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Biological Monitoring of Cement Factory Emissions in Badarpur,Assam,India,Using *Mangifera Indica* L.

KEYWORDS: Cement Industry, Sub-tropical climate, Biomonitor, Mangifera indica

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ABSTRACT In this study, Mangifera indica was selected for biological monitoring of the emissions from the Badarpur Ghat Industrial Area, Karimganj District, Assam, where some cement factories comprise the major industries. The present study investigated the air pollution tolerance index of M. indica in and around the industrial area. Several parameters such as relative water content (RWC), pH, ascorbic acid (AA), and total chlorophyll (TCh) of the leaves have been estimated to work out the Air Pollution Tolerance Index (APTI). The results obtained indicate that in spite of being known as a fairly tolerant species, M. indica exhibits an APTI that is characteristic of a sensitive species even in the control area. The subtropical, humid climatic conditions of the study area coupled with the nature of pollutants may be the reasons for M. indica showing greater sensitivity to pollutants in this study.

Introduction

Large scale industrialization, urbanization, high energy consumption, and increased vehicular emission are considered to be among the major sources of air pollution (Odilara et al., 2006). Smoke and dust discharged from industries cause serious problems to all living organisms, including plants. Cement dust contains oxides of calcium (CaO), silicon (SiO_2), aluminium (Al_2O_3) and iron (FeO) (Bashar et al., 2009). Dust and gases released from cement industry, which are alkaline in nature (Serdar, 2010), have adverse effects on plants in near vicinity as well as at a considerable distance from the source of emission (Gupta and Mishra, 1994).

Plants are considered to be highly sensitive to air pollutants and can be taken as good indicators of air pollution (Joshi et al., 2009). The collective and cumulative effects of different pollutants depend upon the nature of the pollutant as well as the species of plants (Tingey and Reinert, 1975). Absorption of pollutants from different sources may also change the metabolic activity of plants without showing any apparent morphological changes (Ghouse and Saquib, 1986; Gostin and Ivanescu, 2007; Saquib, 2008; Saquib et al., 2010; Iqbal et al., 2010). Pollutants have direct effects on the epidermal cells of the plant and the closing and opening of stomata (Chaurasia et al., 2013), which in turn affects the gaseous exchange of the plant thereby reducing its biochemical activity. Generally pollutants are absorbed by the foliage, which act as filters to protect the environment (Liu and Ding, 2008). While plants have the unique capacity to adsorb pollutants from the air through their leaves, they are also adversely affected by air pollution (Rao, 2006). It has been found that relative water content, total chlorophyll, ascorbic acid content and pH of leaves are affected by air pollution (Klump et al., 2000). These parameters are considered to be indicators of the tolerance limits of plants. In this paper, estimates of relative water content (RWC), total chlorophyll (TCh), ascorbic acid (AA) and pH of leaves of Mangifera indica L. belonging to the family Anacardiaceae have been made. M. indica was selected since it is one of the most common, economically important and abundant species in the home gardens of the study area. The air pollution tolerance index (APTI) of the plant was also calculated with an aim to explore its suitability in green belts for protection from air pollution caused by emissions from cement industry.

MATERIALS AND METHODS

The study area around the Barak Valley Industrial Area at Badarpur Ghat, Karimganj district, Assam, was divided into four zones based on the distance from the sources of emission. A control zone was also established at a distance further away and without any major emission source nearby (Table 1).

Table 1 about here

Selection of Plant Species and Sampling

Mature leaves of M. indica were collected from a height of 1.5 m (breast height) at 600 angle to the 3D canopy. Three replicates were collected from plants in Zones A-D as well as from the control (Zone E) and immediately taken to the laboratory for analysis. After taking fresh weight of leaves, these were stored in a refrigerator for other analysis (Agbaire and Esiefarienrhe, 2009). In this paper, annual averages during 2012-2014 for each variable have been presented.

Analysis

Relative water content (RWC) was determined and calculated with the formula:

RWC = × 100; where FW = Fresh weight; DW= Dry weight; and TW = Turgid weight. Fresh weight of leaves was obtained by first rinsing them with distilled water, gently blotting them dry, and weighing. The leaves were then immersed in water over night, blotted dry and then weighed to get the turgid weight. Finally, the leaves were dried till constant weight in an oven at 70°C to obtain the dry weight (Liu and Ding, 2008). For obtaining pH of leaf extract, fresh leaves were homogenized in 10 ml deionized distilled water, filtered and the pH of the leaf extract determined with a pH meter (Agbaire and Esiefarienrhe, 2009). Ascorbic Acid content was estimated titrimetrically (Shrestha et al., 2016). Total chlorophyll (TCh) was estimated spectrophotometrically by measuring the absorbance at 645 and 663 nm (Arnon, 1949; Suvarna Lakshmi et al., 2008; Agbaire and Esiefarienrhe, 2009). The air pollution tolerance index (APTI) was calculated as:

APTI = ; where A = Ascorbic acid content (mg g^{-1});

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T=Total Chlorophyll (mg g-1) ; P = pH of the leaf extract; and R = Relative water content of leaf (%). APTI values of <10 indicate sensitive species; 10-16 intermediate species; and > 16 tolerant species (Singh and Rao, 1983; Singh et al., 1991).

