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Toward healthy urban streets: Diversity of roadside tree species in industrial area of Shah Alam, Selangor, Malaysia

HASYA HANNANI RUZIMAN[1,♥], ASMIDA ISMAIL[1,4], AZIAN MOHTI[2], KHAIRUL ADZFA RADZUN[1], FAEZAH PARDI[1,4,♥♥]

[1]Faculty of Applied Sciences, Universiti Teknologi MARA. 40450 Shah Alam, Selangor Darul Ehsan, Malaysia. Tel.: +603-5544-4560, Fax.: +603-5543-4562, ♥email: hannaniruziman@gmail.com
[2]Forestry and Environment Division, Forest Research Institute Malaysia. 52109 Kepong, Selangor Darul Ehsan, Malaysia
[3]Faculty of Business and Management, Universiti Teknologi MARA. 42300 UiTM Cawangan, Selangor Darul Ehsan, Malaysia
[4]Institute for Biodiversity and Sustainable Development, Universiti Teknologi MARA. 40450 Shah Alam, Selangor Darul Ehsan, Malaysia. Tel.: +603-5544-4399, ♥♥email: faezahpardi@uitm.edu.my

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Abstract. *Ruziman HH, Ismail A, Mohti A, Radzun KA, Pardi F. 2023. Toward healthy urban streets: Diversity of roadside tree species in industrial area of Shah Alam, Selangor, Malaysia. Biodiversitas 24: 2674-2681.* Shah Alam, one of the biggest cities in Selangor has undergone a significant transformation with numerous developments to cater the needs of the ever-growing population. However, the rapid urbanization and massive infrastructure developments have indirect effects on landscape patterns and roadside tree diversity. Hence, this study was conducted to assess the species richness and diversity of roadside trees in Shah Alam, Selangor. All trees with height of 1 meter and above in Section 15 and 16 were measured and identified as referred to the Landscape Department of Shah Alam City Council (MBSA) computerized database. The data were analyzed for their taxonomic composition and species diversity. A total of 5,523 trees were recorded where 4,087 trees occurred in Section 15 and 1,426 trees in Section 16. Fabaceae was the most dominant family in both sections in which three leading species, i.e. *Peltophorum pterocarpum* (DC.) Backer ex K.Heyne, *Pterocarpus indicus* Willd. and *Roystonea regia* (Kunth) O.F.Cook, accounted for 14.7% of the planted trees. Section 15 was relatively higher in taxonomic composition with 11 families and 25 species than Section 16, with 8 families and 18 species. The values for species diversity index were considered high in both sections with 8.37 despite the environmental impact from the industrial activities. Thus, it is suggested that future research should include the potential risks of biodiversity loss for proper management practices in urban settings.

Keywords: Ecology, roadside trees, SDGs, species diversity, urban landscape

INTRODUCTION

Roadside trees are an integral part of urban green space. Along with trees within parks and commercial areas, trees along the streets account for a large portion of tree canopy in an urban setting. They provide various benefits in terms of environmental and ecological aspects. Throughout the world, they become distinct component of urban forests aimed to improve urban life by reducing runoff, air pollution and energy use, and improving human health and emotional well-being (Salmond et al. 2016; Vargas-Hernandez et al. 2018). Because of these unique purposes, the species composition and abundance of trees in urban setting should be determined carefully with regard to the design of urban greenery. Roads have a great impact on the structure and functioning of the diversity pattern in an ecological environment and play the role of altering biotic and abiotic factors. It is said that most trees in urban regions are subjected to various stresses due to the harsh environment (e.g. pollution, hot temperature and human disturbances), which cause them to deteriorate and become more vulnerable to insect and diseases (Maruthaveeran and Chen 2023). This practice would result in an increase of maintenance cost in order to remove and replace these unhealthy trees that are unable to survive and thrive. Further, the role of diversity of urban trees may relate to its potential to contribute to climate change mitigation (Nowak et al. 2014; Roebuck et al. 2022). Low species diversity can cause the decrease in carbon stocks where roadside trees act as local biodiversity reservoirs to reduce the atmospheric pollution (Heng et al. 2017; Jaman et al. 2020). In addition, it is recommended that similar tree species should only be planted for less than 10% of total trees altogether (Czaja et al. 2020). This is because of the high possibility of a species-specific pest or disease that might threaten or destroy the significant portion of urban trees especially under a changing climate. Hence, the rationales above suggest that maintaining urban biodiversity is crucial for the ecological functions as well as disease tolerance of roadside tree population.

