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Research article

AIR QUALITY STATUS AND ITS EFFECT ON BIOCHEMICAL PARAMETERS OF ROADSIDE TREES SPECIES IN JALGAON CITY, MAHARASHTRA

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ABSTRACT: Trees naturally clean the environment and help in reducing air pollution. The selection of suitable tree species depends on the response of trees to air pollution and can be understood by analyzing the factors that determine resistance and susceptibility. In order to evaluate the resistance and susceptibility level of plant species to air pollutants, twelve different plant species i.e. *Polyalthia longifolia, Nerium indicum, Tabernamontana divariata, Cassia saimia, plumeria rubra, leucaena leucocephala, Azadirachta indica, Zizipus zizuba, Ficus religeosa, Boughanvellia spectabilis, Annona squamosa & Alstonia Scholaris* was taken from Residential (S1), Commercial (SII) & Industrial (SIII) area of the city as this flora is very much common to the Jalgaon city & is planted on the roadside. The quality of air with respect to SPM, SO_2 and NO_2 has been also assessed on respective sites to see its effect on biochemical parameters of the leaves i.e. pH, total water content, chlorophyll and ascorbic acid and evaluate the air pollution tolerance index (APTI) of various plants. It was concluded that *Alstonia scholaris* (31.29) *and Polyalthia longifolia* (22.78) have very high APTI value over control so these are considered as high tolerant tree species. *Bougainvillea spectabilis* (22.91) *and Tabernamontana divariata* (22.62) *have* slightly more APTI value over control so these are considered as moderately tolerant tree species. *Ficus religeosa* (21.63) *and Plumeria rubra* (22.51) have less APTI value than control, so these are sensitive species respectively. The present studies are therefore handy for future planning. The plant species which are more sensitive act as biological indicators of air pollution. Also, the estimation of four important biochemical parameters gave more accurate and reliable results than based on a single biochemical parameter.
Key words: air pollution, biochemical, chlorophyll, ascorbic acid, APTI.

INTRODUCTION

Air pollution is one of the major problems faced by the people globally, especially in urban areas of developing countries like India. It has become a serious environmental stress to plants due to increasing industrialization and urbanization during the last few decades [13]. The principal air-quality pollutant emissions from petrol, diesel and alternative fuel engines are carbon monoxide (CO), oxides of nitrogen, unburnt hydrocarbons and particulate matter. Air pollution control is more complex than most other environmental challenges. No physical or chemical method is known to ameliorate aerial pollutants [4]. Plants, the main green belt (GB) component, act as a sink and as living filters to minimize air pollution by absorption, detoxification, accumulation and/or metabolization without sustaining serious foliar damage or decline in growth, thus improving air quality by providing oxygen to the atmosphere [3,14,18]. Plants developed characteristic response to particular types & levels of pollution and play an important role in monitoring and maintaining the ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide, oxygen and also provide enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in the air environment [6, 19]. Thus, sensitive plant species are suggested as bioindicators of urban air quality and tolerant species may be useful in mitigating or reducing the air pollution load.

Air Pollution Tolerance Index (APTI) of different tree species based on four biochemical parameters, namely, leaf extract pH, ascorbic acid, total chlorophyll and relative water content was determined by adopting the formulae by Singh and Rao [17] to find out the response of various tree species to air pollutants growing in different areas. Thus, the present study aims to evaluate the air pollution tolerance index (APTI) of various tree species growing in Residential, Commercial and Industrial areas of the city to find out highly tolerant, moderately tolerant and sensitive tree species. Ambient air quality is in these areas is also assessed to see the effect of air pollutants on biochemical parameters of the tree species.

MATERIALS AND METHODS

Study Area

Jalgaon city is the trade and commercial center of North Maharashtra region with NH-6 passing through the city and having significant collection and distribution of agricultural goods mainly cotton-textile and vegetable-oil mills, particularly groundnut-oil and hydrogenation plants. Being a district place, Jalgaon have large MIDC area, reputed educational institutes, government offices, agriculture/grain/vegetable markets, big shopping complexes situated in different parts of the city and hence, exposed to heavy vehicular pollution load. For the study, the locations are divided into three zones - Residential (I) i.e. Adarsh Nagar, Commercial (II) i.e. Bhoite Market, Near Prabhat Chowk and Industrial (III) i.e. Near Legrand, MIDC areas of Jalgaon City. The mean monthly temperature during the study period ranges between 12 to 38◦C.The annual average rainfall was 700 mm; with 70-75% relative humidity during the study period (December 2010 to March 2011). The location map of study area is shown in Fig. 1

