



Effect of Air Pollutants in Biochemical Parameters of Selected Plant

Species of Jhansi City (Uttar Pradesh)

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Abstract: *Though water and land pollution is very dangerous, air pollution has its own peculiarities, due to its transboundary dispersion of pollutants over the entire world. Air pollution is one of the serious problems faced by the people globally, especially in urban areas of developing countries like India. All these in turn lead to an increase in the air pollution levels and have adverse effects on the health of people and plants. Variations in biochemical parameters can be used as indicators of air pollution. Analysis data reveals that SPM and RSPM level were exponentially higher during winter season. The concentration of SO₂ and NO_x was greatly influenced by the automobile emission. Higher concentration of SO₂ and NO_x was found in commercial area as well as heavy traffic street area while NO_x concentration was found higher than SO₂. The content of chlorophyll in all the seasons in plants was higher in residential area than commercial area and heavy traffic street area. The average pheophytin content in plant leaves at all the location in winter was higher than chlorophyll content, which indicates the conversion of chlorophyll to pheophytin or reduced biosynthesis. Carotenoids content was maximum in monsoon and minimum in winter at all locations. Protein content was highest in both plants species in monsoon at all the locations, and the minimum reduction was found in both plants in winter at all the locations where the pollution level was comparatively high. POD activity was lowest in monsoon and highest in winter at all the locations. An increase in POD activity was observed at commercial and heavy traffic street location comparison to residential locations. This study observed the effect of air pollution on Peepal (*Ficus religiosa*) and Ashok (*Polyalthia longifolia*) as well as the suitability of selected plants as intermediate tolerant species to pollution.*

Keywords: *Air Pollutants, Ficus religiosa, Polyalthia longifolia, Protein, Chlorophyll*

I. Introduction

A number of harmful gases are added to the atmosphere as the result of emission from industries and other wastes. They adversely affect air quality and make it unfit for living organisms. In our country data on air quality have been collected by National Environmental Engineering Research Institute (NEERI). Although, there are several parameters to evaluate the air quality. Generally SO₂, NO_x and SPM are used to have a fair idea of pollution load carried by the air^{[1] [29]}. The industrialization is the need of modern world, but its increasing pace has resulted into serious environmental hazards^[16]. Motor vehicles constitute the most significant source of particulate matter in the urban environment^[35]. A direct relationship between particulate constituents and street activity was identified by Chabban^[6]. SO₂ an important gaseous pollutant is released into the urban air by both natural and anthropogenic sources like sulphur bacteria activities, burning of fossil fuel which is used in transportation, domestic sector and power generation^{[7] [32]}. Oxides of nitrogen are released in all types of combustion as are formed by the oxidation of atmospheric nitrogen at high temperature. NO_x are usually emitted from automobile exhaust^{[9] [30]}. The altered ambient environment due to the intrusion air pollutants in urban area is exerting a profound influence on the morphological, biochemical and physiological status of plants, and therefore its responses^[7]. The harmful effects of air pollution on plants are well established^{[10] [11] [30] [33]}. Air pollutants influences various anatomical, physiological and biochemical processes of plants^{[22] [31] [33]}. Air pollutants enter plant leaves through stomata passively during gas exchange of respiration and photosynthesis, and then pass into the intercellular spaces of mesophyll tissue causing various anatomical, morphological and physiological anomalies^{[10] [30]}. Air pollutants either alone or in combination with other pollutants influences plant physiology. Two important plant mechanisms photosynthesis and protein production decreases due air pollution^{[7] [17] [30]}. Peroxidase (POD) is an air pollution marker enzyme. Its activity varies with the species of trees, season and concentration of pollutant gases. Particulates cause occlusion of stomata and decrease in the efficiency of gaseous exchange. Plants are an integral basis for all ecosystems and also most likely to be affected by airborne pollution which are identified as the organisms with most potential to receive impacts from ambient air pollution. Also the effects are most often apparent on the leaves which are usually the most abundant and most obvious primary receptors of large number of air pollutants. Bio monitoring of plants is an important tool to evaluate the impact of air pollution^{[14] [29]}. Trees play an important role in improvement of urban air quality because of the capacity to intercept with the air borne matter; therefore plants are widely used as passive

