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Evaluation of Some Tree Species to Absorb Air Pollutants in Three Industrial Locations of South Bengaluru, India

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Abstract: With the fast growing and excessive increase in industrial projects in Bengaluru, the level of pollution is also increasing. Metal-accumulating woody species have been considered for phytoextraction of metal-contaminated sites. The study examined the air pollution tolerance indices (APTI) of plant species around three industrial areas of south Bengaluru. The physiological and biochemical parameters, which are relative to leaf's water content (RWC), ascorbic acid content (AA), total leaf chlorophyll (TCh) and leaf extract pH were used to compute the APTI values and three heavy metals were selected (cadmium, lead and zinc) for analysis. The result shows that the most tolerant tree species with respect to ATPI and heavy metal concentration were *Ficus religiosa*, *Azadirachta indica* and *Pongamia pinnata* (L.*)*. These plants can be considered as tolerant species in the industrial areas. The APTI values for remaining species are reported lower and are considered as sensitive species. Further studies on air pollution tolerance index with respect to three industrial areas of south Bengaluru indicated that the air pollution was maximum in Jigani industrial area and minimum in Electronic city.

Keywords: Tree species, Pollution, Industrial area, Bengaluru.

Introduction

Air pollution can be defined as the human introduction into the atmosphere of chemicals, particulate matter or biological materials that cause harm or discomfort to humans, or other living organism or damage the environment. Air pollution is a major problem arising mainly from industrialization. Air pollutions can directly affect plants via leaves or indirectly via soil acidification. It has also been reported that when exposed to air pollutants, most plant experience physiological changes before exhibiting visible damage to leaves. Even in the kingdom of plants, there is no escaping Darwin's survival of the fittest. Some plants thrive in environments that others would find toxic, these plants can clean-up various sources of man-made pollution; both organic (petrochemical) and inorganic (heavy metal toxins). Trees remove a significant amount of pollution from the atmosphere as part of their normal functioning. They directly increase the quality of the air in the city and its surrounding area and should be considered an integral part of any comprehensive plan aimed at improving overall air quality. The Indian tree flora comprises of nearly 2000 species belonging to about 800 genera and 150 families of flowering plants. This vast diversity ranks 10^{th} in the world and even higher relative to the area[1]. This includes majority of the cultivated and exotic species. Trees provide a large leaf surface onto which particles are deposited and gases are removed. Pollution is removed by nearly all parts of a tree; the soil, roots and vegetative portions of the tree species. Trees respirate and exchange gases through stomates, or holes, on their leaves; these gases include those necessary for the tree’s functioning as well as other gaseous air pollutants. Once inside the leaf, gases diffuse into the spaces between the cells of the leaf to be absorbed by water films or chemically altered by plant tissues. Trees also reduce air pollution by intercepting airborne particles and retaining them on the leaf surface, called dry deposition. Some can be absorbed by the leaf surface itself, although most remain on the plant surface[7]. Leaf surfaces are most efficient at removing pollutants that are water soluble including sulfur dioxide, nitrogen dioxide and ozone. Pollutants travel through plants by translocation via the xylem and phloem. Chemical pollutants absorbed by the leaves are translocated to the root areas where they can be broken down by microbes in the soil and pollutants absorbed by the roots can be broken down and translocated to the leaves where they are released into the atmosphere.

Experimental

The sampling sites in the present study were three industrial areas (electronic city, bommasandra industrial area and jigini industrial area) of south bengaluru. The traffic density of the locations is moderate to high with peak periods found during morning and evening hours. The durations chosen for sampling the tree species was in summer during 15^{th} March to15^{th} May 2008. Three replicates of fully matured leaves samples from all trees growing in the industrial conditions were selected from the immediate vicinity of the stations for the purpose of determining ATPI index in the leaves. The plant samples[2] were put through a three step washing sequence, air dried, weighed and placed in a dehydrator at approximately 80 °C.

To determine relative leaf water content (RWC) the fresh leaves were weighed and then immersed in water over night, blotted dry and then weighed to get the turgid weight. The leaves were dried overnight in an oven at 55°C and reweighed to obtain the dry weight 5 g of the fresh leaves was homogenized in 10 mL deionised water. This was filtered and the pH of the leaf extract determined after calibrating pH meter using buffer solution.

