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Effect of Thermal Power Plant Emissions on *Catharanthus roseus* L.

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Most of the industrialized nations depend largely on the combustion of fossil fuels for their energy requirements. During the past few years in India quite a few thermal power plants have been commissioned to cater to the increasing energy requirements. As most of the power plants are coal-fired, a complex mixture of several pollutants is released in the atmosphere on the combustion of coal (Hesketh 1973). The well recognised pollutants which are generally emitted are CO, SO_2, HF, NOx, fly ash and particulate matter. Among these, SO_2 forms the major phytotoxic pollutant (Hesketh 1973).

Leaf by virtue of its unique position on plants and functions (organ of gaseous exchange) experiences the maximum brunt of exposure and undergo certain changes in form, structure and function with the changes in surrounding environs, and such modifications are likely to serve as markers of environmental pollution.

The present paper deals with the long term exposure effects of thermal power plant emissions on Catharanthus roseus L. - a common perennial shrub, with glossy leaves and white, mauve or pink coloured flowers and of great medicinal value is grown as an ornamental plant all over the country.

MATERIALS AND METHODS

The study was carried out around Panki Thermal Power Station (generation capacity 284 MW) which is about 15 km on the West of Kanpur city. About 1,500 tons coal/day is burnt which contains 0.4% sulphur as impurities. The emission of SO_2 every day from the stacks theoritically amounts to 12 tons/day approximately. Five different sites were selected along transect line at varying distances from the power plant to provide gradient of pollutant concentration in the air. The details of the sites selected are summarised in Table 1. Seedlings of Catharanthus roseus L. plants were raised in experimental plots and transplanted in 10" earthen pots after attaining the age of 45 days. A set of seven potted plants was placed at all the above mentioned sites (see Table 1). Five foliar samplings of plants were made at an interval of one month each and were subjected to analysis for chlorophyll, amino acid, protein following the methods of Maclachlan and Zalik (1963), Plummer (1971) and Lowry et al. (1951), respectively. Twenty

Table 1. Details of sites selected for study

Name of site	Symbol	Distance from pollution source	Direction
Panki Workers Colony	P_1	500 meters	SE (WW)
Panki Residential Colony	P_2	1000 meters	SE
Gangaganj village	P_3	1500 meters	NW
Barasirohi village	P_4	2000 meters	NE
Residential areas	P_5	2000 meters	SE
Bajrang Nursery	C	5000 meters	NE (LW)

leaves covering all the 4 sides of the plants were plucked at random for the area measurement. The area was measured on a Delta T Device complete area measuring system. Foliar epidermal traits (frequency of epidermal cells, stomata, abnormal stomata) were studied in isolated epidermal peels. The slides were prepared following the method described by Ahmad (1974).

RESULTS AND DISCUSSION

About 38% reduction in leaf lamina size in plants placed in prevailing wind direction receiving the maximum pollutants load, over control was recorded ($P < 0.01$, Table 2). In field study at Ujjain, Dubey et al. (1982) noted reduction in leaf area of plants growing in polluted atmosphere. The similar observations are also reported earlier by Mc Cune et al. (1967), Pawar et al. (1978) and Singh et al. (1985).

Table 2. Leaf area of Catharanthus roseus L in cm^2.

Sites	Sampling details				
	I	II	III	IV	V
P_1	3.65±0.04	3.25±0.02	2.95±0.02	2.83±0.02	3.10±0.01
P_2	2.95±0.01	3.15±0.02	2.89±0.04	2.98±0.02	2.96±0.01
P_3	2.96±0.02	3.15±0.04	3.10±0.02	3.20±0.04	3.05±0.02
P_4	2.98±0.01	3.10±0.01	2.96±0.02	3.20±0.02	2.95±0.04
P_5	2.85±0.05	3.05±0.05	2.88±0.01	2.96±0.01	3.12±0.02
C	4.50±0.56	5.10±0.02	4.12±0.01	5.18±0.02	5.10±0.02

Values are given as mean ± standard deviation.
n= 20, ANOVA: site= $p < 0.01$, sample= not significant.

There was a marked increase in stomatal frequency on upper epidermis whereas a slight decrease was noticed on lower epidermis. An increase in epidermal cell frequency on both upper and lower epidermis was noticed (Table 3). Such modifications in epidermal traits in response

Table 3. Statistical analysis of the frequency of stomata and epidermal cells of Catharanthus roseus L.