indicators of air pollution. Biochemical changes in plants follows the air quality trends hence biochemical parameters seems to be suitable markers of air pollution and can be used to draw or edit air quality maps^[30]. Realizing the importance of trees and their role in air pollution monitoring and control present study is conducted in field conditions. In the present study ambient air quality of Jhansi City is assessed wrt, SPM, RSPM, SO₂ and NO_x. Effect on plants is assessed by the variations in selected biochemical parameters in plant leaves.

II. Material and Methods

a. Study area: Jhansi is one of the important districts out of the seventeen districts of Bundelkhand region. Bundelkhand region occupies almost 70,000 km² of the central plains in India, bounded to the north by the Yamuna River and to the south by the hills of the Vindhyan Plateau. Jhansi city is one of the rapidly growing cities in Central India covering an area of 152 km². It is headquarter of the Jhansi Division and also Jhansi district which lies between 23°35'-26'N and 78°-82' E. The city supports a population of around 5 lakhs and a floating population of around 30,000 arriving from the adjoining villages during the day time. The rapid increase in population and the consequent intensification of anthropogenic activities has led to increase in the environmental pollution including the deterioration of air quality. Unplanned proliferation of urban sprawling, haphazard urbanization and unprecedented vehicular growth has led to exacerbation the air pollution related problems further.

b. Sampling Location: On the basis of activities performed 6 locations were chosen for air and plant monitoring viz residential (Shivaji Nagar, Veerangana Nagar), commercial (Manik Chowk, Jail Chouraha) and Heavy traffic street (Gwalior road nearby BKD, Kanpur road nearby BKU).

C. Plant Species: For the study Ashok (*Polyalthia longifolia*) and Peepal (*Ficus religiosa*) were selected.

D. Air sampling and analysis: Suspended particulate matter (SPM) and Respirable suspended particulate matter (RSPM) were analyzed using Respirable Dust Sampler (RDS) APM 460 and operated at an average flow rate of 1.0-1.5 m³ min⁻¹. Pre-weighted glass fibers filter paper (GF/A) of whatman and cup were used as per standard methods. The respirable particulate matter (RSPM) was collected on glass fiber filter paper and suspended particulate matter was collected by gravity settling method. Samples were collected continuously for 48 h every week at 8-hourly intervals. SPM and RSPM were measured using gravimetric method. SO₂ and NO_x were measured with help of RDS APM 460 with gaseous attachment APM 411 by sucking air into appropriate reagent for 48 h every week at 4-hourly intervals and after air monitoring it procured into lab and analysis for the concentration level. SO₂ and NO_x were collected by bubbling the sample in a specific absorbing (Sodium tetrachloromercurate for SO₂ and Sodium hydroxide for NO_x) solution at an average flow rate of 0.2-0.5 min⁻¹. The impinger samples were put in ice boxes immediately after sampling and transferred to a refrigerator until analyzed. The concentration of NO_x was measured with standard method of Modified^[12] and SO₂ was measured by modified^[34]. The instrument was kept at a height of 2 m from the surface of the ground. It was carried out during the winter (December to January), Summer (April to June) and Monsoon (July to September) in the year 2009-2011.

E. Plant sampling and analysis: Plant sampling was carried in winter, summer and monsoon season. Leaf samples were collected from all the sides of the plant i.e. top middle and bottom of the canopy as per the method suggested Rao^[27]. Chlorophylls, pheophytin and carotenoids were estimated by the method of Arnon^[3]. Peroxidase (POD) and proteins were estimated by Puccinelli and Bragloni^[25] and Lowry et al.^[19] respectively.