The relative abundance of trees planted on roadside is suggested based on taxonomic levels such that their limits of 10% for species, 20% for genera and 30% for family level. However, this numerical limit has little empirical evidence to be a standard for selecting roadside trees (Kendal et al. 2014; Wiryono et al. 2018). In addition, another aspect to consider when determining roadside trees may also be derived from internal factors, such as canopy form and seed dispersal mechanism, and external factors, such as environmental conditions. There is also growing concern about the overpopulation or increasing in population density that can affect trees in urban settings. This is because human settlements in the urban areas need to cater to the population needs, in addition to infrastructural developments (Ramaiah and Avtar 2019). Selangor is the most developed state in Malaysia with good infrastructures, such as highways and transportation systems. The state also has the largest population in Malaysia with 6.32 million people (Chua 2018). Due to the increase in human population, some forested areas in Selangor are sacrificed to make way for development. Over the past 10 to 15 years, Shah Alam, one of the biggest cities in Selangor has undergone a significant transformation with numerous developments including to cater the needs of the ever-growing population. The rapid urbanization and massive infrastructure developments have indirect effects on landscape patterns and urban plant diversity (Norton et al. 2016). Hence, comprehensive studies are needed to support the goal of achieving sustainable development and a healthier environment, especially in urban areas. In accordance with the launch of the Sustainable Development Goals (SDGs) by the United Nation in 2015, such studies are important to align with the third and eleventh goals of SDGs, where SDG 3 aims to ensure healthy lives and promote well-being for all at all ages and SDG 11 focuses on making cities and human settlements inclusive, safe, resilient and sustainable (United Nations 2015). Thus, it is essential to have additional information or knowledge regarding the composition of roadside trees as the fundamental element in green spaces to ensure the sustainability of urban areas.

Therefore, this study was conducted to assess the species richness and diversity of roadside trees in Shah Alam. This research provides more understanding of the importance of the biological diversity of urban trees as one of the key factors in the stability of roadside tree populations. Besides, the information on the status and dynamics of tree species diversity in urban environments is also important for better planning and management practices by relevant authorities to sustain the species diversity and urban aesthetics.

MATERIALS AND METHODS

Study area

The study area was conducted in Shah Alam, which is the capital of Selangor, Malaysia and among the most populous city within Selangor. It is located about 25 km west of Kuala Lumpur near Subang Jaya, between Klang and Petaling Jaya. The city was established in 1963 and was granted the state capital status in 1978 (Habsah 2016). With a population of 541,306 people in 2010, Shah Alam is a major industrial hub (Department of Statistics 2011). This city consists of 56 sections, and it covers a vast area of 290.3 km^2 of land, mainly occupied by housing and industrial complexes.

Two study areas namely Section 15 and Section 16 (Figure 1) represent a range of development history and land use patterns. These two sections are industrial zones with only factories and shop lots with no residential properties located within. Section 15 consists of banks, restaurants, cafes, convenience stores, and mechanic shops. Among the factories that are available in this place are UMW Corporation, Karangkraf Media Group, Bright Steel, Perodua Service Centre, Toyota Service Centre and UMW Holdings.

Section 16 Industrial Park consists of shop lots and factories with land areas between 1,950-118,218 sf. It is located directly beside the Federal Highway and close to the Section 7 commercial center for the convenience of residents and workers. Businesses who have chosen Section 16 Industrial Park include Fortune Laboratories, Synztec Malaysia, Tamura Electronics, Network Food Industries, Wah Kong Corporation, NS Bluescope Lysaght Malaysia, Felio Electronics, Petronas Gas Berhad and CCM Chemicals. Therefore, recent years bear witnessed for aggressive tree planting program in residential areas and along the roadsides. Issues of landscaping are very important as one of the factors that could promote the city as liveable and environmentally healthy.

