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Air pollution tolerance index of plants growing near an industrial site

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ABSTRACT

Green vegetation around industrial premises can provide a cost-effective and eco-friendly technique to mitigate air pollution. Sensitive and tolerant plant species can be identified by evaluating their air pollution tolerance index (APTI). APTI is deduced by evaluating the pH, ascorbic acid, total chlorophyll, and relative water content (RWC) of plant leaves. An APTI score of ≤ 11, 12–16, and ≥ 17 classifies the tree species as sensitive, intermediate, and tolerant towards air pollution respectively. The present study was designed to estimate the air pollution tolerance index (APTI) of 25 plant species growing at Talkatora Industrial Area, Lucknow Uttar Pradesh, India. The biochemical properties of plant species ranged from; ascorbic acid: 0.6–19.6 mg/g, RWC 41.34%–98.62%, pH 4.5–8.2 and chlorophyll content 0.59–1.49 mg/g. Findings revealed that among 25 plant species, *Ficus bengalensis* > *Ficus religiosa* > *Eucalyptus globus* > *Azadirachta indica juss* > *Heveabra brasiliensis* are tolerant towards air pollution; whereas, *Polythalia longifolia* was found to be most sensitive. In addition, the dust capturing potential of the plant leaves has also been evaluated. *Moringa oleifera* leaves were found to have the highest dust capturing potential (5.7 mg/cm^2), whereas, the lowest was noticed in *Acacia nilotica* (0.10 mg/cm^2). Pearson correlation of biochemical parameters revealed that ascorbic acid showed significant correlation (R^2 = 0.897) with APTI. The species having < 11 APTI values may be used as a bio-indicator of air quality, while those having APTI ≥ 17 can be used for green belt designing.

1. Introduction

In recent decades, air quality in major cities of developing countries has deteriorated sharply due to rapid increase in traffic, vehicular and industrial emission, and the reduction of urban vegetation cover (Kim et al. 2015; Santos et al. 2015). Vehicular emission is considered to be a major source of air pollutants viz. particulates, CO, SO_x, NO_x, heavy metals, and polyaromatic hydrocarbons (PAHs) (Kulshreshtha and Sharma 2015; Kisku et al. 2013). Release of such pollutants into the atmosphere not only deteriorates the ambient air quality, but also poses health risk to the people particularly those suffering from respiratory and cardiovascular illness (Jahan et al. 2016; Adrees et al. 2016). To reduce the impact of toxic airborne pollutants, environmentalists and policy makers have emphasized the need of perennial green belt in and around urban areas as well as along roads (Klumpp et al. 2004; Chaulya et al. 2001). Green belts provide the natural ways to reduce the atmospheric pollution by capturing particulate matter, and absorbing gaseous pollutants (Hamraz et al. 2014). Leaves of the plants in particular provide a large surface area for the deposition of atmospheric pollutants and subsequently act as a sink (Kim et al. 2015). Plants have the capacity to remove air

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pollutants by three means: absorption by the leaves, deposition of particulates over leaf surfaces, and the fallout of particulates on the leeward side of the vegetation (Rawat and Banerjee 1996). Plants can remove air pollutants like HF, SO_2, PAN, and heavy metals such as mercury (Hg) and lead (Pb) from the air (Shannigrahi et al. 2003). However, certain air pollutants can adversely affect the plant growth by altering the biochemical composition, rate of photosynthesis, seed germination, number of flower on florescence, length of pedicle, and stomata (Chakraborty et al. 2009). Some plants can adapt to the changed environment by virtue of biochemical adjustments particularly in chlorophyll, ascorbic acid, pH of leaf, and relative water content (Kuddus et al. 2011; Flowers et al. 2007). These adjustments in biochemical characteristics can be combined to determine the air pollution tolerance index (APTI) of a particular plant species. Broadly, APTI can be used for identifying the sensitive, intermediate, and tolerant plants species towards air pollutants (Nayak et al. 2015; Leghari et al. 2011; Das and Prasad 2010; Liu and Ding 2008).

Plant species, those are more sensitive acts as bioindicator of air pollution, while tolerant one act as sink for airborne pollutants and can be used for the development of green belt (Rai and Panda 2014; Kousar et al. 2014; Kuddus et al. 2011; Agbaire and Esiefarienrhe 2009; Singh et al. 1991). Lucknow being the most populated state of India i.e. U.P. is facing twin challenge of high population and uncontrolled vehicular growth, which has adversely affected the ambient air quality particularly in urban areas (Bharti et al. 2017; Barman et al. 2008). Poor air quality problem can be addressed by planting tolerant plant species having high APTI. The present study was conducted to determine the sensitivity/ tolerance of common plants species towards air pollution growing near Talkatora Industrial Area by calculating their APTI. The APTI of various plant species shall be helpful in selection of suitable plants for the purpose of development of green belt in the vicinity of urban/industrial areas.

2. Materials and methods

2.1. Description of study area

Talkatora Industrial Area (26° 83′N, 80°89′E) was selected for the current study (Fig. 1). This industrial area is located about 7 km south from central Lucknow, and was established in 1962. It spreads in an area of about 48.66 acres. Plywood manufacturing factory, metal sewing company, Havells steel plant, chlorinator, and many small scale industries (battery, plastic, phosphorus box, pottery, paint, moribund hosiery units, soap and detergents) are operating in this area (Pandey et al. 2013). The resuspension of road dust, residential, commercial, and industrial emissions during processing contribute significant amount of air pollutants to the atmosphere. Deposition of particulates can be easily seen on the leaves of plants growing around the industrial area (Fig. 2).

2.2. Plant sampling

A total of twenty-five plant species were selected from the industrial area, whereas, the same plants growing in the garden served as control (Table 1). Plants were selected on the basis of presence of visible morphological impacts of pollution on foliage; direction of air flow; plant abundance, and ecological significance of the specific plant species. Matured fresh leaves of selected plant species were collected during the peak crushing time i.e. morning in five replicates. Collected leaves packed in polythene bags and immediately stored in ice box for the analysis of various biochemical characteristics viz. total chlorophyll, ascorbic acid, pH of leaf extract, and relative water content.

2.3. Calculation of dust load

The area of individual leaf was calculated by tracing out the leaves on graph paper (Vora and Bhatnagar 1986; Saini et al. 2011). Further, samples were weighed on pre calibrated electronic balance (Mettler Toledo, Japan) and the amount of dust load was determined gravimetrically by using following formula (Prusty et al. 2005):

$$W = \frac{W_2 - W_1}{A}$$

where, W is the dust content (mg/cm^2), W_1 (g) is the initial weight of beaker, W_2 (g) is the final weight of beaker with dust, and A is the total area of a leaf in cm^2.

2.4. Biochemical analysis

Relative water content (%) of the leaf was calculated by following formula (Liu and Ding 2008):

$$RWC = \frac{FW - DW}{TW - DW} \times 100$$

where, FW is the fresh weight, DW is the dry weight of turgid leaves after oven-drying at 115 °C for 2 h, and TW is the turgid weight (mg) after overnight immersion in water, whereas, total chlorophyll (mg/g) was estimated following Arnon (1949), and Chouhan et al. (2012):

$$\text{Chlorophyll a (mg/g)} = \frac{12.7_{D663} - 2.69_{D645} \times V}{1000 \times W}$$

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