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APPROPRIATENESS OF MOIST DECIDUOUS SPECIES AGAINST PARTICULATE POLLUTION ABATEMENT AND MONITORING

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Abstract: The productivity of trees decreases proportional to their tolerance level. The objective of the study was to compare the air pollution tolerance index of important moist deciduous forest species found near Malabar cements Ltd., Walayar, so as to identify the trees least affected by particulate pollution. *Butea monosperma* was the most tolerant to particulate pollution stress, while *Bombaxceiba* was the most sensitive to particulate pollution. While *Tectonagrandis*, which is predominantly found planted in the region were found to be of intermediate tolerance. The knowledge of tolerance of trees are extremely handy, since it gives an insight to the level of productivity to be expected from these trees under pollution stress, and help in selecting the best tree for the given urban environment. Though evergreen species are best suited for pollution abatement, trees that are capable of growing well in the moist deciduous are preferable since they are more suited for such localities along with the availability of promising deciduous species capable of abating and monitoring of pollution levels in the modern day settings.

Keywords: Teak, particulate pollution, apti, cement dust etc.

Introduction

Trees are capable of impinging, absorbing and accumulating air pollutants to reduce the pollutant level in the environment by providing enormous leaf area. Plants remove pollutants from air by three processes, namely deposition of particulates, absorption by leaves and aerosols over leaf surface (Prajapati, 2008). But the problem is that different species are having different capacities for providing these services (Hove *et al*., 1999). Plants are highly suitable for the detection, monitoring and mitigation of air pollution effects (Singh, 2005). Plants that are constantly exposed to environmental pollutants will absorb, accumulate and integrate these pollutants into their systems. It's reported that depending on their sensitivity level, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites (Agbaire and Esiefarienrhe, 2009). Sensitive species are useful as early warning indicators of pollution while tolerant ones help in reducing the overall pollution load, leaving the air moderately free of pollutants (Rao,

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1983). It is possible to estimate the overall effect of a large number of pollutants as total pollution by measuring changes in the plants (Agbaire, 2009).

Air Pollution Tolerance Index (APTI) is an essential tool for the estimation of the level of tolerance of plants to air pollution stress. Studies in the past have shown that particulate pollutants have effects on plant parameters like ascorbic acid content (Hoque *et al.,* 2007), relative water content (Rao, 1979), total leaf chlorophyll (Flowers *et al.,* 2007), and pH of the leaf extract (Klumpp *et al.,* 2000). However, these parameters gave conflicting results for the same species itself. Since one of these parameters may show the plant species as sensitive to pollution while another of these parameter may implicate the same plant species as being tolerant to pollution (Han *et al.,* 1995). For this very reason that a single parameter fails to provide a clear picture about the tolerance level and pollutant induced changes in the plant species, Air Pollution Tolerance Index (APTI) based on these four parameters has been used to identifying the tolerance level of plant species. The combining of variety of these parameters gives a more reliable result than each of these individual parameter (Agbaire, 2009). The APTI values are studied for ten species commonly found in and around the Malabar cements. This helps in understanding to what level these trees are able to cope with its surrounding environmental and anthropogenic conditions. This also gives an insight to how well these select trees are able to tolerate the effects of cement dust pollution, to which they are constantly exposed. APTI is used for comparison of tolerance because of the universal acceptance that just a single factor cannot be used as an indicator of pollution tolerance.

Materials and Methods

The study was carried out in the Walayar range, Palakkad under the Eastern Circle of the western Ghats region of India. Random sampling was done near the Malabar cement premises at 10°51' N 76°50' E, which was the affected area by particulate pollution, mainly cement dust from the Malabar cements factory. The control plot was taken at 10°49' N 76°48' E, about 5 km away from this area, which was used as a reference for understanding the degree to which the trees are affected by the particulate pollution and the tolerance levels of different species that are studied. In this area trees of moist deciduous nature were randomly selected for taking the readings and sample collections. The readings for the estimation of Air Pollution Tolerance Index (APTI) are carried out season wise during winter (December - June), summer (February - March) and monsoon (June - July).

