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ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol. 06, Issue 08, pp. 1686-1689, August, 2015

RESEARCH ARTICLE

PLANTS AS BIOINDICATORS BASED ON AIR POLLUTION TOLERANCE INDEX

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ARTICLE INFO

Article History:
Received 21st May, 2015
Received in revised form
30th June, 2015
Accepted 11th July, 2015
Published online 31st August, 2015

Key words:
Plants,
Bioindicators,
APTI- Air Pollution Tolerance Index.

ABSTRACT

In the present study 30 Plants i.e. 10-Trees, 12-Shrubs and 8-Herbs growing in various places of Hyderabad city were selected and analysed for certain physiological and bio-chemical parameters, p^H of the leaf extract, Leaf Relative Water Content, Ascorbic acid content and Total chlorophyll content. Based on these parameters APTI (Air Pollution Tolerance Index) values were calculated. Plants absorb the air pollutants and they act as natural-sinks, depending on the APTI values the plants are categorized into "Tolerant" species and "Sensitive" species. According to the present study *Azardirachta indica, Peltaforum alba* and *Cassia* species among the trees; *Annona squamosa, Ocimum sanctum* and *Hibiscus rosasinensis* among the shrubs; *Tridax procumbence, Portula* species and *Croton* species among the herbs- are the "Tolerant" species. These tolerant plants can be used as bioindicators to monitor the health of the environment. The tolerant plants can also be used by the landscapers for planting them on either side of roads, parks, dividers etc.

INTRODUCTION

Today's growing population and increased Urbanization resulted in increased air-pollutants in the atmosphere. The Hyderabad mega-city is facing this problem because of the merger of surrounding municipalities with Hyderabad municipal corporation, Hyderabad Metropolitan Development Area (HMDA). The inaugural of the International Airport at Shamshabad, construction of Dr. P.V. Narasimha Rao elevated X-press way corridor, the inner-ring road, the outer-ring road, the fly-overs, the Metro-Rail project and bridges contribute to the development on one side and air pollution on the other side. Plants are considered for investigation because they are exposed to the changing air pollution and their foliar surface area acts as natural sinks for pollutants specially the gaseous ones.

(Bernatsky, 1969) has suggested that Greenbelts milght help reduce air pollution, plants growing in polluted environments often responded and showed significant changes in their morphology, physiology and bio-chemistry. Some plant species and varieties are so sensitive that they can be conveniently employed as biological-indicators or bio-monitors of specific pollutants; they can further assist man in planning the urban cities. The plant species can be used as Biological indicators to monitor the health of the environment. (Nugrahani *et al*., 2012) worked on Ornamental shrubs as plant pellets elements and bioindicators based on air pollution tolerance index in Surabaya city, Indonesia. Begum and Harikrishna in 2010 evaluted some tree species to absorb air pollutants in three industrial locations of South Bengaluru, India. Priyanka and Dibyendu in 2009 worked on Biomonitoring of air quality in the industrial town of Asansol using the Air Pollution Tolerance Index Approach. YAN-JU LIU and HUI DING in 2008 worked on Variation in Air Pollution Tolerance Index of plants near a Steel Factory: Implications for landscape plant species selection for industrial areas. Dwivedi and Tripathi in 2007 worked on Pollution tolerance and distribution pattern of plants in surrounding area of Coal-Fired industries. Joshi and Swami in 2007 worked on the Physiological responses of some Tree species under road side Automobile Pollution Stress around city of Haridwar, India. Banerjee and Agarwalla in 2006 worked on Dispersion Modeling for a Chemical Manufacturing Plant. Gaikwad et.al., in 2006 worked on Plants as Bio-indicators of Automobile Exhaust Pollution – a case study of Sangli city. In 2005, Cynthia and Shailaja worked on Air Polution Tolerance Index of Certain plants of Hyderabad City – Balanagar. Singh in 2003 worked on Phytomonitoring of Urban industrial pollutants: A new approach.