Traits	Surface		Exposed	Control
Stomatal frequency mm^{-2}	Lower	R	125-375	75-375
		x±s	2.4±12.51	219±20.50
		cv	0.0610	0.0936
	Upper	R	50-175	50-125
		x±s	115±10.50	68±16.31
		cv	0.0913	0.2398
Epidermal cell frequency mm^{-2}	Lower	R	110-120	86-89
		x±s	115±2.14	87.7±.6096
		cv	0.0186	0.0069
	Upper	R	48-64	44-48
		x±s	55±3.41	45.7±.8544
		cv	0.0621	0.0186

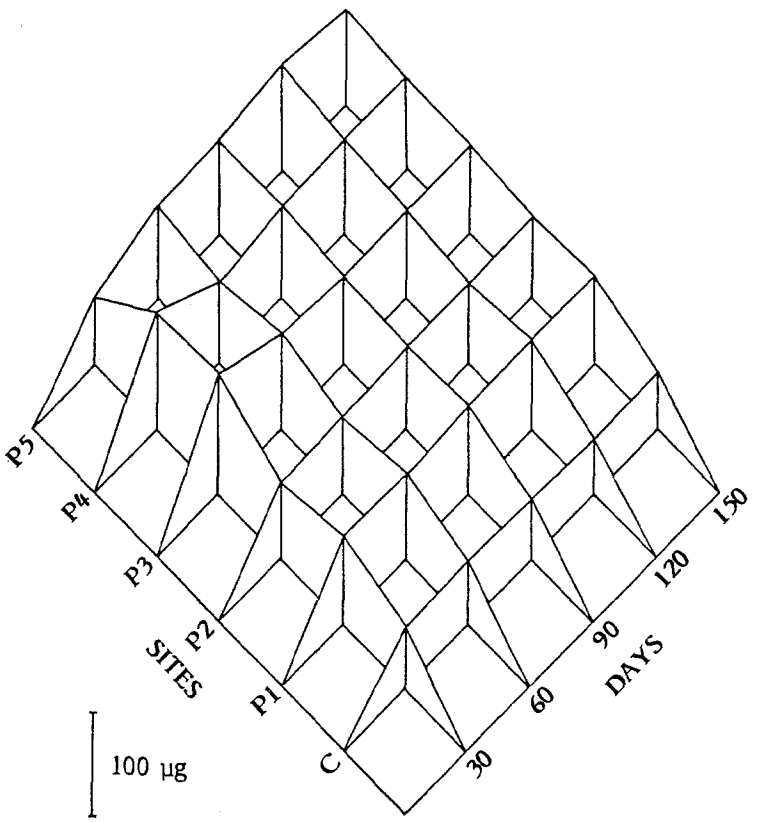

Figure 1. Total free amino acid content in leaves of Catharanthus roseus in relation to time and distance from the power plant (sites). Vertical axes indicate the amount of amino acids (µg/g fresh leaf).

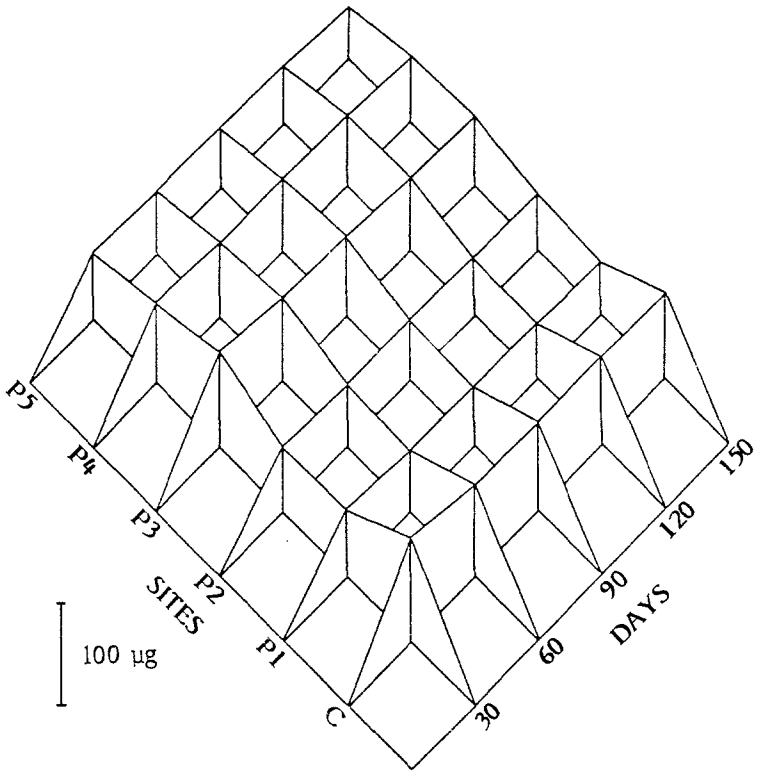

Figure 2. Protein content in leaves of Catharanthus roseus in relation to time and distance from the power plant (sites). Vertical axes indicate the protein contents (µg/g fresh leaf).