III. Result and Discussion

The average concentration of SPM and RSPM in Jhansi City has been given in Table 1. The SPM during winter season at residential, commercial and heavy traffic street ranged between 388.11±2.41 - 390.29±2.03, 481.86±2.46 - 484.33±3.16 and 453.51±2.18 - 459.49±2.55, in summer its ranges between 316.18±2.07 - 318.82±3.27, 387.15±3.08 - 387.45±3.04 and 364.64±2.21 - 366.78±1.94 while in monsoon season it ranges between 281.02±3.89 - 282.92±3.51, 357.42±2.39 - 357.82±2.39 and 330.18±1.91 - 331.89±1.64 respectively. The RSPM during winter season at residential, commercial and heavy traffic street ranged between 190.83±1.99 - 194.45±2.94, 245.22±2.70 - 248.93±3.38 and 235.50±2.14 - 238.66±3.46, in summer its ranges between 132.45±2.03 - 132.52±2.19, 194.72±2.17 - 194.88±2.00 and 181.09±1.67 - 182.86±1.45 while in monsoon season it ranges between 114.69±1.94 - 115.47±1.86, 173.89±1.98 - 174.28±1.84 and 158.13±1.61 - 159.23±1.39 respectively. It was observed in study that SPM concentration at all sites was well with the National Ambient Air Quality Standard but The concentration of SPM at all the locations was highest in winter season followed by summer and then in winter. While, RSPM concentration at commercial and Heavy traffic street was higher than NAAQM Standard. It is also observed that RSPM concentration was higher in winter

season than other seasons. Higher concentration of TSPM and RSPM in ambient air was due to automobile exhaust^{[26] [30]}. The average concentration of SO₂ and NO_x in Jhansi City has been given in Table 2. The SO₂ during winter season at residential, commercial and heavy traffic street ranged between 19.57±0.10 - 20.17±0.15, 28.04±0.16 - 29.40±0.38 and 24.86±0.10 - 25.73±0.17, in summer its ranges between 16.23±0.21 - 16.40±0.22, 19.58±0.20 - 19.79±0.22 and 18.76±0.16 - 19.36±0.16 while in monsoon season it ranges between 10.76±0.13 - 11.39±0.19, 16.06±0.22 - 16.61±0.23 and 13.97±0.20 - 15.94±0.22 respectively. The NO_x during winter season at residential, commercial and heavy traffic street ranged between 35.73±0.26 - 36.77±0.44, 43.59±0.14 - 44.76±0.32 and 41.31±0.14 - 43.01±0.41, in summer its ranges between 30.10±0.15 - 30.11±0.15, 33.41±0.35 - 33.58±0.37 and 31.45±0.15 - 31.50±0.14 while in monsoon season it ranges between 23.28±0.69 - 23.40±0.73, 30.09±0.09 - 30.20±0.11 and 27.84±0.33 - 28.03±0.34 respectively. It was observed that Concentration of SO₂ and NO_x was within the NAAQM standard at all the locations. While Concentration of SO₂ and NO_x was higher in winter season than summer and monsoon. It may be due to the higher nitrate formation in cold season^{[26] [30]}. Concentration of NO_x was found higher than SO₂. It is due to the rise in the number of diesel driven vehicles degradation of photosynthetic pigment has widely been used as an indicator of air pollution^{[21] [30]}.

Table 1: SPM and RSPM concentrations (all values are given in µg/m³) in different seasons and different areas of Jhansi City

Area	Monitoring Location	Winter		Summer		Monsoon	
		SPM	RSPM	SPM	RSPM	SPM	RSPM
Residential Area	Shivaji Nagar	390.29±2.03	190.83±1.99	316.18±2.07	132.45±2.03	282.92±3.51	115.47±1.86
	Veerangana Nagar	388.11±2.41	194.45±2.94	318.82±3.27	132.52±2.19	281.02±3.89	114.69±1.94
Commercial Area	Manik Chowk	481.86±2.46	245.22±2.70	387.45±3.04	194.88±2.00	357.42±2.39	174.28±1.84
	Jail Chauraha	484.33±3.16	248.93±3.38	387.15±3.08	194.72±2.17	357.82±2.39	173.89±1.98
Heavy Traffic Street	Gwalior road nearby BKD	459.49±2.55	235.50±2.14	366.78±1.94	182.86±1.45	331.89±1.64	159.23±1.39
	Kanpur road nearby BKU	453.51±2.18	238.66±3.46	364.64±2.21	181.09±1.67	330.18±1.91	158.13±1.61