MATERIALS AND METHODS

The leaf samples of different species of Plants were collected in the morning hours of Summer of 2009 (April), fully matured leaves of each species were selected and care was taken to see as far as possible that the plants were collected from iso-ecological conditions of light, water and soil. The

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leaf samples collected were analyzed for pH of leaf extract (Singh and Rao, 1983) Total chlorophyll (Arnon, 1949), Ascorbic acid (Singh 1977), Relative water content (RWC, %) (Singh, 1977).

Air Pollution Tolerance Index

An attempt has been made to determine the air pollution tolerance index (APTI) which gives an empirical value for the tolerance level of plant to air pollution.

The formula for APTI is

$$APTI = \frac{A\,(T+P)) + R}{10} \quad \text{(Singh and Rao, 1983)}$$

Where, A = Ascorbic acid (mg/100ml)
T = Total chlorophyll (mg/g)
P = p^H of leaf extract
R = RWC of leaf extract (%)

The entire sum is divided by 10 to obtain a small manageable figure.

Based on the development and evaluation of APTI values among the plants they are categorized into three groups namely:–

- 10.5 - 8.5 as Tolerant species;
- 8.4 – 5.0 as Intermediate species; and
- < 5 as Sensitive species.

RESULTS AND DISCUSSION

The 30 Plants analysed are arranged in the descending order of APTI given in Tables- 1, 2, 3 and 4 plants having higher index values are more tolerant to air pollution than those having lower index values. In the present study leaf parameters like Total chlorophyll, Ascorbic acid, Relative water content and leaf extract p^H are used in evaluating their degree of tolerance to air pollution. In Table -1, it gives the Relative water content, Total chlorophyll content, p^H and Ascorbic acid content of the 30 plant species. The Relative Water Content of leaves is an indicator of the plants water status with respect to its physiological consequences of cellular water and it ranged between – 14.4% and 99.6%; highest value was seen in *Azardirachta indica* and lowest value in *Nerium* species. The Total chlorophyll content ranged from 1.50 mg/g and31.6 mg/g, the highest chlorophyll content was seen in *Euphorbia hirta* and lowest chlorophyll content in *Pongamia glabra*. The p^H content ranged from 6.5 and 7.5, the highest p^H value was seen in *Hibiscus rosasinensis* and lowest p^H value was seen in *Azardirachta indica*. The Ascorbic acid content ranged from 0.016 mg/100ml and 0.6 mg/100ml, the highest value was seen in *Acalypha* species and lowest value was seen in *Lantana camera*.

The Ascorbic acid content, a Stress reducing factor is a strong reducing agent and is associated with Tolerant ones. It reduces the effect of Sulphurdioxide and acts as an anti-oxidant. A high content of Ascorbic acid content in plant leaf is related to bio-chemical and physiological species of a particular environment.

Table 1. Air pollution tolerance index values of certain plants of Hyderabad city

