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Identification of Plant Species for Biomonitiring of Air Pollution at Visakhapatnam City

KEYWORDS: Biomonitoring, Sensitive species, Air pollution tolerance index, Chlorophyll, Ascorbic acid,

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ABSTRACT *Urban vegetation can reduce Environmental pollution to some extent; it may be affected adversely if the pollution levels are beyond the tolerance limits necessitating monitoring both the levels of air pollution and the response of vegetation. In spite of well-developed physico-chemical monitoring programmes, Biomonitoring of air pollution is gaining popularity because of its inherent strengths. The present paper deals with the identification of sensitive species that can help biomonitoring of air pollution at Visakhapatnam, a fast developing industrial city of Andhra Pradesh.*

INTRODUCTION:

Quality urban vegetation can reduce air pollution, regulate microclimate, save energy consumption, protect watersheds and can also aid waste recycling to a limited extent (Airola and Buchholz, 1984). Though monitoring programmes based on physico-chemical methods are developed for continuous monitoring of Air pollution, these monitoring types may not help in understanding the impacts on vegetation, human beings and structures (Subba Rao, 2005). This can be addressed through Biomonitoring of Air pollution. Though biomonitoring of air pollution is still in its infancy, several studies indicate that biomonitoring techniques can be effectively used for both monitoring of air pollutants and monitoring of impacts on vegetation (WHO 2000).

The present paper is an attempt in this direction and deals with the identification of sensitive plant species that can help biomonitoring of air pollution at Visakhapatnam, a fast developing industrial city of Andhra Pradesh.

METHODS:

The sampling stations selected for the Visakhapatnam (17^0 42^1N -83^1 E) study include: Site 1: ***Waltair Area***, primarily a Residential Zone; Site 2: ***Marripalem Highway Area***; Site 3: ***Mindi Area***; and Site 4: ***Port Area***.

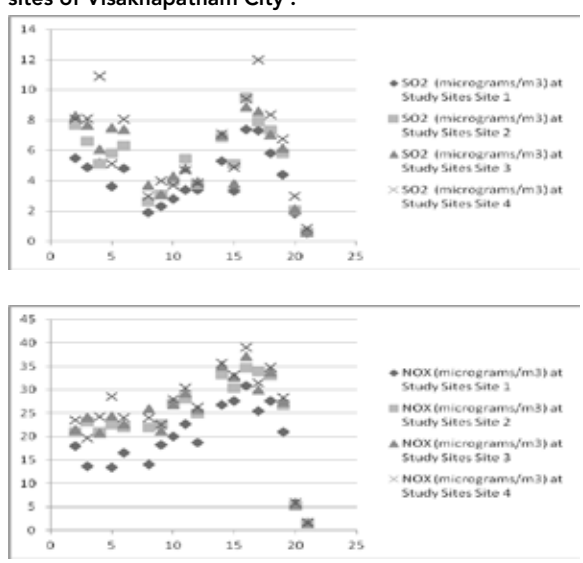
Sites 2, 3 and 4 can be considered as industrial zones of the city. The four stations selected are at considerable distance and reasonably cover the Bowl area of the city's air spread. Tender leaves of all the six plant species (Ocimum tenuiflorum, Tridax procumbens, Cathranthus roseus, Tribulus terrestris, Croton bonplandianum and Sida acuta.) were collected from the above four sites. All the chemicals used in the experiment are of analytical grade. The tender leaves were analyzed for pH, Relative water content, Ascorbic acid and Chlorophylls using standard methods (Sadasivam and Manickam, 1997). The data relating to SPM and PM_{10}, Sulphur dioxide (SO_2) and Oxides of Nitrogen (NO_x) was drawn from the ongoing National Ambient Air Quality Monitoring program (NAAQM). Ambient air was monitored for SPM and PM_{10}, Sulphur dioxide (SO_2) and Oxides of Nitrogen (NO_x) as per the standard methods (West and Gaeke 1956 and West and Ordiveza, 1962).

The Air Quality Index (AQI) of the four sites in the city for the critical pollutants has been estimated by two widely used approaches (CPCB, 2012).Air pollution Tolerance Index (APTI) was derived using the leaf parameters; pH of the leaf extract, Relative water content, Ascorbic acid and Chlorophyll as described by Rao et al., (1985).

RESULTS AND DISCUSSION:

The results relating to the present study are presented in Tables 1-3. The SO_2 concentrations as shown in (Figure 1) had overlapping ranges among the 4 sites.

