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Changes in diversity and composition of flora along a corridor of different land uses in Karachi over 20 years: Causes and implications

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ABSTRACT

Karachi Metropolitan Corporation has been extensively planting few species along the streets over the last few decades. However, the suitability of the species was not properly studied before planting them in Karachi. This is evident from the fact that many species were profusely planted in Karachi during different decades, which were later removed for various reasons. For instance, *Eucalyptus* was extensively planted during 1980s and 1990s along the streets in Karachi, which was later removed due to their fast growing roots and shoots that damaged many civic services. Therefore, the current study investigates (i) the changes in taxonomic diversity and the composition of the species growing along a major roadway of different land uses in Karachi, (ii) causes and implications due to the changes in their diversity and composition. This study reveals that monoculture plantings were commonly practiced in Karachi. Currently, *Conocarpus erectus* is the most frequent species, which alone has 83.55% individuals on the street under study. Earlier, the same street was extensively planted with *Eucalyptus* and *Guaiacum officinale.* In 1993, the street under study was represented by 32.04% native plants and 67.96% exotic plants from 67 different species. Currently, the same street is represented by 53 species. The target-based 10:20:30 heuristic guidelines and non-target based Shannon and Inverse Simpson Diversity indices have been applied to analyze the flora of the street. Inverse Species Diversity index of the plants along the corridor has declined substantially from 8.75 to 1.41 over the last two decades that shows an increase in monotonous landscaping along the street under study, which make them vulnerable to diseases and pests. The changes in species richness along different land uses have also been analyzed.

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1. Introduction

Street trees provide many ecosystem services to urban dwellers (Soares et al., 2011). They help to reduce urban air pollution (Nowak et al., 2006), sequester tropospheric carbon (Nowak and Crane, 2002; Brack, 2002), conserve energy by reducing demand for cooling (Akbari et al., 1997; McPherson and Simpson, 2003), mitigate the urban heat island effect (Loughner et al., 2012; Enete et al., 2012), reduce heat stress and solar radiation particularly on hot summers days (Kotzen, 2003; Konarska et al., 2014) and attenuate vehicular traffic noise (Fang and Ling, 2005). Moreover, their presence along streets increases the rental and sales price of residential properties (Donovan and Butry, 2011) and protects street vendors from the sun and the rain (Nagendra and Gopal, 2010).

Consequently in recent years, many cities around the world have started extensive plantings of trees and shrubs along streets, avenues and boulevards in their urban landscape for environmental benefits of their inhabitants. For instance, the large-scale tree planting programs such as Million Tree Planting Initiatives are currently underway in many mega cities including Los Angeles, New York City and London.

Similarly, Karachi (Pakistan) has also been experiencing extensive plantings of trees and shrubs in the urban landscape. Nevertheless, monoculture plantings were practiced in the streetscape of the city during different decades (Hussain 2003; Mandhro, 2015). For instance, during 1980s and 1990s, large statured *Eucalyptus* was extensively cultivated along the streets of the city. Later in 2005, the civic agency of the city started to replace *Eucalyptus* with medium statured *Conocarpus erectus* primarily due to damages to civic services, which were caused by the rapid growth of their roots and shoots. Currently, *C. erectus* is the most extensively cultivated species in Karachi, making them more susceptible to diseases and pests.

Biologically diverse species have been advocated for plantings and replacements in urban landscape to reduce potential damage from pests and diseases (Subburayalu and Sydnor, 2012). A diverse

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composition of species and their population is better adapted to environmental changes, diseases and insect infestation. The risk associated with planting one or few species could be reduced by increasing diversity – both in total number of species represented and in their relative abundance. Many researchers have recommended diversifying urban forests at higher taxonomic levels to reduce the risk of pests and diseases (Raupp et al., 2006; Lacan and McBride, 2008).

Another area of concern is large scale plantings of exotic species. The exotic species were preferred over native species for plantings along the streets in Karachi over the years (Menghwar 2013). It has also been observed that native species were replaced with exotic species during different planting campaigns.

The exotic plant species were being introduced in the country over many centuries. For instance, in the 4th century BC, the army of Alexander the Great introduced *Phoenix dactylifera* (date palm – a native of Iraq) in the Indus Valley (Newton et al., 2013). Later, in the 7th century AD, the Arab conquerors cultivated this species in this area (Chandra and Gupta, 1992). In the second half of 19th century, *Prosopis juliflora* was introduced in this part of the country from Mexico (Pasiecznik et al., 2001). In 1860, *Eucalyptus* was introduced in Pakistan from Australia (Siddique et al., 1979). The pace of introduction of exotic species in this city has accelerated after the independence of the country in 1947. A few years back, *C. erectus,* an exotic species, was introduced and cultivated extensively in the urban landscape of Karachi.

Nevertheless, the planting of native species has gained particular importance in most of the planting programs for the restoration of native ecosystems in urban landscape (Sullivan et al., 2009; Clarkson et al., 2012). Million Trees Program of South Australia is dedicated to planting three million native plants across Adelaide metropolitan areas. Some studies advocate that the native trees require reduced external inputs such as water and fertilizer. For instance, all the exotic species require irrigation in contrast to the native species in Mendoza, Argentina (Breuste, 2013).