Ascorbic acid content was estimated using the method prescribed by Sadasivam and Manickam (1996). While the chlorophyll content of the leaf samples was estimated using the method described by Arnon (1949). For the estimation of pH of the leaf extracts, five grams of the fresh leaves was homogenized in 10 ml deionised water. This was then filtered and the pH of leaf extracted determined after calibrating pH meter with buffer solution of pH 4 and pH 7. Relative water content of the leaves were determined by the method described by Singh (1977).

The air pollution tolerance indices of ten common plants were determined following the method of Singh and Rao (1983). The formula of APTI is given as

$$APTI = [A (T+P) + R]/10$$

Where,

A - Ascorbic acid content (mg/g)

T - Total chlorophyll (mg/g)

P - pH of leaf extract

R - Relative water content of leaf (%)

After calculating the individual APTI values, they are divided and graded into four grades of air pollution tolerance (Liu and Ding, 2008) as tolerant (T/ grade I), moderately tolerant (MT/ grade II), intermediate (I/ grade III) and sensitive (S). The tolerance grades were identified according to the following criteria:

1. Tolerant: APTI > mean APTI + SD
2. Moderately tolerant: mean APTI < APTI <mean APTI + SD
3. Intermediate: mean APTI – SD < APTI < mean APTI
4. Sensitive: APTI < mean APTI – SD

Based on the grades a final score is given. The maximum score of four for grade tolerant (T), then decreasing to a minimum score of one for grade sensitive (S). So the maximum score of each species over three seasons and two plots will be 24. When the score was same for trees, then their performance during the most polluted seasons (lack of adequate precipitation) i.e. winter and summer in the polluted plot were given higher priority. Even if that was obscure enough to differentiate between two species of similar score, then their performance irrespective of season and plot was used to determine the species superiority in tolerating pollution.

Results and Discussions

On statistical analysis, APTI during winter and monsoon were significantly different between species, statuses as well as the interaction between species and status. But during summer, it was significant between species as well as between statuses, but was not significant between statuses and species. The values of APTI were higher in control plots than the polluted during summer and monsoon, while it was higher in the polluted plot during winter. The APTI was the highest in *Butea monosperma* during winter (5.64) and monsoon (4.74), while it was highest in *Pterocarpus marsupium* (4.55) during summer. The values of APTI ranged between 5.64-2.2 during winter, 4.55-2.09 during summer and 4.74-2.8 during monsoon. The APTI was higher during winter than during summer and monsoon seasons.

