Journal of Environmental Biology
May 2008, 29(3) 377-379 (2008)

Effect of ambient air sulphur dioxide on sulphate accumulation in plants

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(Received: December 12, 2005; Revised received: July 07, 2006; Accepted: August 12, 2006)

Abstract: *Present study deals with the relationship between ambient air sulphur dioxide and sulphate content in leaf of selected tropical plant species, Ficus religiosa. The study reveals a positive correlation between ambient air sulphur dioxide and sulphate in the leaves. Two way ANOVA finds the obtained values to be highly significant (p<0.001). Amount of sulphate in leaves shows positive correlation with sulphur dioxide in air (p<0.001) during most part of the study. A marked reduction of sulphate content in leaf was found during October when reduction in ambient air sulphur dioxide was recorded.*

Key words: *Macronutrient, Cysteine, Brick kilns, Coal, Ficus religiosa*
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Introduction

Most of the studies regarding ambient air quality monitoring direct towards the higher concentration of sulphur dioxide, as also reported by Rao *et al.* (2005), Wagh *et al.* (2006) and Sharma *et al.* (2005). The concentration of sulphur dioxide in surroundings is largely affected by anthropogenic interference through burning of the fossil fuel. Brick kilns, located along periphery of cities, play significant role in elevating the SO_2 concentration in the ambient air, as they are fed with sulphur rich, inferior quality of coal (Dwivedi and Tripathi, 2007). In India, there are about 1 lakh small or large brick industries. Baking of 1000 bricks require about 180 kg of coal. As per one estimate on an average about 20 million tonnes of coal are consumed by brick industries each year in India. According to Pandey (1997) 0.4536 kg of sulphur dioxide is produced by burning of 1 tonne coal. Consequently, 9.072 million kg of sulphur dioxide is released in the atmosphere by the brick kilns during summer and winter, when the kilns are functional. Objects in vicinity of such area, are subjected to the exposure to very high concentration of SO_2 during the period. SO_2 toxicity to plants and other organisms is studied to some extent (Tripathi and Dwivedi, 2002; Mandal, 2006). Still a paucity exists where relation between ambient air SO_2 and the amount of sulphate accumulated in plants was needed. Therefore, the present study was conducted through leaves of a deciduous tree *Ficus religiosa*.

Materials and Methods

To conduct the present study, four brick industries situated in district Varanasi in India were selected. Pot culture experiment was conducted using 20 young saplings of *Ficus religiosa* planted in Earthen pots of 30 cm diameter filled with garden soil. After one month period of acclimatization the plants were placed around the kilns in the wire net chambers (1x1.5x1 m^3) setup at the study sites. The study was started in March 1999 by the newly sprouting leaves and continued till March 2000 untill the leaf fall.

Ambient air quality monitoring for sulphur dioxide in air and analysis of sulphate in the leaves of *F. religiosa* was done fortnightly following West and Gaeke (1956) and Rossum and Villarvuz (1961) method respectively. The obtained data were expressed as monthly average along with S.D. The data were also subjected to two way ANOVA and correlation to study the statistical relationship.

Results and Discussion

Mid-June to mid-October is the rainy season, while the remaining 8 months are dry in Varanasi (Fig. 1). Brick industries are functional only during the dry periods *i.e.* from November to the mid June. Monthly mean of sulphur dioxide in ambient air was found to be highest during January 2000 (182.32 ± 39.08 $\mu g/m^3$) while minimum during September 1999 (46.43±7.87 $\mu g/m^3$). Gradual lowering in the value of sulphur dioxide was recorded during August to September 1999, thereafter increase was recorded till January 2000 (Fig. 2). Consequently, higher value of sulphur dioxide in ambient air was found during winter followed by summer and rainy season. In winter, owing to lower temperature of surrounding and higher dissipation rate, burning of larger amount of coal resulted in higher SO_2 in ambient air. Monthly mean of sulphate in the newly emerging leaves *i.e.* in March 1999 was found to be minimum (0.0581 µg/g). The same value was highest during February 2000 (0.2014 µg/g). During March to June 1999 the rate of accumulation of sulphate in leaves was found to be lower (Fig. 2) as compared to that during October 1999 to February 2000. Reduction in the value of sulphate was recorded during June to October 1999 and February to March 2000. The linear relationship of sulphate shows positive correlation with atmospheric sulphur dioxide significant at 0.1 percent level of significance at all the sites.

