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Short communication

Plant regeneration potential in fly ash ecosystem

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ABSTRACT

Ability of certain plant species to regenerate by adaptive growth can address the harsh conditions of fly ash dumps in fly ash ecosystem. In the present study, we examined the status of regeneration potential of planted tree species in three life forms at fly ash ecosystem of tropical zone. On the basis of importance value index *Prosopis juliflora* (Sw.) DC., *Pithecellobium dulce* (Roxb.) Benth. and *Pongamia pinnata* (L.) Pierre have been found as dominant species in fly ash ecosystem. In this regeneration status study, the above three tree species (68.91%) have been found in good regeneration category which can be used for revegetation of new fly ash dumping sites.

1. Introduction

Continuous increase in the number and area of fly ash (FA) dumpsites is a worldwide concern due to their potential toxic effects and heavy metals released in the environment (Pandey, 2015). The toxic elements i.e. As, Cd, Cr, Pb, Hg, etc. and polycyclic aromatic hydrocarbons (PAHs) are the potential pollutants of FA that can contaminate air, soil and water in the vicinity of coal-based thermal power plants (Pandey et al., 2011; Ribeiro et al., 2014; Verma et al., 2015). In this direction, mismanagement of FA dumps may contaminate the surrounding air, soil and water and could lead to pollution levels that can affect human health and their livelihood (Pandey et al., 2011; George et al., 2015). All the environmental problems of FA can be mitigated by revegetation of the ash dumpsites. For the successful restoration and revegetation of a FA landfill, an investigation of plant adaptability and their regeneration potential is needed in FA ecosystem. It is well known fact that natural plant colonization processes on FA dumps take place slowly due to unfavorable substrate and local conditions (Pandey and Singh, 2012). Thus, the plantation of suitable phytoremediating plants should be adopted to boost the plant colonization on these sites. Successful plantation on FA dumps is a tough job due to its physicochemical limitations regarding plant growth (Carlson and Adriano, 1993; Pandey et al., 2009a). However, revegetation is the best approach to eliminate the hazardous effects of FA dumpsites (Haynes, 2009; Pandey et al., 2009a), which can be achieved through ecological engineering (Pandey and Singh, 2012, 2014; Pandey, 2015). Planting of grass, shrub, and woody species stops erosion and stabilizes toxic trace elements either by the plant uptake or the binding of ash particle by their roots, and ultimately creating the conditions towards soil formation (Ram et al., 2008; Juwarkar and Jambhulkar, 2008; Jambhulkar and Juwarkar, 2009; Pandey et al., 2012, 2015a).

Most of the research work on FA as a soil ameliorant has been done in agriculture area (Lee et al., 2006; Ram et al., 2007; Pandey et al., 2009b, 2010; Singh et al., 2011; Singh and Pandey, 2013; Pandey and Kumar, 2013) as well as in reclamation of degraded lands (Pandey and Singh, 2010; Ram et al., 2006; Ram and Masto, 2010; Srivastava et al., 2014). Likewise, several researches have been carried out on phytoremediation, restoration and revegetation of FA dumpsites through potential plant species (Gupta and Sinha, 2008; Maiti and Jaiswal, 2008; Mitrovic et al., 2008; Ram et al., 2008; Pandey et al., 2012, 2014, 2015a,b; Kumari et al., 2013; Pandey, 2015). Some studies have also been conducted towards microbial remediation of FA hazards (Tewari et al., 2008; Rau et al., 2009; Babu and Reddy, 2011). Furthermore, Tropek and his colleagues have worked on FA dumps and showed interesting results about conservation potential of FA dumps for colonizing by some insects and arthropod groups (Tropek et al., 2013, 2014). To the best of our knowledge, there are no reports on the regeneration status of planted species in rehabilitated FA ecosystem. Therefore, the present study provides the information about the regeneration status of the planted tree species on FA dumps of Panki Thermal Power Station, Kanpur district of Uttar Pradesh, India. The aim of this study was to assess the regeneration potential of tree species

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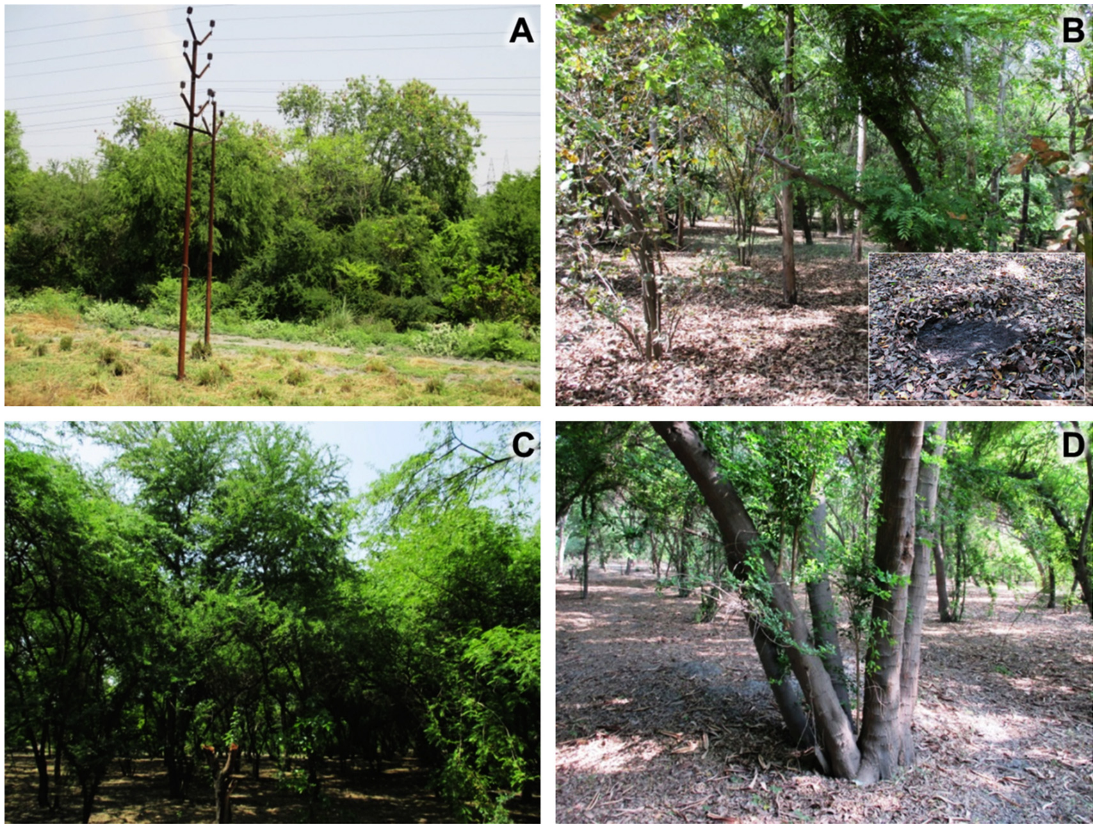