S.No	NAME OF THE PLANT	RELATIVE WATER CONTENT %	TOTAL CHLOROPHYLL CONTENT mg/g	p^H	ASCORBIC ACID mg/100ml	APTI VALUE
1	*Azardirachta indica*	99.6	2.75	6.5	0.4	10.33
2	*Peltaforum alba*	81.7	4.23	6.5	0.4	8.59
3	Cassia species	83.8	23.0	6.5	0.027	8.46
4	*Plumaria alba*	77.9	5.08	6.5	0.1	7.90
5	*Mangifera indica*	65.5	20.0	6.5	0.033	6.64
6	*Pongamia glabra*	61.7	1.50	6.5	0.027	6.19
7	*Ficus religiosa*	55.3	24.0	6.5	0.033	5.63
8	*Albizzia lebbek*	45.1	17.1	6.5	0.44	5.55
9	*Tecoma stans*	53.6	13.3	6.5	0.027	5.41
10	Kasava species	45.2	4.08	6.5	0.03	4.84
11	*Annona squamosa*	95.5	24.0	7.0	0.044	9.69
12	*Ocimum sanctum*	75.5	4.56	6.5	0.022	8.6
13	*Hibiscus rosasinensis*	84.2	23.0	7.5	0.08	8.66
14	Clerodendron species	75.1	4.6	7.5	0.1	7.63
15	*Cassia tora*	71	27.4	7.0	0.027	7.19
16	*Calotropis procera*	58.6	6.64	6.5	0.03	5.9
17	Acalypha species	51.6	5.3	6.5	0.6	5.86
18	*Bougainvilla spectabillis*	53.6	8.83	7.0	0.1	5.52
19	Amaranthus species	43.8	4.5	6.5	0.1	4.49
20	*Lantana camera*	27.7	6.83	7.0	0.016	2.79
21	Duranta species	22.1	6.98	6.5	0.022	2.2
22	Nerium species	14.4	4.49	6.5	0.022	1.46
23	*Tridax procumbens*	98	30.5	6.5	0.094	10.15
24	Portula species	98.5	17.6	7.0	0.027	9.92
25	Croton species	94.9	3.9	6.5	0.03	9.52
26	*Vinca rosea*	71.3	21.3	6.5	0.2	7.68
27	Crosssandra species	71.7	24.5	7.0	0.1	7.4
28	*Euphorbia hirta*	66.8	31.6	7.0	0.05	6.8
29	Vernonia species	54.7	9.6	7.0	0.05	5.55
30	*Coccinia cordifolia*	22.2	27.1	6.5	0.022	2.29

Table 2. Showing APTI values of certain plants (trees) of Hyderabad city

S.No	Scientific Name	Common Name	Family	APTI value
1	*Azardirachta indica*	Neem tree	Meliaceae	10.33
2	*Peltaforum alba*	Konda Chinta	Caesalpinaceae	8.59
3	Cassia species	-	Caesalpinaceae	8.46
4	*Plumaria alba*	Devakanchana	Apocyanaceae	7.90
5	*Mangifera indica*	Mango	Anacardiaceae	6.64
6	*Pongamia glabra*	Kanuga	Fabaceae	6.19
7	*Ficus religiosa*	Peepal	Moraceae	5.63
8	*Albizzia lebbek*	Dirisena	Mimosaceae	5.55
9	*Tecoma stans*	Yellow bells	Bigoniaceae	5.41
10	Kasava species	Topioca	Euphorbiaceae	4.84

Table 3. Showing APTI values of certain plants (shrubs) of Hyderabad city

S.No	Scientific Names of Shrubs	Common Name	Family	APTI Value
1	*Annona squamosa*	Seethaphalam	Annonaceae	9.69
2	*Ocimum sanctum*	Tulasi	Lamnaceae	8.6
3	*Hibiscus rosasinensis*	Mandaram	Malvaceae	8.66
4	*Clerodendron*	Glorybower	Verbenaceae	7.63
5	*Cassia tora*	Thangedu	Caesalpinaceae	7.19
6	*Calotropis procera*	Jilledu	Asclepiadaceae	5.9
7	Acalypha species	-	Euphorbiaceae	5.86
8	*Bougainvilla spectabillis*	Paper flower	Nyctaginaceae	5.52
9	Amaranthus species	-	Amaranthaceae	4.49
10	*Lantan camera*	Lantana	Verbenaceae	2.79
11	Duranta species	-	Verbenaceae	2.2
12	Nerium species	Ganneru	Apocyanaceae	1.46

