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A STUDY ON THE AIR POLLUTION TOLERENCE INDEX (APTI) OF SELECTED PLANTS FROM KOTTAYAM DISTRICT, KERALA.

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ABSTRACT

Air pollution is considered globally as one of the major existing threat. The increase in industrialization has a huge impact in urban areas. To mitigate the air pollution, plants can be utilized as a cost effective and sustainable tool. Plants serve as bioindicator for biomonitoring the impact of air pollution and can also be used in the development of urban green belts. The present study was undertaken to assess the air pollution tolerance index (APTI) of the ten common plant species from Kottayam district, to identify its sensitivity and tolerance to air pollution. Among the selected plants, *Macaranga peltata* (9.85mg/g), *Psidium guajava* (10.9mg/g), *Garuga pinnata* (11.08mg/g), *Mangifera indica* (11.3mg/g) and *Tamarindus indica* (11.4mg/g) shows sensitivity towards air pollution indicating its use as bioindicator. For the development of green belts in polluted area *Delonix regia* (12.7mg/g), *Ficus benghalensis* (14.9mg/g), *Cassia fistula* (14.2mg/g), *Lagerstromeia speciosa* (13.9mg/g) and *Terminalia catappa* (15.7mg/g) with intermediate ATPI values can be used.

KEYWORDS: Air pollution tolerance index, Bioindicator, Green belts.

INTRODUCTION

Pollution is an existing threat to human population (Landrigan et al., 2018). The term is used to describe the contamination of environment by substances that harm human health, quality of life or the ability of ecosystem to function naturally. The world health organization (WHO) provides information on six main air pollutants: lead, nitrogen oxides, sulphur oxides, ground level ozone and particle pollutant. Fine particulate matter, ozone, oxides of sulphur and nitrogen, petroleum waste, lead, mercury, pesticides, industrial chemicals, electronic waste and radioactive waste are all examples of pollutants (Rizwan et al., 2013). Despite the fact that a variety of natural occurrences like volcanoes, fire, etc. have the potential to discharge a variety of pollutants into the environment; anthropogenic activities are the main contributor to air pollution. A key concern to urbanization and industrialization is the increasing level of air pollution (UNDESA, 2018) (Lester et al., 1970). Urban areas are mainly affected by air pollution. Increased use of vehicle and rapid urbanization has been the main contributors to air pollution (Carolina et al., 2015).

Bioindicators are used to monitor the health of the natural ecosystem including plants, planktons, animals and bacteria (Trishala et al., 2016). Biomonitoring of air pollution using plants has recently gained popularity since it is cost effective, sustainable and ecologically friendly. Some plant species are extremely sensitive to specific air contaminants and respond to it by exhibiting distinct damage symptoms (Hamza, 2017) (Durga et al., 2023). By exchanging gases and acting as a sink for air pollutants, trees are significantly enhancing air quality. To reduce air pollution, they function as living filters to remove particulate particles. Depending on their level of sensitivity, trees exposed to environmental pollutants absorb, collect and integrate these toxins into their systems. Plants exhibit observable harm, such as changes to metabolic processes or an accumulation of certain metabolites. These modifications are used for calculating the APTI (Khureshi, 2013). The air pollution tolerance index (APTI) could be calculated by integrating changes in the biochemical characteristic of plants. The relative water content, leaf extract pH, ascorbic acid content and total chlorophyll concentrations are combined to produce APTI which is commonly used to assess the effect of air pollution on plants (Khanoranga et al., 2017). A plant species with a higher APTI rating is more tolerant to pollution and can thus be planted in polluted areas to enhance air quality. On the other hand, sensitive species are predicted to have low APTI scores and can be used as indications of environmental pollution (Molnar et al., 2018).

Screening plants for air pollution sensitivity or tolerance is significant because sensitive plants can serve as bio-indicators while tolerant plants can serve as sinks (green belts) for mitigating air pollution in urban and industrial regions (Mohammed, 2011). Urban green belts are known as lungs of cities, because they act as a sink for some of the toxic gases emitted by vehicles and industry. Green belts formed of pollutant tolerant trees perform a significant role in reducing pollution by filtering, intercepting and absorbing pollutants in a sustainable manner (Sirajuddin et al., 2014) (Gareth et al., 1992). In this study, plants are screened based on the ATPI value to identify whether the selected plants are sensitive or tolerant. The sensitive plants can be used as bioindicator of air pollution while the tolerant species are used for designing the green belt in urban areas (Aasawari et al., 2017).

MATERIALS AND METHODS

Collection of plant materials

The mature leaves of *Delonix regia* (Bojer ex Hook.) Raf, *Macaranga peltata* Mull.Arg., *Garuga pinnata* Roxb., *Ficus benghalensis* L., *Tamarindus indica* L., *Cassia fistula* L., *Lagerstromeia speciosa* L., *Psidium guajava* L., *Mangifera indica* L. and *Terminalia catappa* L., were collected from both polluted (urban) as well as non-polluted (rural) areas of the five taluks of Kottayam district and identified using Flora of the Presidency of Madras by J.S. Gamble.