Air Pollution Status

Ambient air pollution status of Jalgaon city at three sites selected for the study was evaluated. The study was carried out for the period of four months i.e. from December 2010 to March 2011. The air quality with respect to different parameters such as SPM; SO_2 and NO_2 was studied in the selected areas. Air sampling was done by high volume sampler on glass fibre filter paper for 24 hr. The SPM ($\mu g/m^3$) was calculated by difference in the initial and final weights of the filter paper. The concentration of SO_2 ($\mu g/m^3$) gas in the ambient air was measured by West-Geake method [20] and NO_2 ($\mu g/m^3$) gas was estimated by the modified method of Jacob and Hochheisher [8].

Determination of APTI

For the study, twelve roadside tree species such as *Polyalthia longifolia, Nerium indicum, Tabernamontana divariata, Cassia saimia, Plumeria rubra, Leucaena leucocephala, Azadirachta indica , Zizipus zizuba, Ficus religeosa, Annona squamosa, Boughanvellia spectabilis and Alstonia scholaris* were randomly selected from the immediate vicinity of the selected locations in different zones. The fully matured fresh leaves of tree species were collected from different sites and brought aseptically to laboratory and stored in refrigerator. The analysis was replicated four times for each biochemical factor for every month (Dec-Mar). All the four biochemical parameters, Relative leaf water content (RWC) by Sen and Bhandari [16], Total Chlorophyll Content by Arnon,[2], leaf extracts pH by Singh and Rao [17] and ascorbic acid content by Keller and Schwager [10] were estimated from the collected leaf samples.

The air pollution tolerance indices of twelve tree species were determined by following the method of Singh and Rao [17] to evaluate the tree species for their tolerance to air pollution. 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, and
R = Relative water content of leaf (%)

RESULTS

The ambient air pollution status at three zones – residential, commercial and industrial areas of Jalgaon District and National Ambient Air Quality Standards are presented in Table 1. From the estimated values it is observed that MIDC (III) is the most polluted site having values as SPM (979.17 $\mu g/m^3$), SO_2 (82.25 $\mu g/m^3$) and NO_2 (68.68 $\mu g/m^3$) and Adarsh Nagar (I), having the concentration of SPM (185.38), SO_2 (14.27) and NO_2 (20.95), is observed as the least polluted site. The ambient air near Legrand, MIDC area is found to be polluted with high concentration of SPM. This may be due to various industrial operations and excess traffic volume in the area.

Air Pollution Tolerance Index (APTI) was calculated for 12 tree species growing in residential, commercial and industrial areas of Jalgaon city and the data is presented in Table 2, 3 and 4 respectively. From the obtained APTI values it can be observed that *Ficus religeosa* shows the highest value at Adarsh nagar (24.35) which is a residential site and *Alstonia scholaris* shows the highest value at Bhoite market, Prabhat chowk (28.39) as well as legrand, MIDC site (31.29) which are commercial and industrial sites respectively but Cassia *saimia* shows lowest values at I (18.28), at II (17.08) and at III (14.02). The highest APTI values at the residential Site (I) were reported in Ficus *religeosa* (24.35), *Leucaena leucocephala* (23.43) and *Plumeria rubra* (23.15). The lowest APTI values were reported in *Polyalthia longifolia* (19.23) and *Cassia saimia* (18.28) (Table 2). At commercial Site(SII) (Table 3), the highest APTI values were reported in *Alstonia scholaris* (28.39), *Tabernamontana divariata* (24.22) *and Polyalthia longifolia* (24.21) and the lowest APTI values were observed *in Cassia saimia (*17.08) and *Ficus religeosa* (20.12).High APTI values were reported in the species *Alstonia scholaris* (31.29)*, Boughanvellia spectabilis*(22.91)*, Polyalthia longifolia* (22.78) growing at the industrial area while the low values in the plant species *Cassia siamia* (14.02) and *Azadirachta indica* (18.72) (Table 4). APTI of twelve different plant species at residential, commercial and industrial area are given in Fig. 1