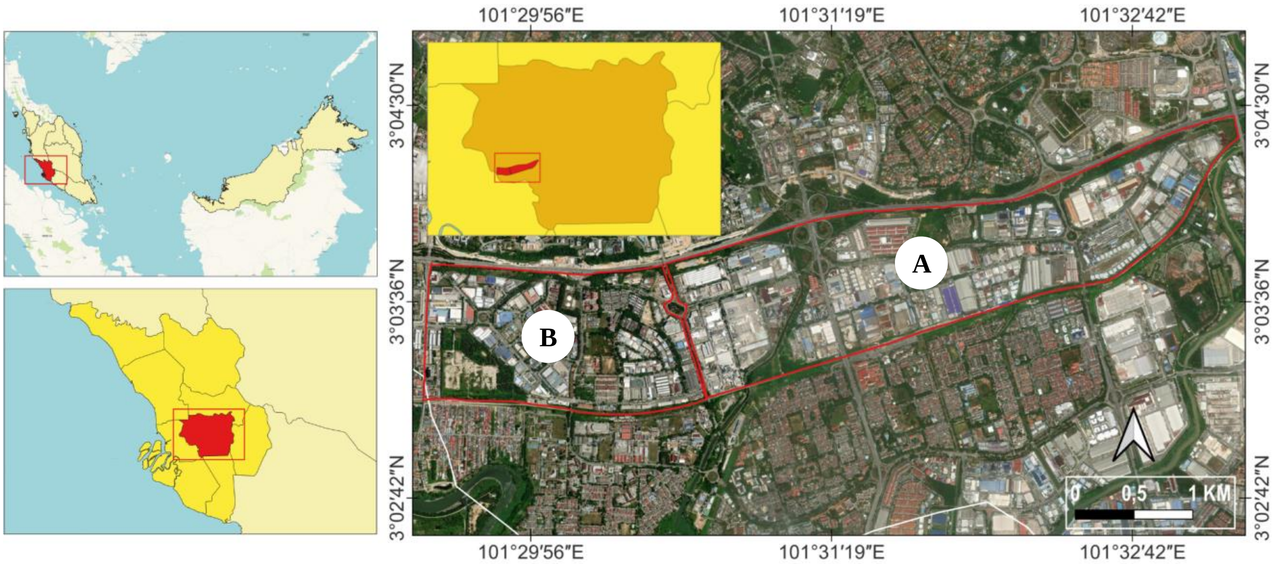

Figure 1. Map of study area at Section 15 (A) and 16 (B) of Shah Alam, Selangor, Malaysia

Data collection

The data was obtained from Landscape Department of Shah Alam City Council computerized database. This database contained a complete inventory of the trees with minimum height of 1 m, which is regularly updated and maintained to assist in the management of urban trees. Groundwork and observation at the study area were also conducted to verify the database information of planted roadside trees. The trees were categorized according to shade trees and palms by referring to Plant Material Booklet 2: Wayside Trees of Malaya (Corner 1998). The origin of plants was determined whether they were species from Southeast Asia region, including Malaysia or exotic species from outside the region of Southeast Asia.

Data analysis

The quantification of community structure is an important part of this study to gain a vital insight and comprehension of the roadside population as well as to access comparison between Section 15 and Section 16. The indices used in this study were Shannon Wiener Diversity Index (Weaver and Shannon 1949), Shannon Evenness Index, and Margalef Index calculated in PAST software ver 1.93 (Magurran 1988; Zolkfilee et al. 2022). The data was also analyzed to indicate the Species Diversity Index (SDI), Simpson's index, density and relative abundance of the roadside tree species present in each selected sections of Shah Alam. SDI was calculated manually according to Sun (1992).