Ascorbic acid content (AA) (mg/g) was measured using spectrophotemetric method. 1 g of the fresh foliage was put in a test-tube, 4 mL oxalic acid - EDTA extracting solution was added, then 1 mL of orthophosphoric acid and then 1 mL 5% tetraoxosulphate(VI) acid added to this mixture, 2 mL of ammonium molybdate was added and then 3 mL of water. The solution was then allowed to stand for 15 minutes. After which the absorbance at 760 nm was measured with a spectrophotometer. The concentration of ascorbic acid in the sample was then extrapolated from a standard ascorbic acid curve.

To determine total chlorophyll content (TCh) in the leaves, 3 g of fresh leaves were blended and then extracted with 10 mL of 80% acetone and left for 15 minutes for thorough extraction. The liquid portion was decanted into another test-tube and centrifuged at 2,500 rpm for 3 minutes. The supernatant liquid was then collected and the absorbance taken using a spectrophotometer at 645 nm and 665 nm. Calculations were done according to the formula given below.

$$\text{Relative leaf water content} = \frac{\text{Fresh weight - Dry weight}}{\text{Turgid weight – Dry weight}} \times 100$$

$$\text{Air pollution tolerance index} = \frac{\text{AA (TCh + pH) + RWC}}{10}$$

$$\text{Chlorophyll 'a'} = \frac{12.7\text{ Dy} \times 663 - 2.69\text{ Dy} \times 645 \times \text{V}}{1000\text{ W}}\ \text{mg/g}$$

$$\text{Chlorophyll 'b'} = \frac{22.9\text{ Dy} \times 645 - 4.68\text{ Dy} \times 663 \times \text{V}}{1000\text{ W}}\ \text{mg/g}$$

Where AA - Ascorbic acid content (mg/g), TCh = Total chlorophyll mg/g, pH = pH of leaf extract and RWC = Relative water content of leaf, % TCh = Chlorophyll a + b mg/g, Dy = Absorbance of the extract at the wavelength y nm. V = Total volume of the chlorophyll solution (mL) and W = Weight of the tissue extracted (g)[3].

Results and Discussion

Air pollution tolerant index is an index denotes capability of a plant to combat against air pollution. Plants which have higher index value are tolerant to air pollution and can be caused as sink to mitigate pollution, while plants with low index value show less tolerance and can be used to indicate levels of air pollution (Table 2). This study was carried out to assess the impact of industries on the available tree species grown at three different industrial areas (Table 1). In this study, changes in parameters such as ascorbic acid, total chlorophyll, relative water content, pH of leaf extract were used in evaluating the degree of tolerance to air pollution by the plant species. The results are as shown on Table 3-5.

Table 1. Showing the tree species growing in three different stations

S. No.	Tree Species		
	Botonical names	Family	Common Names
1	*Syzygium cumini*	Myrtaceae	Jamun
2	*Michelia champaca*	Magnoliacea	Champa
3	*Acacia melanoxylon*	Fabaceae	Blackwood,
4	*Euculeptus* sp.	graminaea	Euculeptus
5	*Ficus Benghalensis*	Moraceae	Banyan Tree
6	*Delonix regia* Raf.	Fabaceae	flamboyant tree
7	*Morinda pubescens*	Rubiaceae	Indian Mulberry
8	*Millingtonia hortensis*	Bignoniaceae	Jasmine Tree
9	*Leucaena leucocephala*	Fabaceae	Wild Tamarind,
10	*Saraca Indica*	Leguminosae	Ashoka
11	*Caesalpinia pulcherrima*	Fabaceae	Dwarf poinciana
12	*Dalbergia lanceolaria* L.f.	Laguminosae	Dhobin,Satpuria
13	*Ficus religiosa*	Moraceae	Peepal
14	*Azadirachta indica*	Meliaceae	Neem
15	*Pongamia pinnata* (L.)	Fabaceae Dicotyledon	Pongamia
16	*Madhuca latifolia* (Roxb)	Sapotaceae	Mahua
17	*Diploknema butyrace*	Sapotaceaea	Indian butter tree

