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RESEARCH ARTICLE

Non-native flora in seed banks across five diverse urban ecosystems in Indian dry tropics and their economic uses

Chandan Yadav, Arvind Kumar and Rup Narayan*

Abstract: Urban expansion has been reported to facilitate intrusion of alien plants into seed bank flora from different continents of the world. The vegetation structure in anthropogenic ecosystems of Meerut region has become home to variety of alien species that could have a significant impact on the composition of seed bank flora and the ecological processes in vicinity by virtue of better adaptive potential of these exotics. Five anthropic study sites in a dry tropical urban region of Meerut were selected for seed bank studies. A total of 44 alien plant species were recorded in the summer and winter seed banks from 100 soil samples (20 from each site). The most prominent families of dominant alien species in seed banks were: Amaranthaceae (7), Malvaceae (6), Asteraceae (3), Solanaceae (3), Poaceae (2), Convolvulaceae (2), Fabaceae (2) and Euphorbiaceae (2). Seventeen other families had one species each. These urban seed banks were dominated by herbs (93.2%), followed by tree species (4.5%) and climbers (2.3%). Of the 44 alien flora identified in the seed banks, the flora of tropical American continent was most dominant (40.9%) followed by South America (22.7%), Europe and Asia (11.4% each); North America and Africa (4.5% each); and others *viz.* Australia and Asia-Africa (2.3% each). These naturalized alien species in seed banks were threats to Indian dry tropical ecosystems. However, these could variously be utilized to cure skin diseases, stomach problems, fever, parasitic diseases, dysentery, diuretic, eyes, respiratory disorder, cough, decoction, mental disorder, liver, muscles disorder, antimicrobial activities, female sexual disorder, inflammation, piles, diabetes, ear, anticancer, hair, hydrocele, hydrophobia, kidney and could also be used as food & nutrients, fodder, cardio-tonic, anti-toxin, cleaner, insect repellents, environmental friendly.

Keywords: Alien plants, Economic importance, Plant invasion, Subterranean vegetation.

Introduction

A growing number of studies reportedly focus on understanding the above-ground vegetation structure in a rapidly developing nation like India, which is experiencing accelerated anthropogenic activities, particularly in the Indian dry tropics (Gupta and Narayan 2006, 2010, Agrawal and Narayan 2017). Since ancient times, India's kings, leaders, and commoners have traded food items like wheat, rice, vegetables, and other goods with different nations. These trade exchanges could be attributed to rising number of alien plants over time (Yadav and Verma 2021). As a result, the intruded alien plant species are now prevalent in gardens, farms, roads, riverbanks, industrial regions, and/or urban disturbed grounds. Such alien plants could be easily seen in the rapidly modernizing dry tropical urban habitats of Meerut region in India.

Despite the recognition of crucial role of alien flora as determinants of vegetation dynamics, few studies have examined changes in seed banks in relation to plant invasions. Some workers suggest that the impact of invasive alien species on plant communities is based on patterns occurring in the above-ground vegetation e.g. Gioria *et al.* (2014). However, understanding the comprehensive role of seed banks in the invasion process is still considered limited (Gioria *et al.* 2012, Gioria and Pysek 2016), and only recently have large-scale analyses aimed at determining the likelihood of the establishment or spread of alien species based on information on the characteristics of seed banks (Pysek *et al.* 2015). Local adaptation of plant characteristics, especially those related to seeds and seedlings is suggested to be crucial to the invasion process (Kudoh *et al.* 2007, Tognetti *et al.* 2019). As a result, the seed bank serves as a reserve from which new recruitment may take place under

✉ Rup Narayan
rupnarayan2001@gmail.com

Department of Botany, Chaudhary Charan Singh University Meerut, Uttar Pradesh India

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favourable conditions (Kolodziejek and Patykowsk 2015). Whether a naturalized population of alien species in a seed bank becomes invasive at a specific location depends on several variables.

Plant invasion is presently considered the second largest threat to biodiversity. However, the growing predominance of invasive alien species has become a ground reality especially across anthropo-ecosystems in Indian dry tropics (Agrawal and Narayan 2017). Such an ecologically stressed situation calls for exploring the usefulness of alien flora.