RESULTS AND DISCUSSION

Taxonomic composition

There were 5,523 trees recorded in this study with a height of more than 1 meter in Section 15 and Section 16 of Shah Alam (Table 1). The taxonomic composition of the roadside trees consisted of 16 families and 34 species. Section 15 was relatively higher in taxonomic composition with 11 families, 25 species and 4,087 trees compared to Section 16 with 8 families, 18 species and 1,436 trees. Fabaceae was the most dominant family in both sections which accounted for 14.7% of the planted trees with species such as *Peltophorum pterocarpum* (DC.) Backer ex K.Heyne, *Pterocarpus indicus* Willd., *Roystonea regia* (Kunth) O.F.Cook, *Tamarindus indica* L. and *Samanea saman* (Jacq.) Merr.. For an estimated area of 727 ha, the total number of tree species recorded at the roadside in Section 15 and Section 16 of Shah Alam was 34 and this is considered a well-represented number of urban trees compared with temperate-latitude cities (Cowett and Bassuk 2017).

Most of the legume trees (Fabaceae) have been proven successful in urban habitats, due to the existence of the nitrogen-fixing bacteria, *Rhizobium*, in nodules associated with their roots (Mahmud et al. 2020). This is due to the fact that in urban environments like Section 15 and Section 16 of Shah Alam, the soil is nutrient poor as the area was developed into many industrial hubs. Therefore, the ability of independently providing their own source of nitrate is a big advantage. Second most dominant family in the study area, Arecaceae (Palmae) is also a popular choice due to their attractive ornamental attributes (Rusdi et al. 2019). For the whole study area, a small number of popular species dominated the tree population, with the remainder making limited contributions. The top five popular species planted along the roadsides accounted for less than one third of the total trees planted. The most five popular species were legume trees of *P. pterocarpum* (Fabaceae) and *P. indicus* (Fabaceae), followed by palmae tree of *R. regia* (Arecaceae), *T. indica* (Fabaceae) and *S. saman* (Fabaceae). They accounted for 14.7% of the total trees planted in the industrial areas of Shah Alam.

The most dominant tree species, *P. pterocarpum* is a large tree from the Fabaceae family that bears attractive yellow flowers in erect bunches. This species can be easily identified by its mass of purple-brown flattened pods in its crown that last for months. This species is also known for its ability to overcome *Imperata cylindrica* (L.) P.Beauv. or its local name as *lalang*, which is relatively wind-resistant, is not attacked by boring beetles and can regenerate from cuttings. Besides that, *P. indicus* is also another legume tree from Fabaceae family which is commonly planted as roadside trees. It is a majestic, briefly deciduous tree that grows to a height of 25-35 m (82-115 ft). This species is commonly planted for amenity and ornamental purposes in the humid tropics as well as one of the multipurpose tree species in the Pacific islands for reforestation, village-level woodlots, living fencing, and large amenity trees. According to Tukiran et al. (2016), the canopy shape of tree is also an important feature in landscaping due to its suitability for shading. For instance, the two most common species in the studied area, *P. pterocarpum* (Fabaceae) and *P. indicus* (Fabaceae) have a round form of tree canopy where these trees are often used as shade trees in landscape. They are good for shading medium vertical clearance between building and medium-sized street. Furthermore, shading for large lawn and roadside are useful because they are mostly tall with height of more than 60 ft. Rashid et al. (2010) reported that *P. pterocarpum* can give thermal reduction up to 7.6°C.

Roystonea regia (royal palm) is an introduced ornamental palm that has also become common in the city in recent years. Owing to the aesthetic attributes of the palm, this tree is a large and beautiful thus making it a widely cultivated ornamental tree in the tropics and subtropics. *R. regia* was also among the five leading species planted along the roadsides of UNIMAS, Kota Samarahan, Sarawak, which accounted for 6.4% of total trees planted (Zainudin et al. 2012). *S. saman* or locally known as rain tree, is among the exotic species that was introduced for urban planting in the early 1900s and it is still widely planted in urban areas especially along roadsides and highways (Azaruddin 2019). Mature rain tree has a distinctive form of spreading crown and domed which makes them an ideal shade tree for roadsides.