Total chlorophyll content

5g of fresh leaf sample was grinded thoroughly using a clean mortar and pestle **(Fig.1).** Add 10 ml of 80% acetone in to it. Keep the sample aside for extraction up to 15 minutes **(Fig.2).** Repeat the process of extraction until the green colour of the extract get fades. The obtained leaf extracts was centrifuged at 2500 rpm for 10 minute. The supernatant was collected and the absorbance was taken at 645nm and 663nm after calibrating against the blank using a spectrophotometer (Arnon, 1949).

$$TCh=[20.2(A645)+8.02(A663)]\times[v/(1000\times W)]$$

Where, TCh = total chlorophyll (mg/g), A645 = absorbance at 645 nm, A663 = absorbance at 663 nm, V = total volume of the extract (ml) and W = weight of the sample (g).

Leaf extract pH

Freshly weighed, 5 g of the leaf sample was grinded using a mortar and pestle. The crushed sample was homogenized in 50 ml deionized water. The sample was filtered using a double layered cheese cloth **(Fig.3)**. The pH of the leaf extract was measured using a pH meter (Manjunathetal., 2019).

Relative water content (RWC)

Average sized leaves were collected from the plants **(Fig.4).** Three different weights of the leaves were taken using a weighing machine (Barrs et al., 1962).

- Fresh weight, taken immediately after collecting the leaves.
- Turgid weight, after the leaves were immersed in water for 12 hours
- Dry weight of the leaves, after drying it in hot air oven at 70ºC for 6 to 12 hours

$$RWC=FW-DW/TW-DW\times100\%$$

Where, FW = fresh weight, DW = dry weight, and TW = turgid weight

Ascorbic acid content

5g of the leaf was taken and homogenized in mortar and pestle using 4% oxalic acid solution. The homogenate was filtered thoroughly. From the filtered solution, 10 ml is transferred into a conical flask and add bromine water drop by drop, until the solution turns to yellow or orange colour **(Fig.5).** The volume was then made up to 25 ml using 4% oxalic acid and this solution served as the stock solution. From the stock solution, 2 ml of the aliquot is pipetted out and makeup to 3 ml using distilled water in a test tube. Add 1 ml of DNPH (2, 4- di nitro phenyl hydrazine) and 1-2 drops of thiourea into it. Mix it well and incubate at 37ºCfor 3 hours. After the incubation period, add 7 ml of 80% sulphuric acid. The absorbance was read at 540 nm against the blank with ascorbic acid as the standard (Roe and Keuther, 1943).

Air Pollution Tolerance Index (APTI)

APTI was calculated using the following standard method (Singh and Rao, 1983)

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

Where, A = Ascorbic acid content (mg/g) (dry weight), T = Total chlorophyll content (mg/g), P = leaf extract pH, and R = RWC (%).

Sl. No.	APTI value	Response
1	1–11	Sensitive
2	12–16	Intermediate
3	≥ 17	Tolerant

RESULTS

Total chlorophyll content

The study revealed that the total chlorophyll content decreased significantly in the polluted sites compared to non-polluted site. The highest total chlorophyll content was observed in *Delonix regia* (1.45 mg/g) from non-polluted site whereas *Delonix regia* (1.37 mg/g) from polluted site.

Leaf extract pH

In the non-polluted sites, the pH of leaf extract ranges from 5.59-6.91 and in polluted site it ranges from 5.01-7.82. A considerable variation in the pH was observed in both sites with lowest pH observed in *Macaranga peltata* (5.01) from polluted site.

Relative water content

The average relative water content of the plants from non-polluted area was significantly higher when compared to polluted area.The highest value of average relative water content was observed as 92.1% in *Terminalia catappa* from non-polluted site and 87% from polluted site.

Ascorbic acid content

The total ascorbic acid content is mostly higher in polluted site compared to non-polluted site. *Ficus benghalensis* from polluted site shows 8.32 mg/g as high ascorbic acid content while 7.23mg/g from non-polluted site.

ATPI

The APTI of selected plants from non-polluted site ranges from 12.1 to 14.9 (**Table 1)**. Among the 10 plants, all shows moderately tolerant state that means they are in an intermediate condition having their APTI value between 12 and 16. *Mangifera indica*, *Cassia fistula* and *Delonix regia* shows the highest APTI value in the non-polluted area.

The APTI of selected plants from the polluted region ranges from 9.85 to 15.7 **(Table 1).** The lowest ATPI values are shown by *Macaranga peltata* (9.85mg/g), *Psidium guajava* (10.9mg/g), *Garuga pinnata* (11.08mg/g), *Mangifera indica* (11.3mg/g) and *Tamarindus indica* (11.4mg/g). These plants can be used as a pollution indicator since they are sensitive to air pollution.

By comparing the non-polluted and polluted sites, *Macaranga peltata, Psidium guajava, Garuga pinnata, Mangifera indica and Tamarindus indica* can be used as bioindicator for assessing the air pollution and *Cassia fistula, Ficus benghalensis, Terminalia catappa* can be used for the development of green belts.