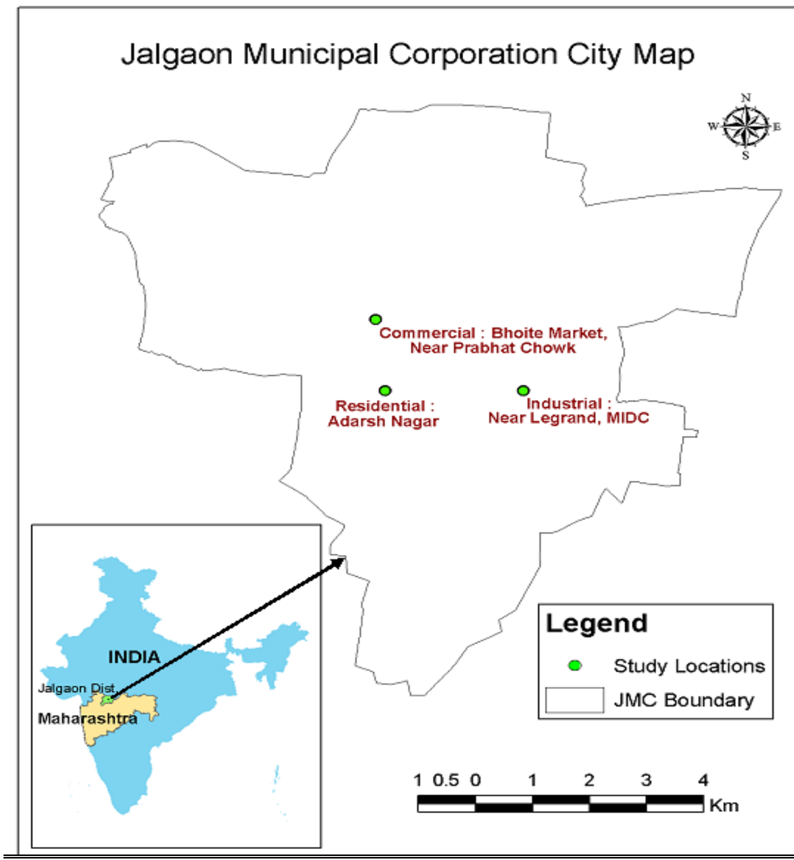

Figure 1: Location Map of Study Area

Table 1 – Ambient air pollution status of respective sites in Jalgaon city.

Site	**Adarsh Nagar (I)**			**Bhoite Market (II)**			**MIDC (III)**		
Parameter	**SPM**	**SO_2**	**NO_2**	**SPM**	**SO_2**	**NO_2**	**SPM**	**SO_2**	**NO_2**
Dec	201.8	15.24	20.58	244.8	22.98	65.42	863.5	84.1	63.9
Jan	249.6	19.64	21.87	279.2	24.49	43.68	768.8	77.5	62.7
Feb	137.5	9.37	18.25	178.3	24.86	61.98	1296.2	79.1	73.1
Mar	152.6	12.84	23.11	258.9	21.62	59.82	988.1	88.3	75.02
Average	185.3	14.27	20.95	240.2	23.48	57.72	**979.17**	**82.25**	68.68
NAAQS	**200**	**80**	**80**	**200**	**80**	**80**	**500**	**120**	**120**

All values are in $\mu g/m^3$;
Average is taken from four months (Dec- Mar)
NAAQS= National Ambient Air Quality Standards

Table 2- Air pollution tolerance index (APTI) of plant species around Residential (I) area of Jalgaon city.

Tree Species	pH	TCh (mg/g)	RWC(%)	AA (mg/g)	APTI
Polyalthia longifolia	6.71±0.76	0.153±0.065	62.17±19.46	14.57±2.33	19.23±1.88
Nerium indicum	6.92±0.78	0.146±0.036	76.50±5.22	17.75±1.31	19.51±0.35
Tabernamontana divariata	6.87±0.27	0.165±0.024	76.00±10.33	19.9±1.57	21.61±1.45
Cassia saimia	4.67±0.45	0.120±0.043	65.58±6.21	16.20±4.32	18.28±1.46
Plumeria rubra	7.09±1.06	0.161±0.085	76.50±5.22	21.37±1.06	23.15±2.64
Leucaena leucocephala	6.92±0.87	0.172±0.094	62.61±14.23	24.1±1.11	23.43±3.16
Azadirachta indica	7.31±0.61	0.132±0.013	71.19±3.28	12.51±1.09	19.37±0.98
Zizipus zizuba	7.19±0.97	0.2±0.063	60.32±16.18	18.9±3.24	19.93±4.28
Ficus religeosa	7.92±0.73	0.116±0.018	72.46±2.27	18.9±3.24	24.35±2.69
Annona squamosa	6.94±1.35	0.191±0.099	60.33±16.18	20.37±3.52	21.86±5.40
Boughanvellia Spectabilis	7.18±0.89	0.236±0.042	67.30±8.05	18.92±4.19	20.69±3.26
Alstonia scholaris	7.32±0.39	0.126±0.089	77.69±4.27	20.12±4.31	21.17±3.47

All values are means (n=4) ± SD.