Species origin

Based on the species origin, about 17 out of 34 species or 50% have original distribution in Southeast Asia region (Table 2). This includes species from the Leguminosae family such as *P. pterocarpum*, *Dalbergia* sp., *P. indicus*, *T. indica* and *Adinobotrys atropurpureus* (Wall.) Dunn. Although not specifically originating from Malaysia, these trees will reflect a local image of a country or a region. Besides, the trees that are indigenous to the region will be more suitable to the climate and surrounding environment resulting in fewer adaptation problems (Ahmad Nazarudin 2016). For instance, Ahmad Nazarudin (2016) also reported that *P. pterocarpum* and *A. atropurpureus* showed high tolerance to soil conditions such as low soil moisture and low soil fertility. This explained the aim of Shah Alam authorities of having more trees indigenous to this region planted. The remaining urban tree species in Section 15 and Section 16 are exotic, and originated from Australia, Africa, Mexico, China, Japan and many more. Further, Susilowati et al. (2021) added that exotic tree species are prevalent in many cities and their adaptation to harsh urban settings may have an impact on the ecological and commercial worth of urban forests.

Species diversity, richness and evenness

Based on Table 3, the Shannon-Wiener Diversity Index for Section 15 and Section 16 was 2.36 and 2.0, respectively. According to Magurran (1988), a value of Shannon-Wiener Diversity Index which falls within the range of 1.0 to 2.4 is considered to be a low species diversity while moderate species diversity for index value within the range of 2.5 to 3.5. Meanwhile, if the value falls within the range of 4.0 to 5.0, then it is considered as highly diverse (Magurran 1988). Based on the value obtained in this study, both sections showed moderate species diversity that can be considered as favorable environment that are sufficient to accommodate more urban plant species easily. However, considering that the study area comprised only two out of 56 sections, the sample collected was not adequate to represent the whole of Shah Alam city. Similar findings of medium diversity index were obtained in the city of Ahmad Yani Park, Medan, Indonesia with value of H' = 2.75 (Harahap et al. 2022).

Table 1. Taxonomic composition of roadside tree species in Section 15 and Section 16 of Shah Alam, Malaysia

Family	Species	No of trees		Grand total
		Section 15	Section 16	
Annonaceae	*Cananga odorata*	-	1	1
Apocynaceae	*Cerbera odollam*	25	-	25
Arecaceae (Palmae)	*Roystonea regia*	609	-	609
Arecaceae (Palmae)	*Veitchia merrillii*	11	-	11
Arecaceae (Palmae)	*Livistona* sp.	8	-	8
Asparagaceae	*Beschorneria yuccoides*	56	-	56
Bignoniaceae	*Spathodea campanulata*	-	3	3
Bignoniaceae	*Tabebuia* sp.	320	2	322
Bignoniaceae	*Tecoma stans*	10	15	25
Calophyllaceae	*Mesua ferrea*	-	295	295
Casuarinaceae	*Casuarina* sp.	-	7	7
Combretaceae	*Bucida* sp.	-	5	5
Combretaceae	*Terminalia catappa*	-	9	9
Cupressaceae	*Juniperus* sp.	65	-	65
Fabaceae (Leguminosae)	*Adenanthera pavonina*	-	57	57
Fabaceae (Leguminosae)	*Adinobotrys atropurpureus*	12	-	12
Fabaceae (Leguminosae)	*Acacia* sp.	24	-	24
Fabaceae (Leguminosae)	*Dalbergia* sp.	6	25	31
Fabaceae (Leguminosae)	*Delonix regia*	20	-	20
Fabaceae (Leguminosae)	*Gliricidia sepium*	46	6	52
Fabaceae (Leguminosae)	*Peltophorum pterocarpum*	899	412	1311
Fabaceae (Leguminosae)	*Pithecellobium dulce*	32	1	33
Fabaceae (Leguminosae)	*Pongamia pinnata*	82	-	82
Fabaceae (Leguminosae)	*Pterocarpus indicus*	721	173	894
Fabaceae (Leguminosae)	*Samanea saman*	286	255	541
Fabaceae (Leguminosae)	*Schizolobium parahyba*	-	74	74
Fabaceae (Leguminosae)	*Tamarindus indica*	409	-	409
Gentianaceae	*Fagraea fragrans*	61	-	61
Meliaceae	*Swietenia macrophylla*	131	-	131
Moraceae	*Ficus benjamina*	5	62	67
Moraceae	*Streblus asper*	8	-	8
Myrtaceae	*Eugenia oleina*	231	-	231
Rubiaceae	*Gardenia* sp.	-	34	34
Sapindaceae	*Filicium decipiens*	10	-	10
Total		4087	1436	5523