Figure1: Concentrations of the SO_2, NO_X at the four study sites of Visakhapatnam City .



The annual mean of the SO_2 concentration at Site 1 was 4.41 µg/m^3 while at Site 2, Site 3, and Site 4, the annual means of SO_2 concentration were 5.81 µg/m^3, 6.15 µg/m^3 and 6.75 µg/m^3, respectively. The annual mean of the NO_X concentration (Figure 1) at Site 1 was 20.96 µg/m^3 while Sites 2, 3, and 4, recorded 26.65 µg/m^3, 27.42 µg/m^3 and 28.34 µg/m^3, respectively. The results indicate that Site 1 had relatively lower concentrations of NO_X in the ambient air, while Site 4 exhibited comparatively higher values. Compared to the concentrations of the SO_2, the NO_X concentrations were higher at all the sites, in all the seasons throughout the monitoring period.

Among the concentrations of the three pollutants Figure 2, the SPM concentrations were higher at all the sites, in all the seasons throughout the monitoring period and relatively they are nearer to the permissible levels and PM_{10} also followed the same trend.

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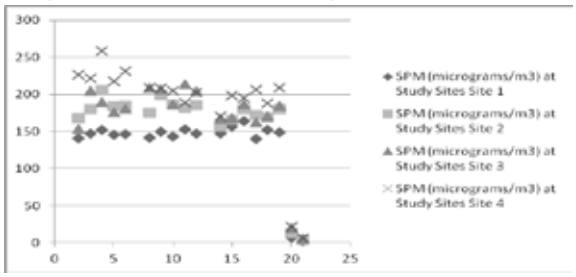
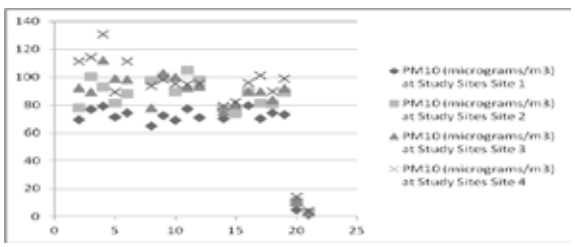
Figure 2: Concentration of the SPM & PM_{10} at the four study sites of Visakhapatnam City.





The data relating to AQI presented in Table 2 show that all the Sites can be considered as Lightly Polluted Sites. However, among the four sites, Site 1 was the Least Polluted, while the pollution loads at Sites 2, 3 and 4 have increased by 23.1%, 26.9% and 37.5% respectively, over Site 1.

Table 2:Ambient Air Quality Index and the Exceedence Factor of the Air Quality Parameters at the four study sites of Visakhapatnam City

Particulars	Site 1	Site 2	Site 3	Site 4
Air Quality Index				
Winter	32.3	40.03	42.45	49.28
Summer	31.9	42.25	42.93	43.31
Rainy	36.55	41.15	42	45.18
Annual	33.48	41.23	42.48	46.05
Exceedence Factor				
SO_2	0.055	0.076	0.077	0.084
NO_X	0.262	0.333	0.343	0.354
SPM	0.412	0.499	0.514	0.58
PM_{10}	0.61	0.741	0.765	0.824

AIR POLLUTION TOLERANCE INDEX (APTI)

Air Pollution Tolerance Index was computed from pH, Relative water content, Ascorbic acid and Chlorophylls which are shown in Tables 1 & 3.

Table 1: pH, Ascorbic Acid &Relative water content (%), Air pollution tolerance index (A.P.T.I) content of the Leaf Extracts of the Test Species at Visakhapatnam Study Sites 1, 2, 3 and 4