Fig. 1. Lush growth of planted tree species on fly ash dumps of Panki Thermal Power Station, Kanpur District of Uttar Pradesh, India: (A) Landscape view of manmade plantation on fly ash dump; (B) biomass and carbon storage in fly ash ecosystem through plantation and carbon sequestration potential through root secretion and litter turnover (Inset); (C) Dense and fast growth of *Prosopis juliflora* towards high adaptability of fly ash dumps; (D) Multiple stem growth of *Pithecellobium dulce* on fly ash dumps, Photographs by V.C. Pandey.

for revegetation of FA dumps. Our hypothesis was that the planted *Prosopis juliflora* (Sw.) DC. on FA dumps has best adaptability than other planted species towards the sustainability of FA ecosystem.

2. Materials and methods

2.1. Study site description

Coal based “Panki Thermal Power Station” is located at Panki in Kanpur district (26°28′19″N 80°14′1″E) of Uttar Pradesh, India. The ash dumped site is situated near Panki Thermal Power Station. The substrate under study here is FA dump, a heap of coal combustion residue of thermal power station. A thick (>10 cm) layer of soil was used to accelerate initial establishment and growth of plantation on the harsh conditions of FA dumps. The plantation was raised on old FA dumping site by the Panki Thermal Power Station. For this, six month old nursery raised saplings of different tree species were used for plantation during the beginning of monsoon. However, protective watering was done manually especially during summer months for the first year. This revegetated area was protected by a fence to check the hindrance of local animals and villagers. Now, this revegetated area of FA dump was converted into a FA ecosystem. At the time of assessing the regeneration status of the planted tree species, natural colonisation of *Lantana camara* L., *Saccharum spontaneum* L., *Calotropis procera* (Aiton) Dryand, *Cannabis sativa* L., *Parthenium hysterophorus* L. and *Argemone Mexicana* L. were also observed on outer side of FA ecosystem. The climate of this region is tropical with three distinct seasons viz., summer (April to June), monsoon (July to September) and winter (November to February). Temperature varies from 4.0 °C to 46.0 °C throughout the year. The average annual rainfall in Kanpur district is 875 mm.

2.2. Data collection

The status of regeneration was assessed in the course of 2014–2015 for the tree plantation at FA dumping site of Panki Thermal Power Station, Kanpur. Three life forms were considered during the study (*i.e.* adult tree, sapling and seedling). Nested random quadrats were laid out to collect the required data; where 10 × 10, 5 × 5 and 1 × 1 m quadrates were used for adult trees, saplings and seedlings respectively. A sum of 27, 52 and 81 quadrates were laid down for adult trees, saplings and seedlings respectively. All three

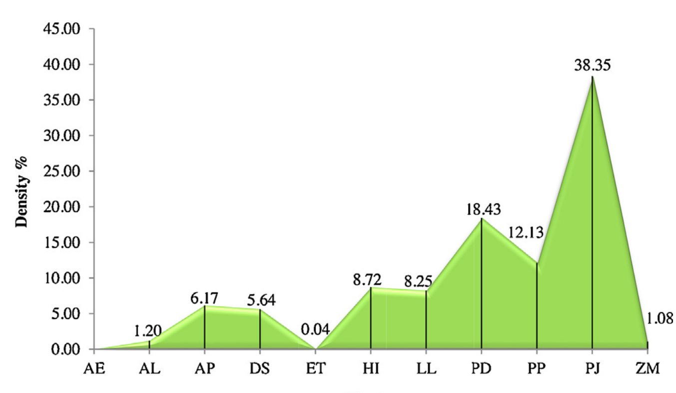

Fig. 2. Density (%) of plants on fly ash dumping site of Panki thermal power station, Kanpur (AE, *Ailanthus excelsa* Roxb.; AL, *Albizia lebbeck* (L.) Benth.; AP, *Albizia procera* (Roxb.) Benth.; DS, *Dalbergia sissoo* Roxb. ex DC.; ET, *Eucalyptus tereticornis* Sm.; HI, *Holoptelea integrifolia* (Roxb.) Planch.; LL, *Leucaena leucocephala* (Lam.) de Wit.; PD, *Pithecellobium dulce* (Roxb.) Benth.; PP, *Pongamia pinnata* (L.) Pierre; PJ, *Prosopis juliflora* (Sw.) DC.; ZM, *Ziziphus mauritiana* Lamk.).