RWC = Relative water content, AA = Ascorbic acid content, TCh = Total leaf chlorophyll

Table 3- Air pollution tolerance index (APTI) of plant species around Commercial (II) area of Jalgaon city.

Tree Species	pH	TCh (mg/g)	RWC (%)	AA (mg/g)	APTI
Polyalthia longifolia	7.37±0.53	0.081±0.047	75.87±10.91	22.2±5.84	24.21±5.29
Nerium indicum	7.16±0.63	0.340±0.53	78.36±8.21	21.12±2.97	23.83±4.48
Tabernamontana divariata	7.11±0.58	0.193±0.040	79.68±2.91	21.95±6.23	24.22±5.53
Cassia saimia	5.91±0.94	0.121±0.041	70.19±7.71	19.5±2.09	17.08±2.36
Plumeria rubra	6.85±0.65	0.112±0.070	70.08±6.09	23.12±3.55	23.06±3.33
Leucaena leucocephala	7.51±1.75	0.112±0.016	76.45±15.88	23.5±2.21	23.77±3.20
Azadirachta indica	7.03±0.41	0.171±0.059	72.77±0.79	23.2±5.42	24.03±4.45
Zizipus zizuba	6.84±0.86	0.170±0.035	59.86±14.64	21.2±2.21	20.80±2.37
Ficus religeosa	6.80±1.28	0.149±0.023	78.62±12.84	18.42±7.29	20.12±3.97
Annona squamosa	7.45±0.42	0.140±0.042	65.79±6.68	23.2±0.78	24.16±0.91
Boughanvellia Spectabilis	7.12±1.29	0.217±0.063	68.73±6.21	20.85±0.61	22.03±2.43
Alstonia scholaris	7.54±0.42	0.198±0.082	78.25±3.82	25.65±3.73	28.39±3.90

All values are means (n=4) ± SD.

RWC = Relative water content, AA = Ascorbic acid content, TCh = Total leaf chlorophyll

Table 4- Air pollution tolerance index (APTI) of plant species around Industrial (SIII) area of Jalgaon city.

Tree Species	pH	TCh (mg/g)	RWC (%)	AA (mg/g)	APTI
Polyalthia longifolia	7.43±0.51	0.146±0.082	69.97±3.41	15.9±8.74	22.78±2.76
Nerium indicum	7.24±0.71	0.184±0.093	66.75±3.17	21.32±1.82	22.08±2.50
Tabernamontana divariata	7.25±1.05	0.211±0.005	60.65±5.69	22.27±1.68	22.62±1.33
Cassia saimia	7.00±1.03	0.188±0.122	54.65±6.56	16.4±5.83	14.02±5.76
Plumeria rubra	7.12±0.58	0.165±0.077	73.33±3.40	20.82±1.31	22.51±1.73
Leucaena leucocephala	6.71±1.00	0.181±0.029	67.69±15.50	21.35±2.90	21.44±2.20
Azadirachta indica	6.56±0.51	0.0181±0.069	61.31±8.19	18.67±2.83	18.72±1.48
Zizipus zizuba	6.91±1.28	0.159±0.094	68.67±11.95	19.85±1.18	20.77±1.52
Ficus religeosa	6.92±1.05	0.180±0.077	69.52±2.01	20.85±2.18	21.63±3.38
Annona squamosa	7.11±0.78	0.204±0.055	60.88±8.70	22.17±2.67	22.43±2.84
Boughanvellia Spectabilis	7.39±0.20	0.208±0.058	62.56±5.92	24.8±3.37	22.91±2.42
Alstonia scholaris	8.01±0.84	0.266±0.044	80.20±6.80	28.12±4.42	31.29±3.03

All values are means (n=4) ± SD.