Furthermore, native street trees offer foraging resources for birds that may be reduced or absent in exotic streetscape. Native streetscapes support a rich community of birds and increase their richness and diversity in the suburbs and adjacent reserves (Ikin et al., 2013). Native trees have also cultural importance. For instance, *Ficus religiosa* (locally known as Peepal) has a religious value in South Asia (Thaiutsa et al., 2008). *Azadirachta indica* (Neem) and *Ficus benghalensis* (Banyan Tree) have been sufficiently celebrated in the literature of Indian sub-continent (Radhakrishnan, 1992; Ray, 2002; Kashikar, 2014).

In recent years, many studies have been conducted to reveal the diversity and the composition of the street trees in many cities across the world (Santos et al., 2010; Nagendra and Gopal, 2010; Kuruneri-Chitepo and Shackleton, 2011; Sreetheran et al., 2011; Yang et al., 2012; Kendal et al., 2012; Deb et al., 2013; Breuste, 2013). The studies mostly reported the existing status of the diversity and composition of the street trees in the urban streetscape. There is little knowledge to demonstrate the changes in the diversity and composition of cultivated trees in urban streets (Kirkpatrick et al., 2011), particularly the changes in the diversity and the composition of exotic and native species along different socioeconomic gradients of the streets of any mega city. Nevertheless, many studies reported existing variations in the diversity and the composition of trees along different socioeconomic gradients of urban landscape (Hope et al., 2003; Kinzig et al., 2005; Kuruneri-Chitepo and Shackleton, 2011). Moreover, the composition and the diversity of the trees in the streetscape of Karachi – the world's largest city – has never been studied.

The purpose of this paper is to investigate changes in the taxonomic diversity and composition of plant species growing along a major street of Karachi over the last two decades and their relationships to different land uses of the corridor.

2. Materials and methods

2.1. Study area

Karachi lies between 24° 45′ N to 25° 37′ N and 66° 42′ E to 67° 34′ E. The city of Karachi is situated in the South of the country along the coastline of the Arabian Sea (Fig. 1). It is home to over 20 million dwellers and is spread over an area of 3530 km^2 (Karachi Metropolitan Corporation, 2014). In the 1941 census, its population was merely 0.38 million, which demonstrates the phenomenal growth of its population over the last seven decades. Kottek et al. (2006) has placed Karachi in Category BWh (arid hot desert) of Köppen-Geiger climate classification update. The natural biotope for the area is a shrub land. It has low average precipitation (250 mm per annum). Its seasonal temperature typically varies from 13 °C to 36 °C and is rarely below 9 °C or above 36 °C. The warm season continues from March to October with an average daily high temperature above 34 °C. The cold season lasts from December to February with an average daily high temperature below 27 °C.

2.2. Earlier study (1993)

In 1993, a study was conducted on the plants, which were growing along Corridor I of the proposed Karachi Mass Transit Project, to assess the impact of its construction on the environment and the landscape around its neighborhoods (Shams et al., 1993). The Corridor I is one of the six proposed Corridors, which forms a network of roadways to cover entire Karachi for the mobility of the people. The total length of the six Corridors is 87 kilometer. The Corridor I is 15.2 kilometer long which passes through the most densely inhabited nineteen union councils of the city. The union councils have an average density of 114,950 inhabitants per square kilometer.

The corridor starts from Merewether Tower and ends at Sohrab Goth, which comprises of M.A. Jinnah Road (5.7 km), Jahangir Road (1.7 km), S.M. Taufiq Road (3.0 km) and Shahrah-e-Pakistan (4.8 km). In 1993, Merewether Tower and Sohrab Goth were two opposite ends of the city and Shahrah-e-Pakistan was the most recently developed residential part of the corridor. Presently, this area has encroachments for commercial activities. M.A. Jinnah Road, which has many historic buildings along its both sides, is the oldest and commercial part of the corridor.

For the study of the plant species and their population, the corridor was divided into 15 transects, each of one kilometer length, except the last transect that was of 1.2 km. Individuals of all the species, which were growing on the median strips and along both sides on the pavements or between the road edges and the property lines in each transect were recorded and reported in Tables 1 and 2. First four transects and 9th transect were taken as "Commercial Area". The 5th to 8th and 10th transects were categorized as "Commercial and Residential Area". While the last five transects were purely "Residential Area", which houses middle income population of the city. This earlier study on the street plants has been used to ascertain the changes in the composition and diversity of the species over the last two decades.

2.3. Current study (2013)

The construction of the proposed Corridor I of the Karachi Mass Transit Project has not yet been started mainly because of the financial constraints and the presence of historic buildings, such as, Khalidina Hall, Karachi Metropolitan Corporation along M.A. Jinnah Road of the corridor. The elevated transit way was proposed for M.A. Jinnah Road of the corridor. It is feared that the proposed elevated

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