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Effect of Air Pollution on the Photosynthetic Pigments of Selected Plant Species along Roadsides in Jamshedpur, Jharkhand

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The present study is aimed at getting the effects of air pollution on the chlorophyll contents in the leaves of three selected plant species – *Polyalthia longifolia, Thevetia nerifolia* and *Alstonia scholaris*. These plants were procured from three different types of areas of Jamshedpur city. For a comparative analysis of the effect of air pollutants industrial, commercial and residential localities were preferred for Industrial pollutants, vehicular gases and relatively less polluted residential areas. Chlorophyll a and Chlorophyll b estimated showed insignificant reduction in Industrial area in *Alstonia* and significant reduction in *Polyalthia*. Increased chlorophyll in Industrial area in the *Thevetia* compelled to think its tolerance towards pollutants. On the index of susceptibility *Polyalthia* was observed to be on higher side and *Alstonia* occupied mid position. Thereby arrangement of hierarchy from susceptibility to tolerance is *Polyalthia longifolia*> *Alstonia scholaris* >*Thevetia nerifolia*.

Key words: Chlorophyll a, Chlorophyll b, Air pollution, Photosynthetic activity

Industrialization and vehicles on streets contribute to the maximum amount of air pollutants in the environment. Increase in the volume of road traffic has increased the deposition of NOx, VOCs and particulate matter that are causing uncertain effects on roadside plants. Exposure to these pollutants in combination may be more harmful to plants than individual ones (KE Percy, 1994). Net photosynthetic rate is a commonly used indicator of the impact of increased air pollutants on tree growth (Woo, 2007). The plants absorb, accumulate and integrate the pollutants into their systems. Depending upon the degree of tolerance and susceptibility, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites (Agbaire and Esiefarienrhe, 2009). A relationship between traffic density and photosynthetic activity of plants has been reported (Honour et al., 2009). One of the most common impacts of air pollution is the gradual disappearance of chlorophyll and concomitant yellowing of leaves which may be associated with a consequent decrease in the capacity for photosynthesis (Joshi and Swami, 2007). Chlorophyll is found in the chloroplast of green plants and is called photoreceptor. There are different types of chlorophyll molecules such as chlorophyll a, chlorophyll b, chlorophyll c and chlorophyll d. Chlorophyll is the principle photoreceptor in photosynthesis. When plants are exposed to increased rates of environmental pollutants, the rate of photosynthesis also varies. The chlorophyll content of plants also varies from species to species, age of leaf, pollution level as well as other biotic and abiotic conditions (Katiyar and Dubey, 2001). To screen the selected plants for their increase or decrease in the total chlorophyll content with respect to levels of air pollution in different areas, the total chlorophyll content of those plants were estimated.

Materials and Methods

The city of Jamshedpur is located at 22.8 degree N and 86.18 degree E. it has an average elevation of 135m (442 ft). It is an industrial city with different concentrations of air pollutants such as CO_2, SO_2, and nitrogen oxides. The major sources of air pollutants in Jamshedpur city are automobile exhaust, small and large industries and railway traffic.

A total of 3 plants species comprising evergreen trees such as *Alstonia scholaris, Polyalthia longifolia*, and *Thevetia neriifolia* from three different areas of Jamshedpur city were investigated with respect to their total chlorophyll content.

Total chlorophyll content was estimated using the method of Singh et al. (1991). In this method 200 mg of leaf sample was ground in a mortar and pestle with small quantity of acid washed sand and 80% acetone. The filtrate was collected and absorbance of the filtrate was measured through spectrophotometer at wavelength 645 nm and 663 nm. Total chlorophyll, was calculated using the formula of Arnon's equation (1949).

Chlorophyll a (mg/g) = ((12.7 * O.D. 663) – (2.69 * O.D. 645)) * V/1000 * W

Chlorophyll b (mg/g) = ((22.9 * O.D. 645) – (4.68 * O.D. 663)) * V/1000* W

Total Chlorophyll = Chlorophyll a + Chlorophyll b

Where:

V = total volume of extract

W = weight of leaves in grams

Result

The concentration of chlorophyll a, chlorophyll b, and total chlorophyll of the selected plant species are presented in Table 1, 2, and 3. Total chlorophyll was found to be higher in *Alstonia scholaris* as compared to other plant species in all the study areas of Jamshedpur.

Polyalthia longifolia

The concentration of photosynthetic pigment in the leaves of *Polyalthia longifolia* was recorded at residential, commercial and industrial sites. A significant reduction in the concentration of chlorophyll b was observed in the samples from the industrial sites in comparison to the commercial and residential sites as shown in Table 1. Concentration of chlorophyll a and total chlorophyll were also reduced in the samples from industrial sites as compared to the commercial and residential sites.

Thevetia neriifolia

When concentration of photosynthetic pigments of *Thevetia neriifolia* in the samples from residential, industrial and commercial sites were compared, significant increase in the concentration of chlorophyll a, chlorophyll b and total chlorophyll were recorded in the samples from the industrial sites as shown in Table 2.