A great deal of promise has been reported for significant pharmacological investigations of the active principles involved in the traditional knowledge and medicinal virtues of these common alien plants in Indian dry tropics (Chaudhary and Narayan 2013). Despite their significant medical relevance, these weeds have never been generally considered part of the traditional medicinal flora (Chaudhary *et al.* 2011). Animal and human life on earth is sustained through the use of wild plants and their products to provide fundamental necessities like food and medicine (Singh *et al.* 2016). There are over 2500 plant species in India that have been recognized and are consumed as food by several people dispersed throughout the nation (Jain 1991). Indigenous medicines are growing popular among people in both rural and urban regions because they are secure, affordable, and efficient (Abbasi *et al.* 2010). There is a concern that indigenous knowledge of traditional medicine is vanishing due to verbal transmission of knowledge (Ssegawa and Kasenene 2007, Bhatia *et al.* 2014) regarding the usage of medicinally relevant plants and behavior from one generation to the next (Bhatia *et al.* 2014). Documentation will aid in the preservation of such knowledge and enable future research on the effectiveness and safety of medicinal herbs to support traditional use (Bunalema *et al.* 2014). The floristic composition of a region's potential soil seed banks, however, has not received adequate attention.

The present study aims to (i) investigate the prevalence of alien flora in soil seed banks across diverse urban ecosystem in an Indian dry tropical region and (ii) understand their life-form, nativity and uses of economic importance.

Materials and methods

Study area

Meerut city is a part of the National Capital Region of Delhi, located between 28°57' N and 29°02' N lat. and 77°40' E and 77°45' E long.). Its eastern and western boundaries are limited by the Himalayan Rivers Ganga and Yamuna respectively. This region has witnessed rapid developmental activity in the last 4-6 decades. Extreme dryness with intensely hot summer months May and June (44.5°C) while cold winter in the months of December and January (2.5°C) is the characteristic of the Meerut climate. Five permanent research sites were selected for the present study representing different habitat conditions. These included (i) the university campus (UC), which is a very crowded campus with students and visitors; (ii) the Kali river bank (RB), a sink for the city's industrial effluents and dumps; (iii) a brick kiln (BK), which uses the most fertile alluvial soils of the upper Gangetic plains; (iv) wasteland (WL), which receives garbage from Meerut City, and (v) a roadside (RS), located at National Highway (NH-334), a highly travelled roadway where developmental operations continued.

Collection, Identification, and Documentation of seedlings emergents

A total of one hundred soil seed bank samples were collected in March 2019, referred to as summer seed bank (SSB), and in November 2019, referred to as winter seed bank (WSB) to investigate the seed bank flora of different land-use conditions. Plant species were identified according to Sharma (1980), Gaur (1999) and according to the available flora by Kanjilal (1928) and Duthie (1960). Ten surface soil samples (each of the size of 25 cm × 25 cm × 5 cm) were collected randomly in summer and winter season from each of the five study sites with the help of a knife and spoon. The collected soil samples were air-dried and sieved through a 2 mm sieve for removing the vegetative fragments. The soil was then spread uniformly in round earthen pots and was placed in a shade house with transparent roof and fiber walls. The pots were watered regularly. The seedling emergence was investigated for eleven months to record the late emergents too. The seedlings were allowed to grow to the identifiable stage and then eliminated. Seed density of sites was estimated by the seedling emergence method which is considered an effective experimental technique for assessing both the

To be continued..

Plate 1: Showing some of the alien plants recorded in soil seed banks across five diverse anthropic study sites in dry tropical region of Meerut, India.

transient and persistent components of seed banks (Thomson and Grime 1979).

Determination of family, life-forms, nativity, and economic importance

These identified plant species were listed alphabetically in tabular form with family, nativity, habitats, and also its uses. Names and families of listed plant species were updated using the "Plants of the world online (POWO)" (https://powo.science.kew.org) taxonomic database and life forms according to the Raunkiaer (1934) and Mishra (1968). The nativity of non-native species, has been confirmed from the published literature *viz.* Negi and Hajra (2007), Khuroo *et al.* (2007), Reddy *et al.* (2008), Khanna (2009), Singh *et al.* (2010), Joshi and Rawat (2011), Kumar and Bihari (2015), Agrawal and Narayan (2017) and online available database https://powo.science.kew.org, https://www.ipni.org. Medicinal properties and other economic uses are described as per published literature.