Table 1: Air Pollution Tolerance Index (APTI) of the selected plants from polluted area and non-polluted area.

Sl.No.	SAMPLE	ASCORBIC ACID (mg/g)	pH	TCh (mg/g)	RWC (%)	APTI
1	*Cassia fistula* (P)	7.76	7.76	1.05	70	14.2
	Cassia fistula (NP)	6.91	6.91	1.22	81.2	14.4
2	*Delonix regia* (P)	7.14	6.82	1.37	85.7	12.7
	Delonix regia (NP)	6.15	6.05	1.45	89.7	14.2
3	*Ficus benghalensis* (P)	8.32	7.82	1.23	74	14.9
	Ficus benghalensis (NP)	7.23	6.15	1.38	84.4	13.8
4	*Garuga pinnata* (P)	7.37	6.09	0.804	72.1	11.08
	Garuga pinnata (NP)	7.18	6.13	1.14	85.2	13.7
5	*Lagerstroemia speciosa* (P)	7.89	6.43	1.10	73.1	13.9
	Lagerstroemia speciosa (NP)	6.86	6.41	1.28	87.3	14.05
6	*Macaranga peltata* (P)	5.92	5.01	0.758	64.4	9.85
	Macaranga peltata (NP)	7.04	6.02	0.955	78.5	12.7
7	*Mangifera indica* (P)	6.02	6.12	0.792	82.4	11.3
	Mangifera indica (NP)	7.92	6.50	0.963	90.3	14.9
8	*Psidium guajava* (P)	6.05	6.08	0.825	60	10.9
	Psidium guajava (NP)	7.09	5.62	0.942	70.8	12.1
9	*Tamarindus indica* (P)	6.12	5.19	1.12	77.7	11.4
	Tamarindus indica (NP)	6.22	5.59	1.23	79.3	12.1
10	*Terminalia catappa* (P)	8.02	7.51	1.33	87	15.7
	Terminalia catappa (NP)	6.4	6.22	1.42	92.1	14.09

(*P - Polluted site and NP- Non polluted site)

Fig. 1: Preparation of plant extract.

Fig.2: Extracts prepared for the estimation of Tch.

Fig.3: Extracts prepared for the estimation of pH.

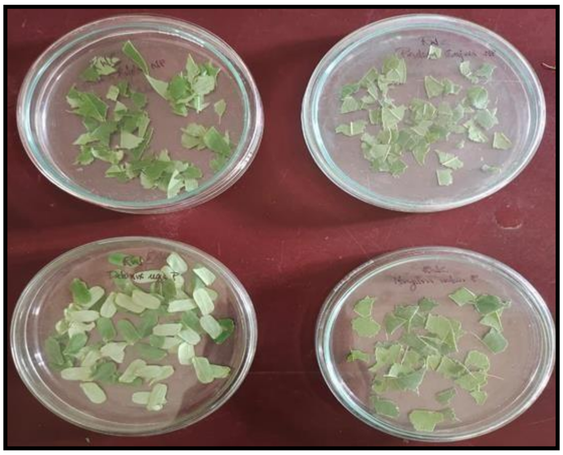

Fig. 4: Relative water content estimation.

Fig. 5: Experimental set up for the estimation of ascorbic acid content.

DISCUSSION

Air pollution is causing a major trouble for all living forms, mainly to the plants exposed to urban roadsides which change the nature of leaves, its tolerance and sensitivity. This sensitivity is measured to calculate the APTI. The relative water content, leaf extract pH, ascorbic acid content and total chlorophyll content are combined to produce APTI which is commonly used to assess the effect of air pollution on plants.

The pollution first affect the chloroplast of the leaves, as the air pollutant enters in to the plant through stomata which causes the disintegration of the chloroplast. Thus decrease in the chlorophyll content maybe due to increase in air pollution. The pH of leaves decreases in the presence of an acidic pollutant, and sensitive species will have a very low pH. Higher pH (around 7 or more) of the leaf extract gives tolerance against pollution. Plants with higher RWC generally have higher tolerance levels for air pollution. Increased RWC aids plants in controlling physiological operations under stress brought by airborne toxins. Another key factor that determines the capacity of plant to neutralise and survive the damaging effects of air pollution is ascorbic acid. With the increase in pollution, ascorbic acid content also increases and acts as a powerful reductant, electron donor, scavenger of free oxygen radicals, facilitates the reduction of sulphide to hydrogen sulphide and reduces the toxicity of SO_2 . Plants having high ascorbic acid possess resistance to SO_2. The air pollution tolerance index can change according to the changes in environmental conditions such as seasons and other environmental variables.

CONCLUSION

According to the study, The results of the present study shows that *Macaranga peltata*, *Psidium guajava*, *Garuga pinnata, Mangifera indica and Tamarindus indica* have less APTI value and can be used as bioindicator. *Macaranga peltata* shows high susceptibility to air pollution. Considering their modest resistance to air pollution, *Cassia fistula*, *Delonix regia*, *Ficus benghalensis*, *Lagerstroemia speciosa*, *Terminalia catappa* can be taken into consideration when constructing the urban greenbelt.

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