Table 2. List of urban tree species planted according to its mature height, origin and family

Species planted	Mature height (m)	Origin	Family
Acacia (Akasia)	10-15	Australia and Africa	Leguminosae
Adenanthera pavonina (Saga tree)	15-20	South East Asia, India	Leguminosae
Adinobotrys atropurpureus	25-30	Southeast Asia	Leguminosae
Beschorneria yuccoides (Mexican lily)	6-15	Mexico	Asparagaceae
Bucida sp. (Dwarf geometry tree)	10-12	Bahamas (Tropical America)	Combretaceae
Cananga odorata	15-20	Southeast Asia	Annonaceae
Casuarina sp.	25-35	East Coast of Peninsular Malaysia	Casuarinaceae
Cerbera odollam	10-15	Mangrove areas of Southeast Asian region	Apocynaceae
Dalbergia sp.	15-20	India, Nepal and Indonesia	Leguminosae
Eugenia oleina	6-10	Malaysia and Thailand	Myrtaceae
Fagraea fragrans	25-30	Southeast Asia	Gentianaceae
Ficus benjamina	25-30	Asia and Australia	Moraceae
Filicium decipiens (Fern tree)	15-20	India, Sri Lanka	Sapindaceae
Gardenia sp.	15-20	Tropical regions of Africa, Asia	Rubiaceae
Gliricidia sepium (Mexican lilac)	10-15	Mexico and Central America	Leguminosae
Juniperus sp.	15-20	China and Japan	Cupressaceae
Livistona sp.	9-15	Southeast Asia region	Arecaceae
Mesua ferrea (Cobra's saffron)	25-30	Sri Lanka. India	Calophyllaceae
Peltophorum pterocarpum	15-20	Coastal areas of Peninsular Malaysia	Leguminosae
Pithecellobium dulce (Madras thorn)	10-15	Tropical America	Leguminosae
Pongamia pinnata (Seashore mempari)	15-25	India	Leguminosae
Pterocarpus indicus	25-30	Malaysia, Indonesia	Leguminosae
Roystonea regia (Royal palm)	20-30	South Florida and Cuba	Arecaceae
Samanea saman (Rain tree)	20-25	South America	Leguminosae
Schizolobium parahyba (Tower tree)	25-30	Brazil	Leguminosae
Spathodea campanulata (African tulip)	15-25	Tropical Africa	Bignoniaceae
Streblus asper	12-30	Southern Asia	Moraceae
Swietenia macrophylla (Mahogany)	20-30	Honduras	Meliaceae
Tabebuia sp. (Trumpet tree)	18-25	South America, Brazil	Bignoniaceae
Tamarindus indica	20-25	Tropical East African, West Asia	Leguminosae
Tecoma stans (Yellow bells)	3-5	America	Bignoniaceae
Terminalia catappa	25-30	Tropical Asia	Combretaceae
Veitchia merrillii	3-5	Philippines	Arecaceae

Table 3. Diversity, Evenness and Richness Index of roadside trees in Section 15 and Section 16, Shah Alam, Malaysia

Index	Section 15	Section 16
Shannon Weiner Diversity Index (H')	2.36	2.00
Species Evenness (J)	0.42	0.41
Simpson's Index (D)	0.87	0.82
Margalef Richness Index (DMG)	2.89	2.34

In addition, the Shannon Evenness Index for the study area indicated value of 0.42 and 0.41 for Section 15 and Section 16, respectively. Evenness index which ranging between 0 and 1 shows the degree of uniformity in the distribution of individual species over a standardized area (Magurran 1988). The value of 1 reflects a situation that all species are equally abundant, and vice versa. Being relatively far from the Evenness Index of 1, it gives an indication of how unevenly the roadside trees in the studied area were distributed. It was observed that the most common species in both sections were *P. pterocarpum* (Fabaceae), *P. indicus* (Fabaceae), *R. regia* (Arecaceae), *T. indica* (Fabaceae) and *S. saman* (Fabaceae) with 1,311 trees, 894 trees, 609 trees, 541 trees and 409 trees, respectively while the remaining species making limited contributions at the studied area (less than 70 trees each). This led to uneven distribution of species in every section. Further, the domination of *P. pterocarpum* (Fabaceae) in the study area indicates low evenness as the high-ranking species have much higher abundances than the low-ranking species. Data on species diversity and composition would serve as a guide for the local authorities in planting, maintaining and planning for future replanting activities.