Table 2. Air pollution index values and plant response to pollution

APTI value	Response[6]
30 to100	Tolerant
29 to17	Intermediate
16 to 1	Sensitive
<1	Very sensitive

Table 3. Air pollution tolerance index (APTI) for tree species from Electronic city of south Bengaluru

S. No.	Tree Species	Total chlorophyll mg/mL	Ascorbic acid, mg/g	pH	Relative water content, %	Air pollution tolerance index, (APTI)
1	*Syzygium cumini*	3.47	0.24	4.7	80.02	16.172
2	*Michelia champaca*	3.41	0.34	4.9	78.56	16.166
3	*Acacia melanoxylon*	3.98	0.15	6.5	77.54	18.234
4	*Euculeptus* sp.	3.43	0.09	6.7	72.53	17.383
5	*Ficus benghalensis*	5.64	0.65	6.4	78.5	19.89
6	*Delonix regia* Raf.	1.56	0.73	5.7	67.35	13.995
7	*Morinda pubescens*	1.54	0.78	5.8	54.65	12.805
8	*Millingtonia hortensis*	1.23	0.99	5.8	60.34	13.064
9	*Leucaena leucocephala*	3.21	0.96	5.7	54.74	14.384
10	*Saraca indica*	2.32	0.54	4.9	51.33	12.353
11	*Caesalpinia pulcherrima*	4.56	0.36	5.1	52.53	14.913
12	*Dalbergia lanceolaria* L.f.	7.44	0.87	6.2	81.6	21.8
13	*Ficus religiosa*	4.56	0.51	5.3	67.45	16.605
14	*Azadirachta indica*	6.03	0.93	5.4	82.5	19.68
15	*Pongamia pinnata* (L.)	7.45	0.64	5.5	85	21.45
16	*Madhuca latifolia* Roxb	4.09	0.57	5.6	65.95	16.285
17	*Diploknema butyrace*	6.48	0.78	5.9	64.35	18.815

Table 4. Air pollution tolerance index (APTI) for tree species Jigini industrial area of south Bengaluru

S. No.	Tree Species	Total chlorophyll mg/mL	Ascorbic acid, mg/g	pH	Relative water content, %	Air pollution tolerance index (APTI)
1	*Syzygium cumini*	4.4	0.44	5.6	86.36	38
2	*Michelia champaca*	4.5	0.56	4.9	61.93	32.6
3	*Acacia melanoxylon*	5.6	0.53	6.5	44.44	28.5
4	*Euculeptus* sp.	4.2	0.4	6.7	55.50	24.2
5	*Ficus benghalensis*	5.64	0.65	6.4	21.47	16.8
6	*Delonix regia* Raf.	5.3	0.73	5.7	18.06	14.5
7	*Morinda pubescens*	3.4	0.78	5.8	41.11	29.5
8	*Millingtonia hortensis*	2.9	0.99	5.8	18.11	15.6
9	*Leucaena leucocephala*	4.5	0.96	5.7	19.30	18.9
10	*Saraca indica*	3.3	0.54	4.9	33.20	14.7
11	*Caesalpinia pulcherrima*	6.2	0.36	5.1	40.31	16.4
12	*Dalbergia lanceolaria* L.f.	7.3	0.87	6.2	27.67	32.5
13	*Ficus religiosa*	4.4	0.51	5.3	37.40	18.5
14	*Azadirachta indica*	6.03	0.93	5.4	33.49	35.6
15	*Pongamia pinnata* (L.)	7.46	0.64	5.5	39.09	32.4
16	*Madhuca latifolia* Roxb	4.09	0.57	5.6	62.64	34.6
17	*Diploknema butyrace*	6.48	0.78	5.9	33.55	32.4

Table 5. Air pollution tolerance index (APTI) of tree species from Bommasandra industrial area of south Bengaluru