Statistical Analysis
Statistical analysis comprising one-way ANOVA and Tukey test were conducted with SPSS 21 for Windows.

Results and Discussion
The values of average relative water content (RWC) of M. indica were 87.64, 85.34, 90.13, 91.08 and 92.01 % in Sites A, B, C, D and E (control), respectively. Thus the lowest RWC was recorded in the zone 1-2 km away from the cement factory (zone B), followed by that 0-1 km distant (zone A). Cement dust containing oxides of calcium, potassium and sodium, escapes from cement industry and is transported by air in areas close to and away from the source (Lerman, 1972). Deposition of particulate matter and pollutants interfere with the normal physiological activity of plants (Prajapati, 2012). Low relative water content of zone B, which is even lower than that in zone A and zone C suggest that this might be due to higher dust deposition in this area, which in turn impeded the water absorption physiology of plants.

Figure 1 shows the annual average values of pH, total chlorophyll (TCh), ascorbic acid (AA), and air pollution tolerance index (APTI) at the different study sites during 2012-2014. The pH of leaf extract in all zones ranged between 6 and 7, thus being slightly acidic, although the values at zones A and B were slightly higher than that in control and zones C and D.

Total chlorophyll content in zone B was the lowest, followed by zone A, zone C and D, with the highest concentration recorded in Control. Low chlorophyll content in the leaf extract is considered to be an indicator of damage and less production of chloroplast which leads to reduction in the productivity of the plant due to pollution (Gibbert, 1968). In the present study, low total chlorophyll content in zone A, B, C and D in comparison to control site (zone E) indicates the effects of pollution due to cement dust. Similar observations were made by Pandey and Simba (1998). Decrease in total chlorophyll content in foliar tissue affected respiration and transpiration rates and hampered normal growth of plants (Sukla at al., 1990).

Ascorbic acid is considered to be a reducing agent and activates and plays a significant role in many metabolic and physiological activities of plants which largely regulate plant growth and life (Raza and Murthy, 1988). M. indica leaf extract in zone B which was 1 to 2 km from cement industry contained the highest ascorbic acid concentration, followed by zones A, C, D and E (control). Ascorbic acid in leaf of a plant acts as a defensive agent (Agbaire and Esiefarienrhe 2009), and its increase indicates increasing stress. In the study site high ascorbic acid in zone B may be due to increased defensive activity in M. indica against stress induced by cement dust deposition on the leaf surface. However, the differences among the different sites in terms of all the variables barring relative water content (RWC %) were not statistically significant as revealed by one-way ANOVA. Multiple comparisons with Tukey test revealed that RWC in zone B was significantly lower than those in zones C, D and E, while that in zone A was lower than those in zones D and E, thereby revealing that the effect of polutants were most pronounced in these two sites.

Figure 1 about here
The APTI values of M. Indica ranged from 8.92 to 10.40 in different zones located at varying distances from the Badarpur Ghat industrial area. A study made on a cement industry of Coimbatore in Tamil Nadu indicates that APTI values for M. Indica shows it to be the most tolerant species among other species such as Tamarindus indica, Ficus religiosa, Albizia lebbeck and Holoptelea integrifolia (Radhapriya et al., 2012). Besides cement dust, this species has also been found to be tolerant to coalfield emissions and vehicular pollution (Choudhury and Banerjee, 2009; Chauhan, 2010). APTI value is somewhat less in zone B than the other zones, including control site. Plants with low index value show less tolerance and can be used to indicate level of air pollution (Singh and Rao, 1983). The subtropical, humid climatic conditions of the study area coupled with the nature of pollutants may be the reasons for M.indica showing greater sensitivity in this study.

Conclusions
The present study clearly indicates that the cement dust emitted from the cement industry has adverse impact on M. indica, especially within 1-2 km radius of the source. However, the relatively low APTI for this species even in the control site suggests that pollutants other than cement dust are also instrumental in affecting this species in the study area.

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Table 1: Zonation, coordinates and elevation (msl) of the collection sites

Zone	Km	Coordinates	Elevation
A	0Km -1Km	N 24 51’ 830” S92 34’ 631”	29 msl
B	1Km-2Km	N24 52’301” S92 35’006”	18 msl
C	2Km-3Km	N24 52’531” S92 35’212”	13 msl
D	3Km-4Km	N24 53’22” S92 35’332”	18 msl
E	Control 40km	N24°32’165” E92°44’379”	38 msl

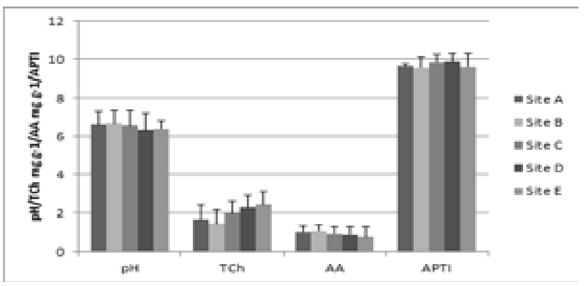

Fig.1. pH, total chlorophyll, ascorbic acid and air pollution tolerance index values (mean ± SD) in the study sites during 2012-2014

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