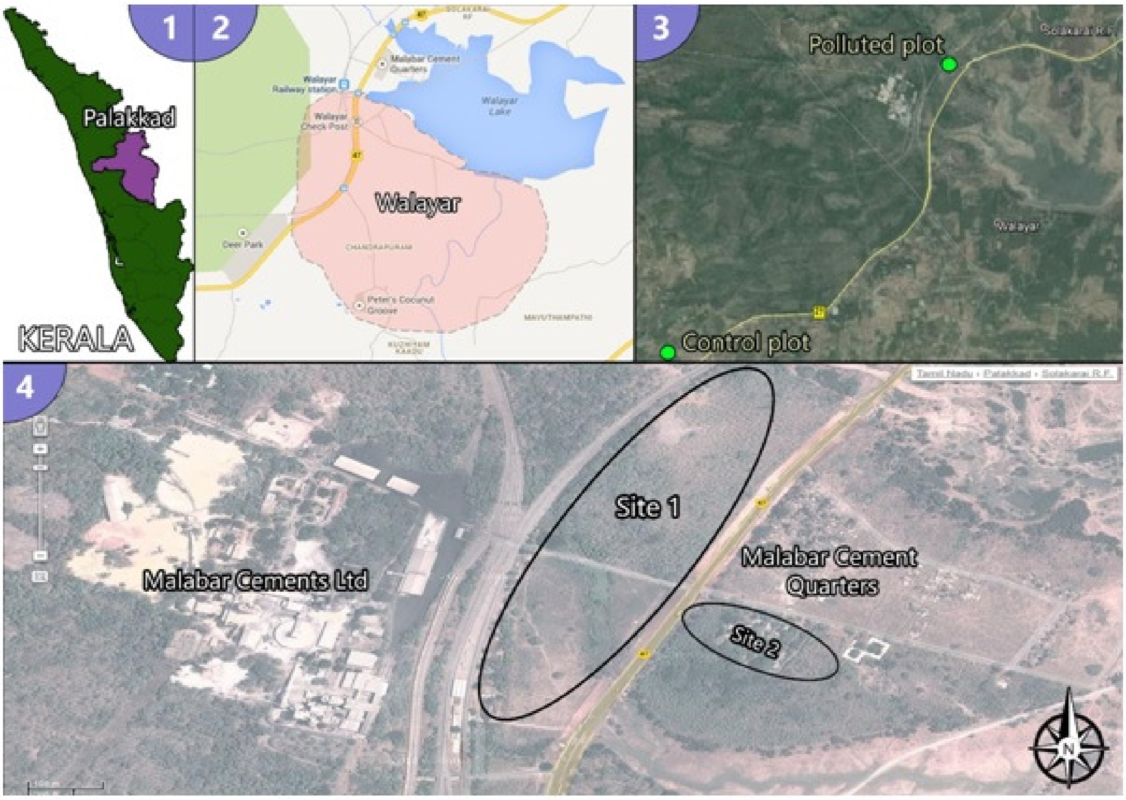

Fig 1. Location of study; 1. Map of Kerala, 2. Map of Walayar, 3. Location of polluted and control plot, 4. Location of polluted plots near Malabar cements Ltd

After the estimation of APTI of the ten species, they were graded into four tolerance classes according to the procedure prescribed by Liu and Ding (2008). The species with higher tolerance in the polluted area were given priority than those in control plots. After grading, it is evident (Table. 1) that *Butea monosperma* was the most tolerant to the particulate pollution, followed by *Cassia fistula*. The most sensitive species were found to be *Bombaxceiba* and *Terminalia catappa. Tectonagrandis,* one of the most prominent moist deciduous species seen in the Western Ghatsfell in the intermediate tolerance category according to this classification. During winter *Butea monosperma* exhibited very high APTI value of 7.76 compared to others not only during winter but for all seasons.

The low tolerance level of *Bombaxceiba* was in accordance with the observations of Varshney (1985), thus very suitable for being used as an indicator species. As it was indicated by Chauhan (2010) that plants with low APTI values can be used to indicate air pollution levels in an area. *Tectonagrandis* which is established in the area in the form of plantations, was below average in tolerating pollution. Varshney (1985) also observed a similar trend in teak and classified it as a sensitive species and as a very good indicator of combination of pollutions. This was further supported by Krishnayya (1997) who also found *Tectonagrandis* to be sensitive to pollution.

Cassia fistula fell in the category of tolerant species based on its performance during all the seasons and was one of the most tolerant species in this study when exposed to particulate pollution stress. *Cassia fistula* had moderate tolerance during winter and summer season, while it expressed highest APTI values in monsoon when exposed to cement dust pollution which is in accordance with the findings of Varshney (1985) and Raza *et al.* (1991). It is also considered as a good indicator of cement dust pollution (Varshney, 1985).

Terminalia catappa was observed to be moderately tolerant when exposed to cement dust pollution during winter. While during summer and monsoon it expressed an intermediate APTI in the polluted plot. But according to APTI grading, *Terminalia catappa* is the second most sensitive species in this study which contradicts with the results of Krishnayya (1997) who observed it to be tolerant when exposed to air pollution stress.

Lakshmi *et al.* (2008) recorded APTI values of 4.57 and 6.42 for *Cassia fistula* and *Artocarpusheterophyllus*, which were similar to the values obtained by these same species in this study. In this study, *Cassia fistula* exhibited a value of 4.50 during monsoon under pollution stress, while the maximum APTI value exhibited by *Artocarpusheterophyllus* were 4.59 during monsoon period in the control plots. But most species exhibited markedly different APTI values during different seasons. This observation stresses that studies of tolerance index of tree species are affected to a great extent by the weather conditions also, and its index will vary with the surrounding environmental factors. Thus it’s important to study the APTI of a species over different time periods to have a better understanding of air pollution tolerance character of the species. For example *Grewiatiliifolia* exhibits moderate tolerance during winter and monsoon periods while during summer, when there is an additional stress of drought this species was found to be sensitive.

