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Study of Plant Responses To Polluted Air in Selected Localities: 1. Deoghar, Jharkhand (India)

Abstract

Deoghar, one of the oldest cities of the Jharkhand state, is highly esteemed for its cultural and religious heritage. Overgrowth of its population has been polluting its environment considerably. Considering the role of plants in optimizing environment the present work determines the Air Pollution Tolerance Index (APTI) and certain pertinent biochemical properties of 29 tree species commonly occurring in Deoghar. Among these species 19 were found to be very sensitive and 10 intermediately tolerant to pollution. No highly pollution tolerant species could be detected from the area. This is alarming since absence of tolerant species is likely to subdue pollution abatement. Thus the present environmental scenario in Deoghar necessitates optimization through planting of tolerant indigenous species, protection of its intermediately tolerant species and periodic monitoring of air quality by evaluating the teratological changes in the sensitive species.

Keywords: Deoghar, Air Pollution Tolerance Index, Optimization, Monitoring, Environment

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Introduction

Plants have been evolving through ages the strategies to encounter environmental pollution. Responses of plants to air pollution on evaluation reveal their efficiency as indicators and mitigators of pollution (Mukherjee, 1993; Ghosh and Mukherjee, 2003). The plants provide enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in the air environment. They act as the scavengers for many air borne pollutants and suspended particulate matter. Sensitivity and tolerance of plants to air pollutants get indicated by the pH, relative water content (RWC), ascorbic acid (AA) and total chlorophyll contents of their leaves. Environmental scientists have been trying to optimize environment by utilizing the ability of plants to control pollution. With a view to find out a green solution to the increasing pollution hazards, APTI (Air Pollution Tolerance Index) of the species commonly prevailing in the overcrowded sacred places of Deoghar were determined. This work is in conformity with the earlier work of the present authors (Banerjee and Mukherjee, 2013) emphasizing up on the urgent need to materialize periodic surveillance of both water and air qualities step by step keeping parity with the successive stages of urban development.

Study Site

Deoghar, the main city of Deoghar District of Jharkhand State, is located at 24.48°N and 86.7°E with an average elevation of 254 meters above the mean sea level. Deoghar is also familiar as “Baidyanath Dham" and "Baba Dham". It is a very important pilgrimage centre for Hindus for the Vaidyanath Temple which is one of the twelve Shiva Jyotirlingams and one of the 51 Shakti Peethas in India. Deoghar is aptly considered the God’s ('Dev') abode ('ghar').

The place has a very charming set-up with undulations, water courses and small hills and hillocks. There are a number of small hills in the north- west, south-east, south and southwest parts of Deoghar most of which are covered with forest and appear as series of long ridges with intervening depressions. There are two rivulets, the Yamunajor and Dharua flowing close to the town.For the present work certain locations in and around Deoghar with overcrowding by devotees were selected, viz. Satsanga Ashram, Nandan Pahar, Trikut Pahar (13 km from Deoghar) Tapovana (10 km from Deoghar).

Climate

The district experiences hot summer (March to May), heavy monsoon rains (June to September) and cold dry winter (October to February). Average annual rainfall is 1239 mm and the mean maximum temperatures is 43°C in the summer and mean minimum temperature is 8°C in the winter.

Materials and Methods

For determination of APTI leaf-samples were collected from 29 plant species growing in the study sites by plucking them in the early morning from the tree height of 1 to 2 meters which were brought to laboratory in polythene bags, kept in ice box to encounter the adverse effect of high light intensity and temperature.

The values of concentration of ascorbic acid (Mukherjee and Choudhuri, 1983) and chlorophyll (Arnon, 1949), pH (Singh and Rao, 1983) and relative water content (Barrs and Weatherley, 1962) of the leaf samples were determined. By using these values APTI (Air Pollution Tolerance Index) of each species was determined. The values of pH were determined by using a digital pH meter. Ascorbic acid (Rahman Khan *et al*., 2006) and total chlorophyll content (Arnon, 1949) of leaf extracts were estimated by spectrophotometric methods. Relative water content was estimated gravimetrically by determining the leaf weight under different conditions of hydration (fresh-, wet- and dry-weights) following the method used by Agarwal *et al*., (1991). APTI was then calculated using the following formula.

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

Where R stands for is relative water content in mg/g of leaf sample.

AA stands for the ascorbic acid in mg/100g of dry weight of leaf sample.

T stands for the total chlorophyll in mg/100g and P stands for pH of leaf sample.

On the basis of APTI values plants were categorized into three groups.

1. Sensitive species with values <10
2. Intermediate species with values from10-16
3. Tolerant species with values >17

Results and Discussion

Values of APTI, total chlorophyll (T), pH (P), ascorbic acid (A) and relative water content (R) of leaf samples of each species are indicative of their resilience to environmental pollution (Table 1) which has been discussed in the following.

Chlorophyll content of plants signifies its photosynthetic activity as well as the production of biomass. It is known that chlorophyll content of plants varies from species to species depending upon the age of leaf, pollution level as well as influence of other biotic and abiotic conditions (Katiyar and Dubey, 2001). Degradation of photosynthetic pigments has been widely used as an indicator of air pollution (Ninave *et al*., 2001).Higher chlorophyll content of a plant is certain to augment its tolerance to pollutants. Total chlorophyll content was found to be highest in *Mangifera indica* (4.00 mg/100g fresh weight).

Estimated values of pH of most of the plant samples indicated acidity which may be due to the presence of SO_2 and NO_x in the ambient air causing a change in pH of the leaf sap towards acidity (Swami *et al*., 2004). Low leaf extract pH is known to show a good correlation with sensitivity to air pollution (Escobedo *et al*., 2008 & Pasqualini *et al*., 2001).The change in leaf-pH is likely to influence the stomatal sensitivity to air pollutants. The plants with high sensitivity to SO_2 and NO_2 are known to close stomata faster when they are exposed to the pollutants (Larcher, 1995).

