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Original article

Lantana camara invasion in urban forests of an Indo–Burma hotspot region and its ecosustainable management implication through biomonitoring of particulate matter

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ABSTRACT

The present study was performed in urban forests of Aizawl, Mizoram, north east India falling under an Indo–Burma hot spot region of existing ecological relevance and pristine environment. The phytosociology of invasive weeds has been studied, showing that *Lantana camara* was the most dominant invasive weed. Further, the air quality studies revealed high suspended particulate matter as well as respirable suspended particulate matter in the ambient air of Aizawl. Biomonitoring through plant leaves has been recognized as a recent thrust area in the field of particulate matter science. We aimed to investigate whether *L. camara* leaves may act as a biomonitoring tool hence allowing its sustainable management. The quantity of respirable suspended particulate matter and suspended particulate matter at four different sites were much higher than the prescribed limits of Central Pollution Control Board of India during the summer and winter seasons. The dust deposition of *L. camara* leaves was 1.01 mg/cm^2 and, pertaining to the biochemical parameters: pH was 7.49; relative water content 73.74%; total chlorophyll 1.91 mg/g; ascorbic acid 7.06 mg/g; sugar 0.16 mg/g; protein 0.67 mg/g; catalase 30.76 U/mg protein; peroxidase 0.16 U/mg protein; and air pollution tolerance index was 12.91. *L. camara* was observed in the *good* category in anticipated performance index, which shows the tolerant and conditioning capacity of air pollution. Therefore, the present study recommends the use of *L. camara* as biomonitor that may further have sustainable management implications for an invasive plant.

Introduction

Plant invasion is a priority threat to global biodiversity and hence deleterious to both ecology and economy of any nation. Invasive plants or weeds transmogrify the landscapes of urban forests and duly affect their phytosociology as well as the diversity of native species in a complex and intricate manner (Rai 2013). Various hypotheses have been proposed to understand the basic mechanism of succession in order to device sustainable management strategy; however, none describe it completely (Rai 2013, 2015a, 2015b, 2015c, 2015d).

Lantana camara is an important weed of agro and forest ecosystems, where it forms dense thickets that livestock cannot penetrate (Rai 2015d). The leaves are toxic when ingested by most domestic livestock or native mammals, although toxicity varies greatly between strains (Goulson and Derwent 2004). In Australia (Leigh and Briggs 1992; Groves and Willis 1999), like other countries, plant invasion has been associated with the extinction of several valuable endemic plant species such as *L. camara* (Gooden et al 2009).

L. camara is the dominant invasive species in many parts of Rajasthan resulting from landscape modernization (Robbins 2001). Rai (2009, 2013, 2012, 2015d) ecologically investigated *L. camara*, *Mikania micrantha*, and *Ageratum conyzoides* in the forests of an Indo–Burma hot spot region. In aquatic ecosystems of India several invasive plants such as *Eichhornia crassipes* have been reported (Rai 2008, 2009, 2012).

Pollination success in diverse habitats, such as in the cases of *L. camara*, *Ligustrum robustum*, and *Mimosa pigra*, through profuse nectar and prolonged flower production (Ghazoul 2002) aid in their invasion success. As demonstrated in the case of *L. camara*, forest gap/canopy openness plays a major role in invasive spread

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therefore canopy intactness may be one prime management strategy, although this is rather difficult to maintain (Totland et al 2005; Rai 2013). Many invasive aquatic plants such as *E. crassipes* and the terrestrial shrub *L. camara* are reported to be very good in heavy metal-rich environments as well as particulate pollution phytoremediation (Rai 2008, 2009, 2012; Rai and Panda 2014). Thus, the utilization of invasive plants in pollution abatement phytotechnologies may assist in their sustainable management.

Unfortunately, urban ecosystems of ecologically sensitive regions such as Indo–Burma hot spot are under severe air pollution stress (Rai 2012). Air pollutants comprised of both particulate matter (PM) and gaseous pollutants may cause adverse health effects in humans, affect plant life, and impact the global environment by changing the atmosphere of the Earth (Rai et al 2014; Rai 2015e). Air pollution emanating from PM is particularly deleterious as they lead to various cardio-pulmonary diseases through oxidative stress (Rai 2013, 2015e).

In light of the above mentioned, the present study attempts to investigate the biomonitoring potential of *L. camara* through biochemical measurements of plant leaves, which may aid in its ecosustainable management. Further, a note on other options on ecosustainable management including this study is presented.