± denotes the SE of means

Table 2: SO₂ and NO_x concentrations (all values are given in µg/m³) in different seasons and different areas of Jhansi City

Area	Monitoring Location	Winter		Summer		Monsoon	
		SO ₂	NO _x	SO ₂	NO _x	SO ₂	NO _x
Residential Area	Shivaji Nagar	19.57±0.10	35.73±0.26	16.23±0.21	30.11±0.15	10.76±0.13	23.28±0.69
	Veerangana Nagar	20.17±0.15	36.77±0.44	16.40±0.22	30.10±0.15	11.39±0.19	23.40±0.73
Commercial Area	Manik Chowk	29.40±0.38	44.76±0.32	19.58±0.20	33.58±0.37	16.61±0.23	30.09±0.09
	Jail Chauraha	28.04±0.16	43.59±0.14	19.79±0.22	33.41±0.35	16.06±0.22	30.20±0.11
Heavy Traffic Street	Gwalior road nearby BKD	25.73±0.17	41.31±0.14	18.76±0.16	31.50±0.14	15.94±0.22	28.03±0.34
	Kanpur road nearby BKU	24.86±0.10	43.01±0.41	19.36±0.16	31.45±0.15	13.97±0.20	27.84±0.33

± denotes the SE of means

Chlorophyll content of plant is important for its photosynthetic activity as well as for the growth and development of biomass. The chlorophyll content of plant varies from species to species; age of leaf and also with the pollution level as well as with other biotic and abiotic conditions^{[15] [18]}. The content of chlorophyll in all the seasons in Ashok was lowest at commercial area followed by heavy traffic street and then in residential area (Table 3). Pollution activities were high in commercial and heavy traffic street as compare to residential area. Average chlorophyll content in Ashok was maximum in monsoon at residential area (3.57 mg g⁻¹ fresh wt.) and minimum in winter in commercial area (1.37 mg g⁻¹ fresh wt.). This higher level of total chlorophyll observed may be due to its tolerance nature^{[5] [14]-[8]}. Chlorophyll observed may be due to its tolerance nature^{[5] [14]}. These changes can be co-related with high pollution level during winter. Average content of pheophytin in all the seasons in Ashok was lowest at commercial area and highest at Heavy Traffic Street (Table 3). Reduction in chlorophyll content brought by acidic pollutants like SO₂ which causes pheophytin formation by acidification of chlorophyll^{[4] [28]}. Average pheophytin content was highest in winter at Heavy Traffic Street (3.54 mg g⁻¹ fresh wt.) lowest in monsoon at commercial area (1.74 mg g⁻¹ fresh wt.). At residential location highest pheophytin content was observed in winter and least in monsoon. Average carotenoids content in Ashok in residential area was highest in monsoon (1.04 mg g⁻¹ fresh wt.) and lowest in winter (0.85 mg g⁻¹ fresh wt.) (Table 2). Similar trend was observed at all the locations. Carotenoids content was maximum in monsoon and minimum in winter at all locations. Average protein content in Ashok was highest at residential area (2.78 mg g⁻¹ fresh wt.) and lowest at commercial area (1.04 mg g⁻¹ fresh wt.) (Table 2). The protein content was maximum in monsoon and minimum

in winter season. SO₂ and NO_x in combination adversely affect the plants as well as the protein content as observed ^[2]. Similar trend was observed at all the locations. Average peroxidase (POD) activity in Ashok was highest at commercial area in winter (9.56 mg g⁻¹ fresh wt.) and lowest at residential area in monsoon (2.40 mg g⁻¹ fresh wt.) (Table 2). Peroxidase activity was maximum in winter and minimum in monsoon at all locations.