Other than diversity, species richness is also important indicator to determine species diversity (Magurran 1988). Margalef richness index and Simpson index had a similar trend to express species diversity. Simpson index was also one of the widely used indices and simple to calculate, but heavily weighted towards the most abundant or dominant species in the sample (Simpson 1949). Therefore, it would result in a good discriminate ability in a community that was dominated by a couple of species because it was weighted towards species dominance. As observed in this study, Margalef index and Simpson index value for Section 15 (2.89 and 0.87, respectively) are higher than Section 16 (2.34 and 0.82, respectively) as Section 15 has more species (25 species) than Section 16 (18 species). This can be concluded that urbanization reduces the richness of plant species as well as homogenizes the environment, as supported by de Barros Ruas et al. (2022).

The Species Diversity Index (SDI) was 7.8 and 5.64, respectively for Section 15 and Section. Meanwhile, the SDI value for combination of two sections was 8.37 (Table 4) and this can be considered as a high value compared to the value obtained in other Asia countries such as in Longyan, Fujian, China which was 6.0. All cities in non-tropical cities in the United Kingdom had low value ranging from 4.0 to 8.0, while in the United States the value was from 5.0 to 20.1 (Sun 1992). Malaysia under a tropical climate does not support such low value of SDI in terms of quality of environment prior to roadside tree growth. However, since only two out of 56 sections were sampled in Shah Alam with an estimated size area of 727 hectares, the restricted sampling may have provided an underestimation of the species diversity present.

Abundance and density

Table 5 listed the number of trees planted for each species and relative abundance (RA; in percentage) for Section 15, Section 16, and both sections combined. Abundance was studied to obtain a figure of the number of individuals of a particular species. The most dominant species found across the two sections was *P. pterocarpum* with relative abundance of 23.74% out of the total 5523 trees. Other tree and palm species found with higher total number of individuals compared to the rest were *P. indicus* (RA=16.19%), *R. regia* (RA=11.03% RA) and *S. saman* (RA=9.80%) in the two sections combined. As for density where the number of trees was divided by the street length in kilometers (km), it was observed that *P. pterocarpum* was the densest species at Jalan 15/14, Section 15 while *Schizolobium parahyba* (Vell.) S.F.Blake at Bulatan Kemajuan, Section 16.

Table 4. Species Diversity Index (SDI) for roadside trees in Section 15 and Section 16 of Shah Alam, Malaysia

Species	No. of trees (Nj)	Nj * (Nj-1)
Acacia sp.	24	552
Adenanthera pavonina	57	3192
Adinobotrys atropurpureus	12	132
Beschorneria yuccoides	56	3080
Bucida sp.	5	20
Cananga odorata	1	0
Casuarina sp.	7	42
Cerbera odollam	25	600
Dalbergia sp.	31	930
Delonix regia	20	380
Eugenia oleina	231	53130
Fagraea fragrans	61	3660
Ficus benjamina	67	4422
Filicium decipiens	10	90
Gardenia sp.	34	1122
Gliricidia sepium	52	2652
Juniperus sp.	65	4160
Livistona sp.	8	56
Mesua ferrea	295	86730
Peltophorum pterocarpum	1311	1717410
Pithecellobium dulce	33	1056
Pongamia pinnata	82	6642
Pterocarpus indicus	894	798342
Roystonea regia	609	370272
Samanea saman	541	292140
Schizolobium parahyba	74	5402
Spathodea campanulata	3	6
Streblus asper	8	56
Swietenia macrophylla	131	17030
Tabebuia sp.	322	103362
Tamarindus indica	409	166872
Tecoma stans	25	600
Terminalia catappa	9	72
Veitchia merrillii	11	110
Total	5523	3.644,322
Species diversity index		8.37