Based on the APTI gradation values for the trees, it was found that some species were found to be more sensitive when not exposed to pollution stress than those exposed to pollution. Such a trend was observed in *Artocarpusheterophyllus* and *Terminalia catappa,* both of which exhibited sensitivity during winter, but when exposed to pollution, they expressed moderate tolerance. *Cassia fistula* also tended to be sensitive during monsoon even though it expressed high tolerance while exposed to pollution stress. This may be due to the fact that the trees in the polluted areas were well adapted to the adverse habitat and thus show high tolerance levels compared to those located in non-polluted areas (Radhapriya *et al*., 2012). The APTI value is the least during summer, followed by winter and monsoon. The reason for such lower tolerance during summer can be the exposure to the pollutants for longer periods than other seasons without much of a precipitation to remove the dust load. The high amount of dust on these leaves also made some species sensitive during the summer season. The reason for monsoon having higher APTI than winter periods can be due to the fact that the trees are exposed to lower dust load during monsoon than other seasons, since the dust are washed off by rainfall during this period.

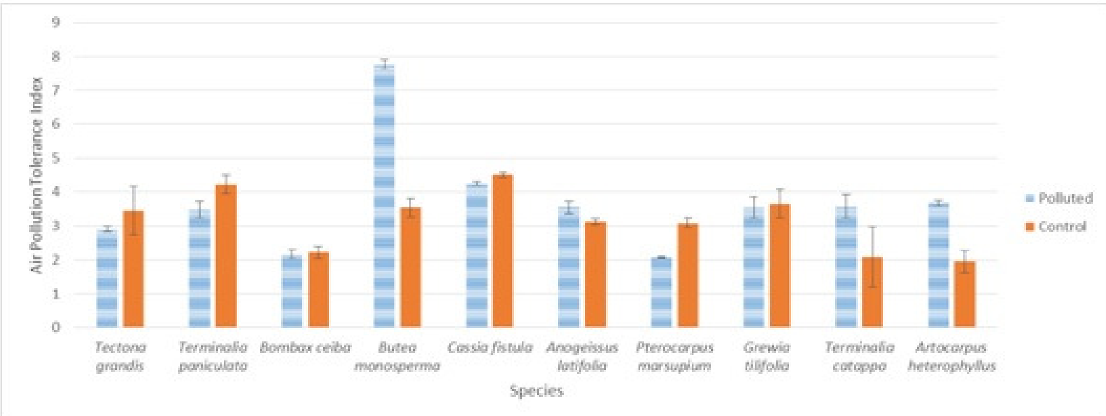

Fig. 2. APTI among different species between polluted and control during winter

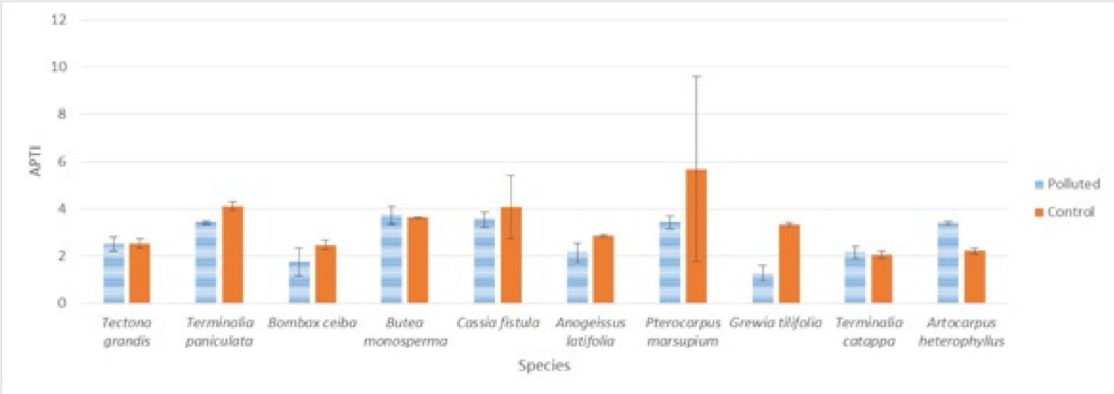

Fig. 3. APTI among different species between polluted and control during summer

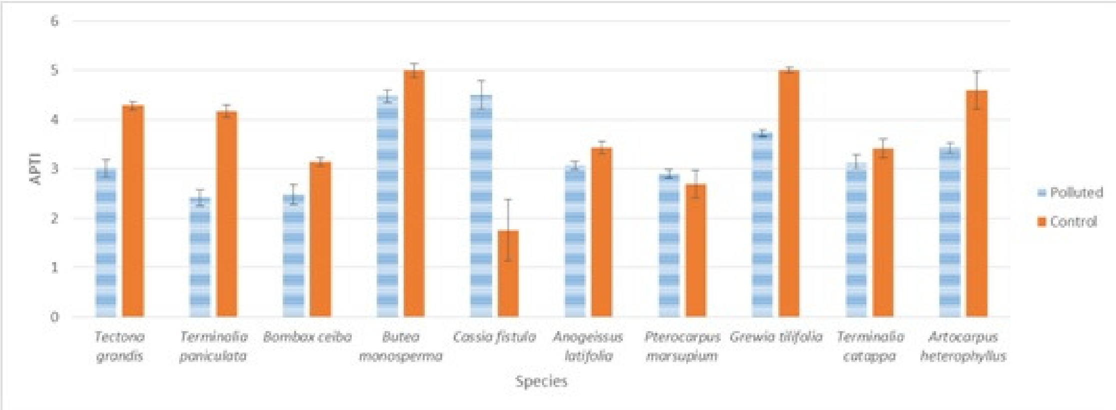

Fig. 4. APTI among different species between polluted and control during monsoon

Table. 1. Tress graded according to APTI values in descending order

Sl No.	Species	Polluted			Control			Score (out of 24)
		Winter	Summer	Monsoon	Winter	Summer	Monsoon	
1	*Butea monosperma*	T	MT	T	MT	MT	T	21
2	*Cassia fistula*	MT	MT	T	MT	T	S	18
3	*Terminalia paniculata*	MT	MT	S	MT	T	MT	17
4	*Grewiatiliifolia*	MT	S	MT	MT	MT	T	17