Table 3: Effect of air pollution on biochemical parameters (mg g⁻¹ fresh wt.) in leaves of Ashok (*Polyalthia longifolia*)

Seasons	Bio chemical Parameter (mg/g fresh weight)	Residential Area			Commercial Area			Heavy Traffic Street		
		Shivaji Nagar	Veerangana Nagar	Avg	Manik Chowk	Jail Chauraha	Avg	Gwalior road nearby BKD	Kanpur road nearby BKU	Avg
Winter	Chlorophyll	2.33	2.31	2.32	1.38	1.36	1.37	2.19	2.17	2.18
	Phaeophytin	2.90	2.87	2.89	2.88	2.82	2.85	3.57	3.50	3.54
	Carotenoid	0.84	0.85	0.85	0.80	0.78	0.79	0.80	0.81	0.81
	Protein	1.15	1.21	1.18	1.02	1.09	1.06	1.08	1.05	1.07
	Peroxidase Activity	8.80	8.25	8.53	9.66	9.45	9.56	9.25	9.17	9.21
Summer	Chlorophyll	2.82	2.87	2.85	2.53	2.57	2.55	2.52	2.50	2.51
	Phaeophytin	2.83	2.79	2.81	2.72	2.67	2.70	2.74	2.75	2.75
	Carotenoid	0.94	0.93	0.94	0.90	0.90	0.90	0.90	0.91	0.91
	Protein	2.25	2.27	2.26	1.68	1.77	1.73	1.99	1.96	1.98
	Peroxidase Activity	6.34	6.58	6.46	8.43	6.85	7.64	7.43	7.55	7.49
Monsoon	Chlorophyll	3.56	3.58	3.57	3.11	3.06	3.09	3.65	3.45	3.55
	Phaeophytin	1.98	1.95	1.97	1.86	1.62	1.74	2.22	2.15	2.19
	Carotenoid	1.05	1.03	1.04	1.06	0.93	1.00	0.98	1.00	0.99
	Protein	2.75	2.80	2.78	2.12	2.16	2.14	2.17	2.21	2.19
	Peroxidase Activity	2.25	2.54	2.40	3.54	3.43	3.49	3.11	3.21	3.16

Similarly, the content of chlorophyll in all the seasons in Peepal was highest at residential area among the commercial and heavy traffic street (Table 4). It may be because of vehicular intensity was low in residential area as compare to commercial and heavy traffic street. Average chlorophyll content in Peepal was maximum in monsoon at residential area (3.78 mg g⁻¹ fresh wt.) and minimum in winter in heavy traffic street (1.91 mg g⁻¹ fresh wt.). It might be due to the washout of dust particles (which will increase photosynthetic activity) from the leaf surface, low level of pollution and water content of soil ^[30]. The decreased chlorophyll concentration in plant fumigated with SO₂ was often associated with degradation of chlorophyll a ^[17]. Pollution stress decreases the chlorophyll level in tree species ^{[20][23]}. Average content of pheophytin in all the seasons in Peepal was highest at commercial area (Table 4). Average pheophytin content was highest in summer at commercial area (3.84 mg g⁻¹ fresh wt.) lowest in monsoon at heavy traffic street (2.48 mg g⁻¹ fresh wt.). At residential location highest pheophytin content was observed in summer and least in monsoon. Average carotenoids content in Peepal in residential area was highest in monsoon (1.50 mg g⁻¹ fresh wt.) and lowest in winter (1.16 mg g⁻¹ fresh wt.). Joshi and Swami ^[13] also reported significant reduction in carotenoid content of different plants grown at polluted sites. Similar trend was observed at all the locations. Carotenoids content was maximum in monsoon and minimum in winter at all locations. Average protein content in Peepal was highest at residential area (2.95 mg g⁻¹ fresh wt.) and lowest at heavy traffic street (1.23 mg g⁻¹ fresh wt.) (Table 4). The protein content was maximum in monsoon and minimum in winter season. Many have reported decrease in protein content on SO₂ fumigation ^[17]. Similar trend was observed at all the locations. Average peroxidase (POD) activity in Peepal was highest at commercial area in winter (10.85 mg g⁻¹ fresh wt.) and lowest at residential area in monsoon (3.74 mg g⁻¹ fresh wt.) (Table 4). Peroxidase activity was maximum in winter and minimum in monsoon at all locations. The level of Peroxidase enzymes is universally accepted as an indicator parameter to environmental pollution especially air pollution ^{[17][30]}