Results and discussion

Altogether, 44 identified plant species were recorded as aliens across summer and winter seed banks (Plate-1) at five anthropogenic study sites in the Meerut region distributed over 25 families and 40 genera. The most prominent families of alien flora in seed banks (number of species in parentheses) were: Amaranthaceae (7), Malvaceae (6), Asteraceae (3), Solanaceae (3), Poaceae (2), Convolvulaceae (2), Fabaceae (2) and Euphorbiaceae (2). Seventeen other families had only one species each (Fig. 1). These top eight families are major contributors (61.4%) of the alien species in many regions of Asia (Wu *et al.* 2004 a b, Zebre *et al.* 2004) and the world (Pysek 1998). Previous studies on invasive species diversity by different authors (Rao and Murugan 2006, Huang *et al.* 2009; Khuroo *et al.* 2007) reported Asteraceae family to be a noxious group of species in the tropical and subtropical regions of the world. Some alien species occurred at all the five study sites (UC, RB, BK, WL, and RS) *viz. Chenopodium album, Oxalis corniculata* and *Torenia crustacea* (Table 1).

Out of the 44 identified alien species, herbs (41) formed the most dominant life form followed by trees (2) and climbers (1). Herbaceous species' seeds commonly predominate in seed banks, albeit these species' abundance and composition, lifetime and viability of their seeds, germination techniques, and depth distribution of their seeds in the soil varied greatly (Madawala *et al.* 2016). Herbs were mostly dominated by annual plants while shrubs were absent in the seed banks (Fig. 2). This study was also comparable to other urban buried seed bank studies in being dominated by herbaceous species in vacant lots (Pellissier *et al.* 2008, Overdyck and Clarkson 2012, Londe *et al.* 2017).

The tree flora was represented by *Eucalyptus globulus, Morus alba,* and *Ipomoea indica* was *the only species of* climbers recorded in

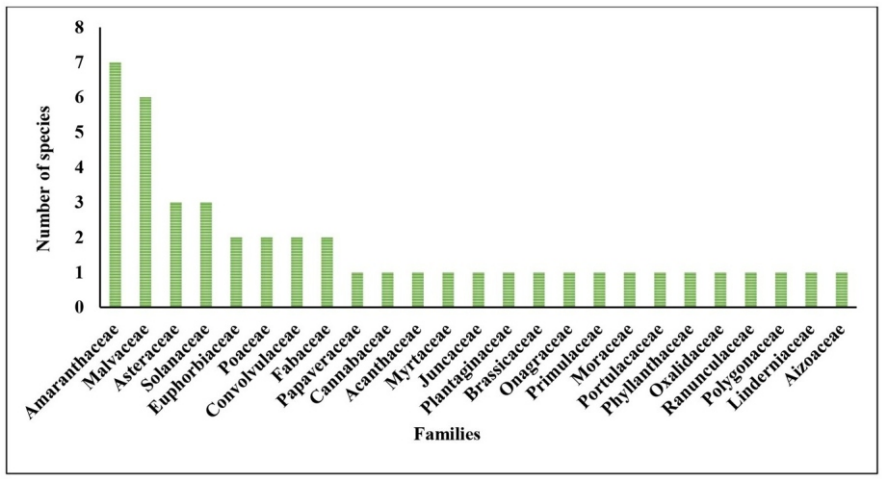

Figure 1: Distribution of alien plant families in soil seed flora across five diverse habitats in a dry tropical urban region of Meerut, India.

Table 1. Alien plants recorded in soil seed banks across five diverse urban habitats in a dry tropical region of Meerut and their economic uses.