Material and methods

Mizoram is the site of particular ecological relevance as it is an Indo–Burma hot spot region. In Mizoram, land use change through shifting cultivation is very frequent, which may exacerbate the problem of biological invasions (Rai 2009b, 2012). The study was conducted at Aizawl, Mizoram, North East India, in 2013. For the leaf dust deposition and the biochemical parameters, the study was performed only in winter and the remaining parameters were performed for all seasons i.e. summer, rainy, and winter. Sites were selected in accordance with varying disturbance intensity.

Phytosociological studies

For phytosociological studies, quadrats of 10 m × 10 m in size were randomly used. Quantitative/phytosociological parameters such as % frequency, density, abundance, and total basal cover of each species present in quadrats has been recorded and analyzed as per the methods of Kershaw (1973) and Misra (1968).

Suspended and respirable suspended particulate matter

Common air pollutants including suspended PM (SPM) and respirable suspended PM (RSPM) were analyzed by using High Volume Air Sampler (Model APM-460NL; Envirotech Instruments Pvt. Ltd.,,Manufacturers of Air Pollution Monitoring Instruments, A-271, Okhla Industrial Area, Phase-1, New Delhi-110020, India) regulating 8 h/d. The instrument was kept 2 m higher from the ground surface. The samples were brought to the laboratory after each sampling, and concentration of RSPM (using Whatman glass fiber filter papers) and SPM (using containers) were determined at an average air flow rate of 1.5 m^3/min.

Estimation of dust deposition

Three replicates of fully mature leaves of *L. camara* were marked. The surface (dorsal side) of leave samples was cleaned and the dust present was collected in a tracing paper (preweighed). The petioles were removed from the leaves for further analysis in the laboratory. The graph paper method was applied for each leaves area (in cm^2). The dust collected was weighed using an electrical balance and calculated using the formula:

$$W = (w_2 - w_1)/a \quad (1)$$

where, W = dust deposited (mg/cm^2), w_1 = weight of tracing paper without dust, w_2 = weight of tracing paper with dust, and a = leaf total area (cm^2) (Prusty et al 2005).

Estimation of pH

A 0.5 g *L. camara* leaf sample was crushed and homogenized in 50 mL deionized water, the mixture was centrifuged and supernatant was collected for measurement of pH using pH meter.

Estimation of relative water content

To estimate of relative water content (RWC) of *L. camara*, the method described by Liu and Ding (2008) was followed based on the formula and the result was expressed in (%).

$$RWC = (wf - wd) \times 100/(wt - wd) \quad (2)$$

Fresh weight (wf) of the leaf was increased when leaf pieces were weighed after immersing in water overnight to get turgid (wt). The leaf pieces were then blotted to dryness and placed in a dryer at 115°C (for 2 h) and reweighed to get dry weight (wd).

Estimation of total chlorophyll content

For the estimation of total chlorophyll (TCH) content, the method described by Arnon (1949) was used. 0.5 g of fresh leaves of *L. camara* were crushed and extracted with 10 mL of 80% acetone and left for 15 min. The liquid portion was decanted into another test tube and centrifuged at 2500 rpm for 3 min. The supernatant was then collected and the absorbance measured at 645 nm and 663 nm using a spectrophotometer. TCH was calculated using the formula:

$$\begin{aligned} &\text{Chlorophyll a} = 12.7\,DX\,663 - 2.69\,DX\,645 \times V/1000 \times W\ \text{mg/g} \\ &\text{Chlorophyll b} = 22.9\,DX\,645 - 4.68\,DX\,663 \times V/1000 \times W\ \text{mg/g} \\ &TCH = \text{chlorophyll a} + \text{chlorophyll b mg/g} \end{aligned} \quad (3)$$

where, DX = Absorbance of the extract, V = total volume of the chlorophyll solution (mL), and W = weight of the tissue extract (g).

Estimation of ascorbic acid

Estimation of ascorbic acid (AA) was done using method of Keller and Schwager (1977). A 0.5-g sample of fresh *L. camara* leaf was homogenized with 20 mL of extracting solution (5 g oxalic acid + 0.75 g EDTA in 1000 mL of distilled water). It was centrifuged for 15 min at 6000*g* and the supernatant collected. The supernatant (1 mL) was added to 2,6-dichlorophenol indophenol (5 mL of 20 μg/mL), the solution was turning pink. The optical density (OD) of the mixture was taken at 520 nm (Es). After taking the OD of the mixture one drop of ascorbic acid was added to bleach the pink color and again the OD was taken at the same wavelength (Et). The OD of 2,6-dichlorophenol indophenol solution was also taken at 520 nm (Eo). The standard curve was prepared by using different concentration of ascorbic acid by following the same method. Concentration of ascorbic acid is calculated by using formula:

$$AA\ (mg/g) = [Eo - (Es - Et)] \times V/W \times V1 \times 1000 \quad (4)$$