S. No.	Tree Species	Total chlorophyll (mg/ml)	Ascorbic acid mg/g	pH	Relative water content, %	Air pollution tolerance index (APTI)
1	*Syzygium cumini*	5.2	0.32	5.9	98.54	35
2	*Michelia champaca*	4.3	0.51	4.7	65.36	30
3	*Acacia melanoxylon*	5.2	0.44	6.2	52.83	26.5
4	*Euculeptus* sp.	4.4	0.5	6.1	42.29	22.2
5	*Ficus benghalensis*	5.9	0.72	6.2	17.45	15.2
6	*Delonix regia* Raf.	5.6	0.82	5.2	15.24	13.5
7	*Morinda pubescens*	4.8	0.72	5.6	35.39	26.5
8	*Millingtonia hortensis*	3.5	0.67	6.2	22.78	14.5
9	*Leucaena leucocephala*	5.4	0.87	6.3	17.88	18.2
10	*Saraca indica*	4.4	0.62	4.9	24.63	14.2
11	*Caesalpinia pulcherrima*	6.2	0.36	5.1	40.31	16.4
12	*Dalbergia lanceolaria* L.f.	7.8	0.87	6.2	27.67	32.5
13	*Ficus religiosa*	4.4	0.51	5.3	37.40	18.5
14	*Azadirachta indica*	6.03	0.93	5.4	33.49	35.6
15	*Pongamia pinnata* (L.)	6.4	0.82	5.6	32.52	32
16	*Madhuca latifolia* Roxb	4.09	0.89	6.4	35.56	33.2
17	*Diploknema butyrace*	6.42	0.74	5.5	35.71	31.5

At Electronic city, the concentration of the ascorbic acid (AA) ranged between 0.09 and 0.99 mg/g of the green weight, chlorophyll (TCh) concentration ranged between 1.32-7.4505 mg/g of the green weight[5,6]. For the tree species, the study showed that the highest concentration in the ascorbic acid (Vitamin C) was in *Millingtonia hortensis* and the least concentration was found in *Euculeptus sp*. The APTI values ranged between 21.8-12.3, the maximum air pollution tolerance index value was found in *Dalbergia lanceolaria* L.f. (21.8) *Pongamia pinnata* (L.) (21.45) *Azadirachta indica* (19.68), *Diploknema butyrace* (18.815) and minimum were in *Saraca indica* (12.3) and *Morinda pubescens* (12.8)

At Jigini industrial area the concentration of the ascorbic acid (AA) ranged between 0.4 and 0.99 mg/l00 g of the green weight, chlorophyll (TCh) concentration ranged between 3.3-7.46 mg/g of the green weight .The Air pollution tolerance index value was found between 38-14.5 the maximum value was in the following tree species *Syzygium cumini* (38) *Pongamia pinnata* (L.) (35.6) *Madhuca latifolia* Roxb (34.6), *Dalbergia lanceolaria* L.f. (32.5) and minimum was in *Delonix regia* Raf. (14.5) and (14.7) for *Saraca indica.*

At Bommasandra industrial area, the concentration of the ascorbic acid (AA) ranged between 0.32 and 0.93 mg/g of the green weight, chlorophyll (TCh) concentration ranged between 3.5-7.86 mg/g of the green weight. The maximum air pollution tolerance index value was found between 35.6-14.2 the maximum value was in the following tree species *Azadirachta indica* (35.6) *Syzygium cumini* (35) *Madhuca latifolia* Roxb (33.2), *Dalbergia lanceolaria* L.f. (32.5) and minimum was in *Delonix regia* Raf. (13.5) and *Saraca indica* (14.2). The result reveals that out of the seventeen tree species studied, *Syzygium cumini* (Jamun) is most tolerance, followed by *Azadirachta indica, Madhuca latifolia* Roxb and *Madhuca latifolia* Roxb in Bommasandra and Jigini industrial area. For the tree species in all the three station, the study showed that the highest concentration in the ascorbic acid (Vitamin C) was in *Millingtonia hortensis*[8,9] and the least concentration was found in *Euculeptus* sp.

Conclusion

This study has identified the various tree species growing in all the three industrial areas of south Bengaluru. An overview of the entire result obtained from this study reveals that different plants respond differently to air pollution; hence the different indices show that plants growing in apparently polluted environment have higher APTI values compared to moderately polluted environment.

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