Plant species	Family	Life form	Nativity	Urban Habitats	Uses	References
Achyranthes aspera L.	Amaranthaceae	H	North America	UC, RB, BK, WL	Diuretic, renal dropsies	Aggarwal *et al.* 2012
Alternanthera sessilis (L.) R.Br. ex DC.	Amaranthaceae	H	Tropical America	UC, RB, BK, WL	Night blindness, galactagogue properties	Aggarwal *et al.* 2012
Amaranthus spinosus L.	Amaranthaceae	H	South America	RB	Leaves are eaten as a potherb and whole plant extract is used in women's leucorrhoea, used by women to increase the flow of breast milk also used in febrifuge, fever, emollient, eczema.	Aggarwal *et al.* 2012
Amaranthus viridis L.	Amaranthaceae	H	Tropical America	RS	Anthelmintic, dysentery, diuretic, gonorrhea	Aggarwal *et al.* 2012
Argemone mexicana L.	Papaveraceae	H	South America	RB	Cutaneous troubles, plant juice in scabies, and ophthalmic	Aggarwal *et al.* 2012
Cannabis sativa L.	Cannabaceae	H	Asia	RB, BK, RS	To reduce general body inflammation, intoxication, and loss of appetite. Leaves dried are smoked through a pipe and called Hukkahto to relieve depression. Powdered leaf mixed with egg yolk is given to children to treat excessive urination. Leaf essence is used to relieve earache.	Aggarwal *et al.* 2012
Chenopodium album L.	Amaranthaceae	H	Europe	UC, RB, BK, WL, RS	Cough, anorexia, piles, dysentery, and diarrhea kill small worms.	Bakshi *et al.* 1999
Corchorus aestuans L.	Malvaceae	H	Tropical America	UC	Stomachic	Aggarwal *et al.* 2012
Corchorus olitorius L.	Malvaceae	H	Africa	UC, BK	Tonic, febrifuge, cystic, dysuria	Aggarwal *et al.* 2012
Croton bonplandianus Baill.	Euphorbiaceae	H	South America	BK, WL	Rich in fatty acid, the cake is used as manure	Aggarwal *et al.* 2012
Dicliptera paniculata (Forssk.) I. Darbysh.	Acanthaceae	H	Tropical America	UC, RS	Anti-bacterial, snake bite, fever, cold, cough, ear, and eye treatment	Aggarwal *et al.* 2012
Dysphania ambrosiodes (L.) Mosyakin & Clements	Amaranthaceae	H	Tropical America	RB	Anthelmintic against intestinal, parasitic	Aggarwal *et al.* 2012
Echinochloa colonum (L.) Link	Poaceae	H	South America	WL	One of the best fodder grasses for milking cattle is cut three to four times throughout the wet season. The seeds are used as a substitute for rice in Rajasthan, India, where they are boiled in water. Also used as a poison, medicine, and environmental uses.	Yadav *et al.* 2022
Eclipta prostrata (L.) L.	Asteraceae	H	Tropical America	RB, WL	Skin problems, hepatic problems such as jaundice, gastrointestinal problems, respiratory problems such as asthma, and other symptoms such as fever, hair loss and whitening of hair, cuts, wounds, and spleen enlargement. Paste of leaves is applied to cure pimples and boils etc.	Kumar *et al.* 2022; Singh 2015

