01	Moderately Tolerant
15	*Spathodea campanulata* Buch.-Ham. ex DC.	7.35	7.69	8.88	7.97±0.80	Tolerant
16	*Swietenia macrophylla* King	7.11	7.30	7.53	7.31±0.21	Tolerant
17	*Syzygium jambos* (L.) Alston	7.95	7.87	8.26	8.03±0.21	Tolerant
18	*Tabebuia avellanedae* Lorentz ex Griseb.	6.22	6.61	6.82	6.55±0.31	Moderately Tolerant
19	*Terminalia catappa* L.	7.23	9.68	9.89	8.93±1.48	Tolerant
20	*Thespesia populnea* Sol. ex Corrêa	7.82	6.84	7.97	7.54±0.62	Tolerant

Of the three seasons studied, the APTI value was recorded maximum during winter for *Markhamia platycalyx* (6.78) and *Morus nigra* (8.83), during summer for *Polyalthia longifolia* (9.79), and during rainy for *Anthocephalus cadamba* (9.47), *Azadirachta indica* (8.50), *Bauhinia variegate* (7.89), *Dalbergia melanoxylon* (7.49), *Ficus benghalensis* (8.85), *Grevillea robusta* (8.71), *Millingtonia hortensis* (7.75), *Muntingia calabura* (9.00) *Peltophorum pterocarpum* (9.19), *Pongamia pinnata* (6.39), *Samanea saman* (6.90), *Spathodea campanulata* (8.88), *Swietenia macrophylla* (7.53), *Syzygium jambos* (8.26), *Tabebuia avellanedae* (6.82), *Terminalia catappa* (9.89) and *Thespesia populnea* (7.97) (Table 1). Das and Prasad (2010) recorded the seasonal variation of APTI of 14 trees and 6 shrubs of industrial area of Rourkela and reported *Swietenia mahagony* (30.92) and *Acacia mangium* (30.04) as the most tolerant species for air pollution. In the present study, one way ANOVA revealed that the APTI values of the 20 species varied significantly across the three seasons ($F_{(2,57)} = 4.720$, $p < 0.05$). While, Das and Prasad (2010) found no significant variation in APTI values of plant species among different seasons.

Correlation analysis revealed that a strong positive relation (98.6%) was observed between APTI values with relative water content, and no significant correlation was observed between APTI value with other biochemical parameters, ascorbic acid, pH and total chlorophyll. Similarly, Bi et al. (2015), reported a high positive correlation (81%) between APTI and relative water content. Singh et al. (1991) stated that relative water content of leaf is associated with protoplasmic permeability, and plants with higher relative water content values are of more tolerant to air pollutants. Pandey et al. (2015) stated that high relative water content of plant leaf helps to sustain its physiological balance under stress conditions such as exposure to air pollution, and it also serves as an indicator of drought resistance in plants.

In the present study, all the tree species came under air pollution tolerant category, except *Pongamia pinnata, Samanea saman*, *Dalbergia melanoxylon*, *Markhamia platycalyx* and *Tabebuia avellanedae* that came under moderately tolerant category, and no species was found under sensitive category. Similarly, Ogunkunle et al. (2015), classified plants in to three categories, viz., tolerant, moderately tolerant and sensitive category. Pandey et al. (2015) found *Ficus benghalensis* as the most tolerant and *Madhuca indica* as the most sensitive species for air pollution in the Varanasi city.

Noor et al. (2014) stated that tolerance of plant towards air pollutants is specific to a site and depends on the type and level of pollution, and hence, there exists variation in tolerance levels for species for different locations.

CONCLUSION

Greenbelts are the mass plantations of pollutant-tolerant trees for mitigation of air pollution by filtering and absorbing pollutants in sustainable manner and this is considered as an eco-friendly technology to sustain the urban as well as industrial ecosystem restoration (Govindaraju et al., 2012). It is considered as one of the potential and possible long term low cost ecotechnological solution for improving the air quality. The present study assessed the air pollution tolerance levels of 20 plant species located in Tamaka industrial site. Of those, 15 species were found to be tolerant, five were moderatly tolerant species, and no species was of sensitive according to their APTI values. APTI valules of plants can be used as bioindicators of air pollution, and they play a vital role in development of greenbelts for industrial sites. The present study provides useful information on APTI values of plants at Tamaka industrial site which can be used for greenbelts development at the industrial sites of Kolar district of Karnataka, India.

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