to pollutants has been reported by Yunus et al. (1979) and Garg and Varshney (1980). Chlorophyll pigments were reduced in all the plants especially those kept at sites P_5 and P_2 ($P < 0.01$, Table 4). The reduction in chlorophyll due to SO_2 in tree species has been reported by Vij et al. (1981) and Dubey et al. (1982). The reduction in chlorophyll may be attributed to SO_2-induced removal of Mg^{++} ions by two atoms of hydrogen from chlorophyll molecules which converts chlorophyll to phaeophytin, changing the light spectrum characteristics of the chlorophyll molecules (Rao and Le Blanc 1966, Malhotra 1977, Suwannapinunt and Kozlowski 1980, Shimazaki et al. 1980). The reduction in chlorophyll pigment without foliar injury symptoms in Catharanthus roseus L. may also indicate the decreased synthesis of chlorophyll pigments (Shimazaki et al. 1980).

Unlike chlorophyll there was a marked increase in total free amino acid contents and decrease in protein contents (Figs. 1 & 2). This observation reinforces the earlier reports of Fischer (1971), Godzik and Linskens (1974). The decrease in protein content might be the result of decreased photosynthesis (Siz and Swanson 1974, Constan-

Table 4. Changes in chlorophyll contents (μg/g) fresh leaf of Catharanthus roseus L.

Treatment		Sampling details I	II	III	IV	V
P_1	a	0.84±0.01	0.78±0.02	0.72±0.01	0.79±0.01	0.80±0.02
	b	0.71±0.01	0.60±0.02	0.48±0.04	0.58±0.02	0.56±0.02
	Total	1.55±0.04	1.38±0.02	1.20±0.02	1.37±0.02	1.36±0.01
P_2	a	0.86±0.01	0.72±0.04	0.70±0.01	0.75±0.01	0.70±0.04
	b	0.80±0.02	0.55±0.02	0.42±0.02	0.46±0.04	0.47±0.02
	Total	1.66±0.04	1.27±0.02	1.12±0.02	1.21±0.02	1.17±0.02
P_3	a	1.00±0.02	0.92±0.01	0.89±0.04	0.89±0.02	0.98±0.01
	b	0.92±0.02	0.70±0.02	0.68±0.02	0.72±0.01	0.70±0.02
	Total	1.92±0.01	1.62±0.01	1.57±0.01	1.61±0.01	1.68±0.04
P_4	a	0.89±0.01	0.81±0.02	0.78±0.01	0.92±0.01	0.90±0.01
	b	0.78±0.02	0.63±0.02	0.56±0.02	0.68±0.02	0.66±0.01
	Total	1.67±0.02	1.44±0.01	1.34±0.01	1.60±0.02	1.56±0.02
P_5	a	0.80±0.01	0.70±0.04	0.62±0.01	0.69±0.01	0.65±0.01
	b	0.76±0.04	0.54±0.02	0.38±0.02	0.41±0.00	0.40±0.04
	Total	1.56±0.02	1.24±0.02	1.00±0.01	1.10±0.01	1.05±0.02
C	a	1.05±0.01	0.95±0.01	0.90±0.02	0.92±0.02	0.93±0.02
	b	0.89±0.02	0.79±0.00	0.72±0.01	0.73±0.02	0.76±0.02
	Total	1.94±0.01	1.74±0.01	1.62±0.01	1.65±0.02	1.69±0.01

Values are given as mean ± standard deviation.
n=20, ANOVA: site and sample= $P < 0.01$

tinidou and Kozlowski 1979) or inhibition of protein synthesis and/or enhanced protein degradation (Robe and Kreeb 1980). The decrease in protein content followed an increase in the free amino acid content is perhaps either because of the degradation of the existing protein molecules or induced de novo protein synthesis.

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