Table 4. Showing APTI values of certain plants (HERBS) of Hyderabad city

S.No	Scientific Name of Herbs	Common Name	Family	APTI value
1	*Tridax procumbens*	Gayapaku	Asteraceae	10.15
2	Portula species	Gangavayulu	Portulaceae	9.92
3	Croton species	-	Euphorbiaceae	9.52
4	*Vinca rosea*	Pilla ganneru	Apocyanaceae	7.68
5	Crossandra species	Kanakambram	Acanthaceae	7.4
6	*Euphorbia hirta*	Pachabottu	Euphorbiaceae	6.8
7	Vernonia species	-	Asteraceae	5.55
8	*Coccinia cordifolia*	Dondakaya	Cucurbitaceae	2.29

Table 5. Showing tolerant, intermediate and sensitive plant species

S.No	Tolerant	Intermediate	Sensitive
1	*Azardirachta indica*	*Plumaria alba*	Kasava species
2	*Peltaforum alba*	*Mangifera indica*	Amaranthus species
3	Cassia species	*Pongamia glabra*	*Lantana camera*
4	*Annona squamosa*	*Ficus religiosa*	Duranta species
5	*Ocimum sanctum*	*Albizzia lebbek*	Nerium species
6	*Hibiscus rosasinensis*	*Tecoma stans*	*Coccinia cordifolia*
7	*Tridax procumbens*	Clerodendron species	
8	Portula species	*Cassia tora*	
9	Croton species	*Calotropis procera*	
10		Acalypha species	
11		*Bougainvilla spectabillis*	
12		*Vinca rosea*	
13		Crossandra species	
14		*Euphorbia hirta*	
15		Vernonia species	

The APTI values ranged from 1.46 and 10.33, the highest value was seen in *Azardirachta indica* and the lowest value was seen in *Nerium* species.

According to the APTI values plants are classified into three categories. They are

i. Tolerant plant species (10.5 to 8.5)
ii. Intermediate plant species (8.4 to 5.0)
iii. Sensitive plant species (less than 5)

i. Tolerant plant species

The tolerant plants are – *Azardirachta indica*, *Peltaforum alba,* and *Cassia* species among the trees*; Annona squamosa, Ocimum sanctum* and *Hibiscus rosasinensis* among the shrubs and *Tridax procumbens*, *Portula* species and *Croton* species among the herbs.

ii. Intermediate plant species

The intermediate plants are – P*lumaria alba, Mangifera indica, Pongamia glabra*, *Ficus religiosa, Albizzia lebbek* and

Tecoma stans among the trees; *Clerodendron* species*, Cassia tora, Calotropis procera*, *Acalypha* species and *Bougainvilla spectabillis* among the shrubs and *Vinca rosea, Crossandra* species, *Euphorbia hirta* and *Vernonia* species among the herbs.

iii. Sensitive plant species

The sensitive plants are – *Kasava* species, among trees*; Amaranthus* species, *Lantana camera*, *Duranta* species and *Nerium* species among shrubs and *Coccinia cordifolia* among herbs. As shown in the Table 5

Conclusion

Based on the study it can be said that the Air Pollution Tolerance Index (APTI) values estimated using the four bio-chemical parameters in plant leaves, namely- Relative water content, Total chlorophyll content, p^H and Ascorbic acid, can be used as a predictor of air quality. These parameters are significant in studies between plant – environment interactions and used for the development of bio – indicator groups. The APTI values of a particular geographical area can be used for bio – monitoring of air quality. According to the present study *Azardirachta indica, Peltaforum alba* and *Cassia* species among the trees; *Annona squamosa, Ocimum sanctum* and *Hibiscus rosasinensis* among the shrubs; *Tridax procumbens, Portula* species and *Croton* species among the herbs are the Tolerant species. The plant species can be used as Biological indicators to monitor the health of the environment. The tolerant plants can be used by the landscapers for planting them on either side of roads, parks, dividers etc.

Acknowledgements

The authors acknowledge the laboratory facilities given by the Department of Botany, Osmania University College for Women,Koti, Hyderabad. The authors Olive Kezia Ruth and Glory Margaret. A, thank their Guide Prof. Mary Esther Cynthia Johnson for constant help and encouragement. This work is done by Late. Glory Margaret. A

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