5	*Artocarpusheterophyllus*	MT	MT	I	S	I	T	15
6	*Tectonagrandis*	I	I	I	MT	I	MT	14
7	*Pterocarpus marsupium*	S	MT	I	I	T	I	14
8	*Anogeissuslatifolia*	MT	I	I	I	I	I	13
9	*Terminalia catappa*	MT	I	I	S	I	I	12
10	*Bombaxceiba*	I	S	I	MT	I	I	12

T – tolerant, MT – moderately tolerant, I – Intermediate, and S – sensitive.

Though evergreen species are most preferable because of their characteristic to have green canopy throughout the year, deciduous species a fundamental role especially in areas unsuitable for the growth of evergreen species. Deciduous species alas poses another problem, like *T. grandis* which having high dust trapping potential was unable to render its services during much of winter season. It was observed that the deciduous character was prolonged in the *T. Grandis* when under the stress of pollution, and remained largely leafless during the winter season. While another promising trend was exhibited by *Butea monosperma*, which typically a deciduous tree when exposed to pollution remained with full canopy throughout the year.

Conclusion

On estimation of tolerance levels of different species when affected by particulate pollution, *Butea monosperma* and *Cassia fistula* was more tolerant than *Tectonagrandis* which is grown extensively in the form of plantations in the area. While species like *Bombaxceiba* and *Terminalia catappa* was found to be sensitive to such pollution constraints. Selection of trees based on such analysis helps in identifying the best suitable trees for a given location, since APTI factors in the stress factors present in the area. Thus species that are resistive to such stress factors may be planted in order for it to survive and flourish in the region. Also such analysis can help in pointing out sensitive species which can then be later used as an indicator of degradation of the site of interest. Planting of tolerant species of economic or ecological values also confirms its chances of survival as well as remediation of the region.

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