Eucalyptus globulus Labill.	Myrtaceae	T	Australia	RB, WL, RS	Mild inflammation of the respiratory tract, bronchitis, asthma, fever and inflammation of the throat, cystitis, diabetes, gastritis, kidney disease (unspecified), laryngitis, leucorrhea, malaria, pimples, ringworm, wounds, ulcers, of the skin, urethritis, and vaginitis uses described in folk medicines, but not supported by experimental or clinical data.	Rathva *et al.* 2020; EMA 2012
Euphorbia hirta L.	Euphorbiaceae	H	Tropical America	UC, BK, WL	Cough and asthma, colic, dysentery, latex applied in the genitourinary tract	Aggarwal *et al.* 2012
Evolvulus nummularius (L.) L.	Convolvulaceae	H	Tropical America	UC	Used as a vegetable, anthelmintic, and to treat scorpion stings, cuts, fever, wounds and burns, hysteria, and convulsion, the paste is used to treat scabies.	Mullick *et al.* 2018; Namrata *et al.* 2014
Gamochaeta pensylvanica (Willd.) Cabrera	Asteraceae	H	Tropical America	UC, RB, BK, RS	Cooked as a vegetable, antitussive, sedative, cardiotonic, bronchitis, and to treat catarrh and asthma. This weed also causes, it is claimed, skin problems in cattle, and hay fever and dermatitis in some people.	Horo and Topno 2015
Gomphrena celosioides Mart.	Amaranthaceae	H	South America	RS	Antimicrobial activity	Tarnam *et al.* 2014
Ipomoea indica (Burm.) Merr.	Convolvulaceae	C	Tropical America	UC, RB	A bath in a decoction of the plant is used to treat injuries and carbuncles.	Gurib-Fakim *et al.* 1996
Juncus bufonius L.	Juncaceae	H	Europe	BK	Used as animal food, medicine, and environmental uses	Yadav *et al.* 2022
Lepidium didymum L.	Brassicaceae	H	South America	RS	Renal problems and scabies.	Kumar *et al.* 2022
Ludwigia perennis L.	Onagraceae	H	Africa	UC, RB, WL, RS	Labor pain, epilepsy, eye tonic, and root decoction are given to cure fever. Dried fruits placed on lightened charcoal, smoke released is powerful insect repellent, etc.	Singh 2021
Lysimachia arvensis (L.) U.Manns & Anderb.	Primulaceae	H	Europe	BK, RS	Expectorant, stimulant, diaphoretic and vulnerary properties, dropsy, leprosy & cerebral disease. Fresh herb is rubbed between hands, and a large quantity of leather is formed which removes dirt. Extract of the plant is applied for killing lice and allergies.	Aggarwal *et al.* 2012
Malvastrum coromandelianum (L.) Garcke	Malvaceae	H	Tropical America	RS	Carbuncles, wounds, and dysentery.	Carag and Inocencio 2017
Megathyrsus maximus (Jacq.) B.K.Simon & S.W.L. Jacobs	Poaceae	H	Asia, Africa	RB, WL, RS	As animal food, medicine, and environmental uses	Yadav *et al.* 2022
Morus alba L.	Moraceae	T	Asia	WL	A decoction of the leaves is used in case of hypertension and hernia.	Adjanohoun 1983; Gurib-Fakim 1990
Nicotiana plumbaginifolia Viv.	Solanaceae	H	Tropical America	RB, BK, WL, RS	The whole plant (as such or extract) is fed to animals suffering from bloat. The paste of the whole plant is applied externally to the animal's body to get rid of external parasites.	Rao *et al.* 2015