Table 5. Number of trees, and relative abundance (RA; in percentage) for every species in Section 15, Section 16 and the combined sections

Species name	Section 15		Section 16		Combined sections	
	No. of trees	RA (%)	No. of trees	RA (%)	No. of trees	RA (%)
Acacia sp.	24	0.59	0	0	24	0.43
Adenanthera pavonina	0	0	57	3.97	57	1.03
Adinobotrys atropurpureus	12	0.29	0	0	12	0.22
Beschorneria yuccoides	56	1.37	0	0	56	1.01
Bucida sp.	0	0	5	0.35	5	0.09
Cananga odorata	0	0	1	0.07	1	0.02
Casuarina sp.	0	0	7	0.49	7	0.13
Cerbera odollam	25	0.61	0	0	25	0.45
Dalbergia sp.	6	0.15	25	1.74	31	0.56
Delonix regia	20	0.49	0	0	20	0.36
Eugenia oleina	231	5.65	0	0	231	4.18
Fagraea fragrans	61	1.49	0	0	61	1.10
Ficus benjamina	5	0.12	62	4.32	67	1.21
Filicium decipiens	10	0.24	0	0	10	0.18
Gardenia sp.	0	0	34	2.37	34	0.62
Gliricidia sepium	46	1.13	6	0.39	52	0.94
Juniperus sp.	65	1.59	0	0	65	1.18
Livistona sp.	8	0.2	0	0	8	0.14
Mesua ferrea	0	0	295	20.54	295	5.34
Peltophorum pterocarpum	899	22	412	28.69	1311	23.74
Pithecellobium dulce	32	0.78	1	0.06	33	0.60
Pongamia pinnata	82	1.67	0	0	82	1.48
Pterocarpus indicus	721	17.64	173	12.05	894	16.19
Roystonea regia	609	14.9	0	0	609	11.03
Samanea saman	286	7	255	17.76	541	9.80
Schizolobium parahyba	0	0	74	5.15	74	1.34
Spathodea campanulata	0	0	3	0.21	3	0.05
Streblus asper	8	0.2	0	0	8	0.14
Swietenia macrophylla	131	3.21	0	0	131	2.37
Tabebuia sp.	320	7.82	2	0.14	322	5.83
Tamarindus indica	409	10.01	0	0	409	7.41
Tecoma stans	10	0.24	15	1.04	25	0.45
Terminalia catappa	0	0	9	0.63	9	0.16
Veitchia merrillii	11	0.27	0	0	11	0.20
Total	4087	100	1436	100	5523	100

Based on these findings, shade trees were more frequently counted instead of ornamental trees. For instance, shade trees of *P. pterocarpum* showed the highest relative abundance percentage in both sections in order to provide shade, reduce sun reflection and reduce fog density which is useful for road users. Besides, large trees can also influence the road surface temperature to be lower because of their maximum shade coverage by preventing solar exposure (de Abreu-Harbich et al. 2015). A study conducted by Zaki et al. (2020) on the effects of roadside trees on thermal environment in Kuala Lumpur, Malaysia found the average reduction in surface temperature with respect to tree height. Additional research also revealed that the species and height of the tree affect the density of the shade which therefore affects road surface temperature (Rantzoundi and Georgi 2017). Thus, this explained the reasons for the abundance of shade trees planted on the roadside as compared to the ornamental trees.

In conclusion, Shah Alam authority planned different species to be planted in different sections of the city. Other than providing aesthetic and benefits amenities, most of the tree species can withstand the stressful urban environment which explains their special attributes to be planted in the industrial area. In terms of relating the flora impact of industrial factory development in Shah Alam, species diversity in two selected sections can be considered as high, according to Species Diversity Index (SDI). This indicated that high biodiversity areas need to be prioritized and protected from any future disturbances to maintain the integrity of the urban ecosystem. Therefore, it is recommended that tree inventories be updated periodically in order to monitor progress toward maintaining species diversity and overall urban sustainability. Also, further research and monitoring of the potential risks to biodiversity of roadside trees is needed to ensure proper management practices in urban settings.

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