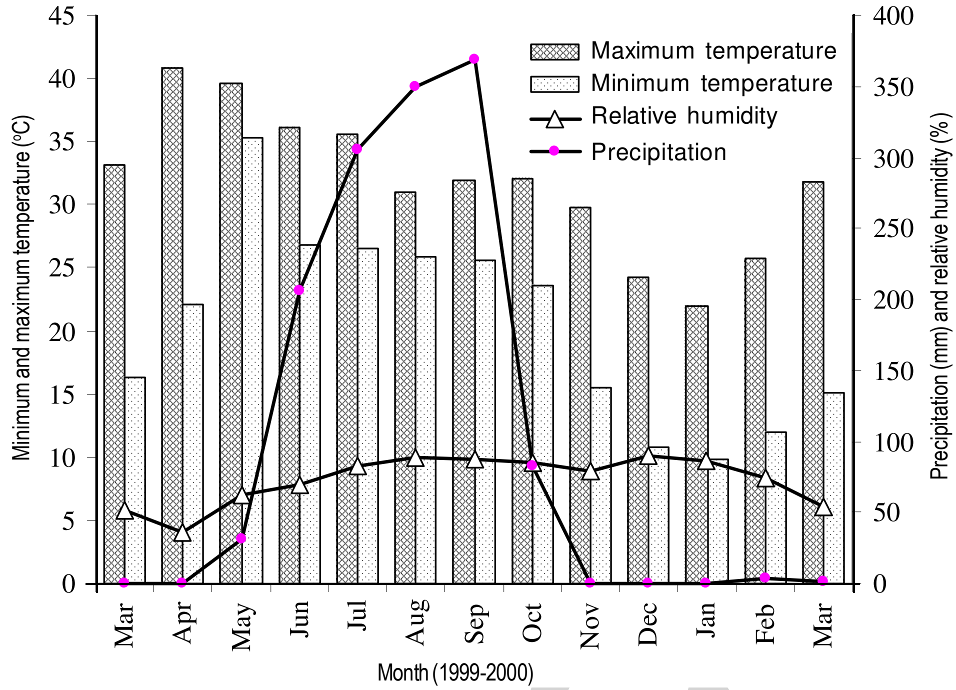

Fig. 1: Meteorological conditions of Varanasi

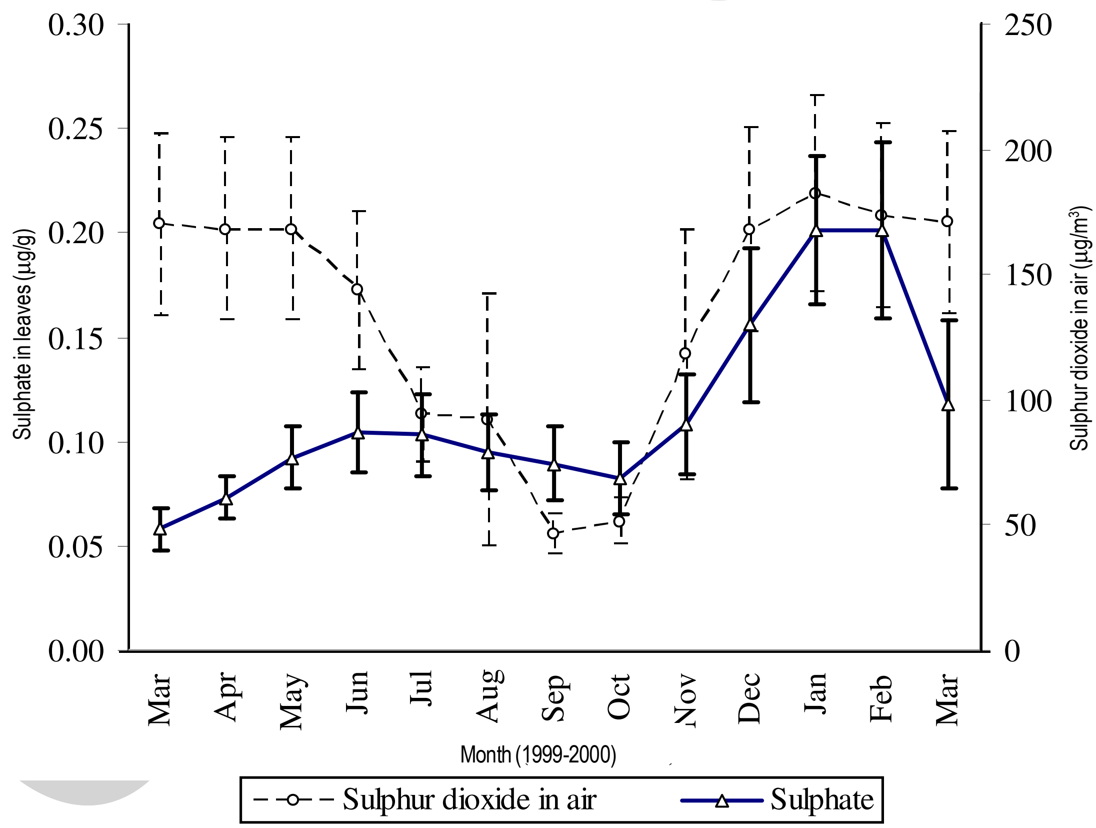

Fig. 2: Monthly mean of sulphur dioxide in air and sulphate in leaves of all the sites

From statistical analysis of the data obtained in pot culture experiment and ambient air analysis it is clear that sulphate ion (SO_4^{2-}) content in leaves directly parallels the sulphur dioxide in air during most of the part of the study *i.e.* July 1999 to March 2000 (Fig. 2). This shows that increase in sulphate of leaf is due to the ambient air sulphur dioxide. Reports of Huang and Murray (1993) and Prasanna *et al.* (2005) are parallel to our findings; they report that plants continuously accumulate the pollutants when they are exposed to it. Initial part of the study, when the new leaves were sprouting shows very low concentration of sulphate in the leaves. Increasing order of sulphate in the leaves noticed from March to June 1999, shows that accumulation of pollutants increases with the increasing age. It also proves that, the early sprouting leaves are less porous and therefore, they allow less amount of gases (pollutants) to enter inside the leaves parallel to the findings of Chandra (2003) and Tripathi and Gautam (2007).

From Fig. 2 reduction in sulphate of leaves from June to October 1999 was due to reduction in ambient air SO_2. October onwards, when the leaves are mature the sulphate in leaves and SO_2 in ambient air continuously show positive correlation. Plants metabolise the absorbed pollutants at a slow (steady) rate; but under highly polluted condition their accumulation starts inside the plants. The plants ultimately get rid of the total accumulated pollutants through the spring leaf fall and the new leaves sprout, which are free from any accumulated pollutant (Aerts, 1990).

Absorbed sulphur dioxide dissolves in water present in the cytosol and forms sulphuric (H_2SO_4) and sulphurous (H_2SO_3) acids. This dissociates to produce sulphate, which react with cations present in the cytosol and forms partially stable salts which also affects developmental behaviour of the plant.

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