Alstonia scholaris

Insignificant reduction in the concentration of chlorophyll a, chlorophyll b and total chlorophyll in the leaves of *Alstonia scholaris* was recorded at residential, commercial and industrial sites as shown in Table 3. A reduction of only 5% was recorded in the concentration of chlorophyll b in the samples obtained from industrial sites in comparison to the commercial and residential sites. The samples from the commercial sites showed increases concentration of photosynthetic pigments as compared to the industrial site.

Table 1: Concentration of Different Photosynthetic Pigments (mg/g) in the Leaves of *Polyalthia longifolia* Collected from Industrial, Commercial and Residential Sites

Photosynthetic Pigment (mg/g)	Industrial Area	Commercial Area	Residential Area	% Reduction
Chlorophyll a	0.403± 0.02	0.456±0.01	0.560±0.03	39
Chlorophyll b	0.458±0.01	0.208±0.01	0.925±0.06	71
Total chlorophyll	0.861±0.02	0.654±0.02	1.485±0.09	59

Table 2: Concentration of Different Photosynthetic Pigments (mg/g) in the Leaves of *Thevetia neriifolia* Collected from Industrial, Commercial and Residential Sites

Photosynthetic Pigment (mg/g)	Industrial Area	Commercial Area	Residential Area	% Increase
Chlorophyll a	0.338±0.02	0.355±0.02	0.161±0.01	58
Chlorophyll b	0.390±0.03	0.249±0.02	0.199±0.01	87
Total chlorophyll	0.728±0.05	0.604±0.04	0.360±0.02	83

Table 3: Concentration of Different Photosynthetic Pigments (mg/g) in the Leaves of *Alstonia scholaris* Collected from Industrial, Commercial and Residential Sites

Photosynthetic Pigment (mg/g)	Industrial Area	Commercial Area	Residential Area	% Reduction
Chlorophyll a	0.437±0.02	0.553±0.00	0.453±0.02	-8.88
Chlorophyll b	0.432±0.03	0.614±0.03	0.548±0.05	5.50
Total chlorophyll	0.869±0.05	1.167±0.03	1.001±0.05	-1

Discussion

The chlorophyll a and chlorophyll b are the main core of energy production in green plants. The amount of chlorophyll a and b varies depending on the plant species (Shweta and Agrawal, 2006). Their amounts are considerable changed by environmental effects on plant metabolism. Several researchers have recorded reduction in chlorophyll content under air pollution (Joshi and Swami, 2009). There are several possible reasons for reduction in chlorophyll content due to increased air pollution. This may be due to several photochemical reactions such as oxidation, reduction and reversible bleaching of the photosynthetic pigments under stressed condition. Another possible reason may be due to the alkaline condition created by the dissolution of chemicals present in dust particles in cell sap which is responsible for chlorophyll degradation. The deposition of dust particles in the stomata interfere with the gaseous exchange that consequently retard the chlorophyll synthesis. Higher concentrations of NO_2 damage the leaves thereby retarding photosynthesis. Many other pollutants such as sulfur dioxide, fluoride and heavy metals released from the industries suppress growth and photosynthesis in tree species. The degradation of chlorophyll b to chlorophyllide is due to the increase in the concentration of SO_2 that removes phytol group of chlorophyll b. High amount of SO_2 gas also causes destruction of chlorophyll structure into pheophytin by replacement of Mg^{++} by two H atoms. Yet another reason for decrease in the concentration of chlorophyll may be disruption of thylakoid membranes in the chloroplasts. The enzymatic activity of enzyme chlorophyllase may also increase due to increased concentration of air pollutants that might be responsible for the destruction of chlorophyll. All these possibilities suggest that chlorophyll is the primary site of attack by the vehicular exhausts that primarily consist of SPM, SO^2, and NOx.

On the contrary, other researchers have shown increase in chlorophyll content due to air pollution. The possible reason could be the increased concentration of carbon dioxide and high temperature in the commercial and industrial regions. The enhanced growth of plants due to higher levels of CO_2 has been reported by H. Poorter (1993). Plants grow faster at higher temperature if provided with adequate levels of CO_2, water, sunlight and plant nutrients. Yet another reason could be the smoke released from the industries that enhance the chlorophyll production in the leaves.

The present study showed both increase and decrease in the chlorophyll content with increase in air pollution as shown in Table 1, 2, and 3. It is quite clear from the results obtained from various sites that *Polyalthia longifolia* and *Alstonia scholaris* showed reduction in the concentration of photosynthetic pigments in the samples of industrial sites. While the decrease was insignificant in case of *Alstonia scholaris*, *Polyalthia longifolia* showed significant reduction in the concentration of photosynthetic pigments in the polluted area. This suggests that *Polyalthia longifolia* is susceptible to air pollution while *Alstonia scholaris* can however resist air pollution. The results obtained from *Thevetia neriifolia* showed significant increase in the concentration of photosynthetic pigments in the samples from industrial site as compared to commercial and residential sites. This suggests that *Thevetia neriifolia* is a tolerant species and can tolerate the air pollutants from the industries.

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