Name of the species	pH			
	Site 1	Site 2	Site 3	Site 4
Cathranthus roseus	7.84	7.25	6.93	6.18
Croton bonplandianum	7.68	6.96	6.24	6.11
Ocimum tenuiflorum	7.99	6.96	6.42	5.24
Sida acuta	7.66	7.45	6	5.9
Tribulus terrestris	7.74	7.14	6.33	6
Tridax procumbens	7.6	6.93	6.19	6.1
	Ascorbic acid (*mg/g*)			
Cathranthus roseus	1.46	0.97	0.83	0.49
Croton bonplandianum	0.88	0.61	0.48	0.33
Ocimum tenuiflorum	1.49	0.65	0.47	0.16
Sida acuta	1.86	0.79	0.74	0.66
Tribulus terrestris	0.97	0.68	0.47	0.41
Tridax procumbens	1.67	0.98	0.48	0.2
	Relative water content (%)			
	Site 1	Site 2	Site 3	Site 4
Cathranthus roseus	94	72	67	53
Croton bonplandianum	95	74	64	50
Ocimum tenuiflorum	96	76	69	54
Sida acuta	93	71	60	52
Tribulus terrestris	97	70	63	51
Tridax procumbens	98	80	70	55
	Air Pollution Tolerance Index (APTI)			
Cathranthus roseus	11.507	8.079	7.335	5.677
Croton bonplandianum	10.378	7.957	6.799	5.257
Ocimum tenuiflorum	11.274	8.167	7.277	5.497
Sida acuta	11.149	7.832	6.575	5.697
Tribulus terrestris	10.648	7.567	6.648	5.389
Tridax procumbens	11.438	8.818	7.364	5.634

Table 3. Percentage Reduction over Control in pH, Ascorbic Acid, Total chlorophyll and Relative water content at visakhapatnam study area.

Name of the species	PH		
	Site 2	Site 3	Site 4
Cathranthus roseus	7.525	11.607	21.173
Croton bonplandianum	9.375	18.75	2.442
Ocimum tenuiflorum	12.891	19.649	34.418
Sida acuta	2.741	21.671	22.976
Tribulus terrestris	7.751	18.217	22.48
Tridax procumbens	8.815	18.552	19.736
	Ascorbic acid		
Cathranthus roseus	33.561	43.15	66.438
Croton bonplandianum	30.681	45.454	62.5
Ocimum tenuiflorum	56.375	68.456	89.261
Sida acuta	57.526	60.215	64.516
Tribulus terrestris	57.526	51.546	57.731
Tridax procumbens	41.317	71.257	88.023
	Total Chlorophyll		
Cathranthus roseus	23.79	69.427	69.427
Croton bonplandianum	5.42	10.06	26.409
Ocimum tenuiflorum	45.33	50.508	74.283
Sida acuta	20.122	22.134	28.302

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Tribulus terrestris	41.11	46.696	48.653
Tridax procumbens	36	36.635	72.048
	Relative Water Content		
Cathranthus roseus	23.404	28.723	43.617
Croton bonplandianum	22.105	32.631	47.368
Ocimum tenuiflorum	20.833	28.125	43.75
Sida acuta	23.655	35.483	44.086
Tribulus terrestris	27.835	35.051	47.422
Tridax procumbens	18.367	28.571	43.877

The Ascorbic acid content being a factor that responds to SO_2, the index primarily indicates the response and tolerance to the SO_2. The index for the test species at the four selected sites was used to understand the relative sensitivity of the species. In all the six species studied, the Air Pollution Tolerance Index has declined in the order Site 1> Site 2 > Site 3 > Site 4.

Plants range in sensitivity to airborne pollutants from highly sensitive to highly tolerant (Weinstein and Laurence, 1989) and tolerance varies on many plant factors and of its environment. Species with low tolerance to a specific pollutant are often called sensitive and these can serve as biological indication of that pollutant. Similarly, plant species response to a pollutant in one geographical region might not be the same in other geographical areas (Raza et al. 1985). The present study has considered the biochemical changes in the leaf to evaluate the tolerance levels of the test plants. In other words, the APTI concept suggested by Singh and Rao (1989) was adopted. In addition to the Chlorophyll and Ascorbic acid contents in the leaf, the pH and the relative water content are also taken in to account.

Kulshreshthra et al (2003) have used the APTI concept that was used in the present study, and evaluated the tolerance levels of several Indian herb species from different areas. The species identified in the present study can be considered as sensitive species and can indicate the air quality. As per the percent decline in the APTI, from Site 1 to Site 4, the degree of the sensitivity of the six species was determined and the order (more sensitive to less sensitive) is given below:

Ocimum tenuiflorum > Tridax procumbens > Cathranthus roseus > Tribulus terrestris > Croton bonplandianum > Sida acuta.

CONCLUSION:

In the present study the biological response, in terms of biochemical changes, of some plants were considered as biomonitors to the air pollution at Visakhapatnam city. Six species of herbs (Cathranthus roseus, Croton bonplandianum, Ocimum tenuiflorum, Sida acuta, Tribulus terrestris and Tridax procumbens), which were found to be common to all the four study sites, were selected for studying the biological response using Air Pollution Tolerance Index (APTI).

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