An average value of pH of leaf extracts of *Emblica officinalis* was recorded to be 3.38 which is indicative of a high level of acidity. However the leaf-pH of *Ficus benghalensis* was highly alkaline (8.17).

The values of ascorbic acid of twenty nine species as shown in Table 1 reveals *Cassia renigera* to register the highest concentration (4.91 mg/100g dry wt.), and *Neolamarckia cadamba* the lowest (1.11 mg/100g dry weight).

Ascorbic acid is an antioxidant which protects plants against oxidative damage resulting from photosynthesis and range of pollutants. Ascorbic acid with its strong reductive properties can augment defence mechanism which is directly proportional to its concentration. A high content of ascorbic acid in plant leaf is related to biochemical and physiological functions of species in adverse environmental conditions including air pollution (Keller and Schwager, 1977). Chaudhary and Rao (1977). It has thus been proved that higher the level of ascorbic acid the greater will be the tolerance of the plant to pollution.

Values of relative water content was found to be the least in *Jacaranda mimosifolia* (62.72%) and highest in *Mangifera indica* (93.15%). The higher value of relative water content in a given leaf indicates its higher moisture level in comparison with other species. Higher relative water content favours drought resistance in plants (Dedio, 1975).

An analysis of the APTI values of 29 species (Table 1) shows as many as 19 species to be sensitive. These species have very low levels of tolerance to air pollution. This is alarming. However these species can be used as pollution indicator in monitoring environmental state. The remaining 10 species were found to be intermediately tolerant being capable of moderately scavenging air pollution. Incidentally there was no highly tolerant species in the list. Rapid optimization of the present state of environment with the intermediately tolerant tree species seems to be questionable. Rather the strategies to ensure mitigation of air pollution with plants must introduce indigenous tolerant species in the nude areas of Deoghar with high anthropogenic activities.

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Table 1.Air Pollution Tolerance Indices (APTI) and Relevant Perspectives of Trees Associated with Sacred Places of Deoghar

Plant species (family) [a]	Relative water content (%) [b]	Total chlorophyll (mg/100g fresh wt.) [c]	Leaf extract P^H [d]	Ascorbic acid Contents (mg/100g dry wt.) [e]	APTI value (category) [f]
Acacia auriculoformis (Fabaceae)	83.49	1.70	5.57	3.47	10.87(I)
Aegel marmelos (Rutaceae)	77.44	2.03	5.41	1.50	8.86 (S)
Ailanthus excelsa (*Simaroubaceae*)	77.93	2.02	5.46	4.33	11.03(I)
Artocarpus heterophyllus (Moraceae)	65.25	1.94	5.15	3.90	9.29(S)
Bauhinia variagata (Fabaceae)	65.99	1.96	5.79	1.53	7.78(S)
Butea monosperma (Fabaceae)	77.80	2.03	5.74	2.53	9.75(S)
Cassia fistula (Fabaceae)	69.57	3.96	5.62	3.84	10.64(I)
Cassia renigera (Fabaceae)	80.71	2.57	5.58	4.91	12.07(I)
Cassia siamea (Fabaceae)	70.26	1.97	4.46	4.40	9.86(S)
[a]	[b]	[c]	[d]	[e]	[f]
Casuarina equisetifolia (Casuarinaceae)	77.13	1.42	5.15	2.24	9.18(S)
Dalbergia sissoo (Fabaceae)	78.04	3.22	5.68	2.31	9.86(S)
Drypetes roxburghii (Euphorbiaceae)	83.07	2.41	4.78	2.02	9.76(S)
Emblica officinalis (Euphorbiaceae)	67.62	2.15	3.38	2.06	7.80(S)
Ficus benghalensis (Moraceae)	78.87	1.65	8.17	2.29	10.14(I)
Ficus infectoria (Moraceae)	87.16	1.61	7.82	1.45	9.98 (S)
Ficus religiosa (Moraceae)	80.68	1.75	5.59	3.44	10.59(I)
Grevillea robusta (Proteaceae)	71.19			2.49	9.06(S)
Jacaranda mimosifolia (Bignoniaceae)	62.72	3.15	5.28	1.26	7.33(S)
Mangifera indica (Anacardiaceae)	93.15	4.00	5.26	3.23	12.31(I)
Melia azadirachta (Meliaceae)	71.80	2.82	5.54	3.68	10.26(I)
Mimusops elengi (Sapotaceae)	82.24	2.77	5.14	2.50	10.20(I)
[a]	[b]	[c]	[d]	[e]	[f]
Moringa oleifera (Moringaceae)	84.07	2.32	5.38	4.791	2.10(S)
Neolamarckia cadamba (Rubiaceae)	82.55	2.10	7.13	1.11	9.17(S)
Parkinsonia aculeate (Fabaceae)	77.12	2.09	5.62	2.87	9.82(S)
Parkia biglandulosa (Fabaceae)	82.32	2.57	5.58	2.92	10.61(I)
Saraca asoca (Fabaceae)	87.68	1.79	5.46	1.42	9.70(S)
Spathodea campanulata (Bignoniaceae)	80.26	2.78	5.53	2.10	9.77(S)
Syzygium cumini (Myrtaceae)	72.65	1.43	4.56	3.42	9.31(S)
Terminalia arjuna(Combretaceae)	71.98	1.54	5.04	1.80	8.38(S)

S=Sensitive species <10; I= Intermediate species: 10-16 & T=Tolerant: >17