Table 4: Effect of air pollution on biochemical parameters (mg g⁻¹ fresh wt.) in leaves of Peepal (*Ficus religiosa*)

Seasons	Bio chemical Parameter (mg/g fresh weight)	Residential Area			Commercial Area			Heavy Traffic Street		
		Shivaji Nagar	Veerangana Nagar	Avg	Manik Chowk	Jail Chauraha	Avg	Gwalior road nearby BKD	Kanpur road nearby BKU	Avg
Winter	Chlorophyll	2.10	2.05	2.08	2.02	2.08	2.05	1.88	1.93	1.91
	Phaeophytin	3.23	3.16	3.20	3.25	3.22	3.24	3.13	3.06	3.10
	Carotenoid	1.17	1.15	1.16	1.11	1.10	1.11	1.15	1.12	1.14
	Protein	1.56	1.63	1.60	1.78	1.69	1.74	1.24	1.22	1.23
	Peroxidase Activity	9.12	9.02	9.07	10.98	10.71	10.85	10.71	10.45	10.58
Summer	Chlorophyll	3.71	3.78	3.75	3.37	3.32	3.35	3.43	3.41	3.42
	Phaeophytin	3.57	3.53	3.55	3.79	3.88	3.84	3.56	3.61	3.59
	Carotenoid	1.36	1.39	1.38	1.30	1.32	1.31	1.33	1.31	1.32
	Protein	2.15	2.19	2.17	2.32	2.37	2.35	2.07	2.06	2.07
	Peroxidase Activity	6.34	6.32	6.33	8.16	7.69	7.93	7.21	7.93	7.57
Monsoon	Chlorophyll	3.79	3.77	3.78	3.46	3.48	3.47	3.57	3.62	3.60
	Phaeophytin	2.64	2.73	2.69	2.68	2.78	2.73	2.47	2.48	2.48
	Carotenoid	1.52	1.48	1.50	1.45	1.42	1.44	1.46	1.44	1.45
	Protein	2.82	2.88	2.85	2.97	2.92	2.95	2.75	2.72	2.74
	Peroxidase Activity	3.59	3.88	3.74	4.50	4.73	4.62	4.57	4.01	4.29

IV. Conclusion

It can be elucidated by study that the changes in photosynthetic pigments in plants were due to air pollutants. The study shows that gaseous (NO_x and SO₂) and particulate pollutants such as SPM and RSPM have detrimental effects on selected trees. The study also elucidates that air pollution emitted from automobiles adversely affecting the ambient air and tree pigments. Peepal (*Ficus religiosa*) and Ashok (*Polyalthia longifolia*) can be utilized for urban plantation and greenbelt development in industrial area to reduce the level of air pollution. It will make the environment clean for healthy life. This work has indicated the suitability of Peepal (*Ficus religiosa*) and Ashok (*Polyalthia longifolia*) as intermediate tolerant species to pollution. The results of these kinds of studies are expected to fulfill the gap to check the further degradation of environment and to provide pollution free environment to forthcoming generation.

V. References

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VI. Acknowledgments

Authors thank to Mr. Antriksh Kumar Jain, Unit Head, JK Cement Works, Muddapur, Karnataka for his valuable suggestions and financial help.