RWC = Relative water content, AA = Ascorbic acid content, TCh = Total leaf chlorophyll

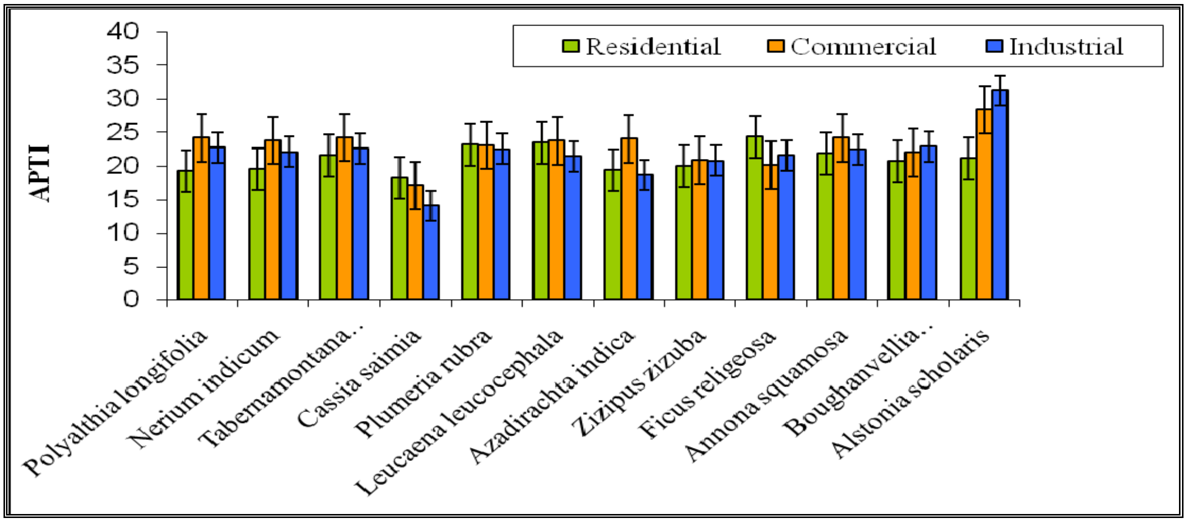

Figure 2: Graph showing APTI±SD of tree species in Residential, Commercial and Industrial areas of Jalgaon city.

DISCUSSIONS

The four biochemical parameters evaluated for APTI varied from species to species and played a significant role to evaluate the tolerance levels and resistance of tree species to air pollution. The tolerant species of plants function as pollution "sink" and therefore a number of environmental benefits can be desired by planting tolerant species in polluted areas [12]. Ascorbic acid is water-soluble and abundant component in plants. It is associated with chloroplasts and apparently plays a role in ameliorating the oxidative stress of photosynthesis. In addition, it has number of other roles in cell division and protein modification. Ascorbic acid also influences the resistance of plants to adverse environmental conditions, including air pollution [10]. Chlorophyll is an extremely important biomolecule and green pigment found in chloroplasts of plant cells that carries out the bulk of energy fixation in the process of photosynthesis. Air pollution causes dust accumulation on the surface of leaves which affects the light availability for photosynthesis and blocks stomatal pores for diffusion of air and thus puts stress on plant metabolism [1,5,7,9]. pH acts as an indicator for sensitivity to air pollution [15]. Relative Water Content (RWC) in leaf tissues are commonly calculated to assess the water status of plants as it gives the relative amount of water present in the plant tissues. Leaf water status is intimately related to several leaf physiological variables, such as leaf turgour, growth, stomatal conductance, transpiration, photosynthesis and respiration [11].

CONCLUSIONS

In conclusion, it seems that different tree species respond differently to air pollution and showed great variation in all the four biochemical parameters. Moreover, an overview of the results obtained from calculation of APTI values of twelve different tree species revealed that all the biochemical parameters are important and greatly govern in evaluation of APTI values and thus, selection of suitable tree species to remove/reduce air pollution. Among all the plant species *Alstonia scholaris*, , *Polyalthia longifolia*, *Nerium indicum* have much more high APTI values i.e. 31.29, 22.78 and 22.08 respectively than the residential area (SI) so these plant species are termed as tolerant tree species. Some plant species as *Bougainvillea spectabilis* , *Tabernamontana divariata* , *Annona squamosa,* *Zizipus zizuba* and *Azadirachta indica* have slightly more APTI values i.e. 22.91,22.62, 22.43,20.77 and 18.72 respectively than the residential area (SI) are termed as moderately tolerant tree species and remaining plant species as *Ficus religeosa*, *Plumeria rubra Leucaena leucocephala* and *Cassia saimia* have low APTI i.e. 21.63, 22.51, 21.44 and 14.02 respectively than the residential area (SI) are termed as sensitive tree species. Thus, the calculation of APTI of tree species is an important tool to identify and evaluate the impact of air pollution.

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