Oxalis corniculata L.	Oxalidaceae	H	Europe	UC, RB, BK, WL, RS	Cooked as a vegetable at times of scarcity, the fresh juice of the plant is given in dyspepsia, piles, anemia, and tympanitis. Infusion of leaves is used to cure opacity of the cornea	Aggarwal *et al.* 2012; Horo and Topno 2015
Parthenium hysterophorus L.	Asteraceae	H	North America	UC, RB, BK, WL	Toxic, febrifuge, emmenagogue	Aggarwal *et al.* 2012
Phyllanthus amarus Schumach. & Thonn.	Phyllanthaceae	H	Tropical America	UC, BK, WL	A decoction of 3 roots along with 7 leaves of *Psidium guajava*, 3 roots of *Melochia pyramidata,* and roots of *Coix lacryma-jobi* is used to treat diarrhea.	Gurib-Fakim *et al.* 1996
Physalis angulata L.	Solanaceae	H	Tropical America	RB, RS	Anticancer, antibacterial, diabetes, treatment of malaria, anemia, and reducing fever. The decoction of leaves and fruit for "Tertian" due to postpartum infections and maceration of aerial parts for the treatment of malaria.	Rengifo-Salgado and Vargas-Arana 2013; Jovel *et al.* 1996
Portulaca oleracea L.	Portulacaceae	H	South America	WL	Tumors, callosities, and heart tonic.	Carag and Inocencio 2017
Ranunculus sceleratus L.	Ranunculaceae	H	Asia	RB	The paste is used on warts, skin diseases, spider toxins, and rheumatism.	Kumar *et al.* 2022
Rumex dentatus L.	Polygonaceae	H	Europe	RB, WL	Rich in Vit. A & C, β carotene, cutaneous disorder. The root powder is taken for eczema and constipation. Leaf paste is applied for burns and injuries.	Aggarwal *et al.* 2012
Senna occidentalis (L.) Link.	Fabaceae	H	South America	UC, BK	Purgative, seeds for external use for skin	Aggarwal *et al.* 2012
Senna tora (L.) Roxb.	Fabaceae	H	South America	RB	Paste of leaves is used against skin diseases and boils etc. The leaves are eaten as a potherb and Skin diseases.	Singh 2015
Sida acuta Burm.f.	Malvaceae	H	Tropical America	UC, RB, BK, RS	Stomachic, antipyretic, astringent, nerving tonic, urinary troubles, and liver revitalization. Demulcent and diuretic- applied to testicular swelling and elephantiasis.	Aggarwal *et al.* 2012
Sida cordifolia L.	Malvaceae	H	South America	RB	Dysentry, Astringent, diuretic, urinary trouble, cystitis	Aggarwal *et al.* 2012
Solanum nigrum L.	Solanaceae	H	Tropical America	WL	Hydrocele, antiseptic, antidiuretic & laxative. Berries are used in fever, diarrhea, eye disease, and hydrophobia. Plant juice is hydragogue, cathartic given in chronic enlargement of the liver, blood spitting, piles, and dysentery.	Aggarwal *et al.* 2012
Torenia crustacea (L.) Cham. & Schltdl.	Linderniaceae	H	Asia	UC, RB, BK, WL, RS	Boils, sores, and itches.	Carag and Inocencio 2017
Trianthema portulacastrum L.	Aizoaceae	H	Tropical America	RB, WL, RS	Asthma, amenorrhea, liver problem, dropsy	Aggarwal *et al.* 2012
Triumfetta rhomboidea Jacq.	Malvaceae	H	Tropical America	UC, RB	Diarrhea, dysentery, intestinal ulcer	Aggarwal *et al.* 2012
Veronica anagallis-aquatica L.	Plantaginaceae	H	Asia	RS	Paste of leaves is applied for healing of the wound and is eaten raw or cooked to treat the respiratory tract.	Singh 2015

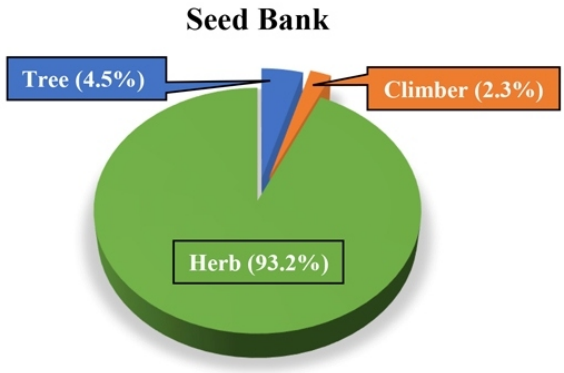

Figure 2: Life form of plant taxa in soil seed banks across diverse anthropogenic sites in a dry tropical region of Meerut, India.

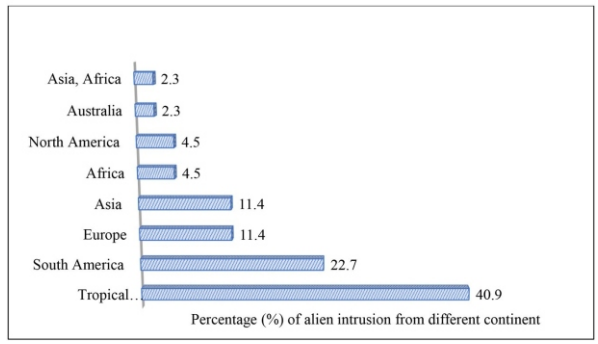

Figure 3: Nativity analysis of seed bank flora in a dry tropical anthropic urban region in India

this study. The most common genera recorded in seed banks included *Amaranthus, Corchorus, Senna,* and *Sida* with two plant species in each.

Amongst the 44 alien plant species identified in the summer and winter seed banks in this study, the alien flora of tropical America was most dominant and contributed 40.9% followed by South America (22.7%); Europe and Asia (11.4% each); North America and Africa (4.5% each); and Australia and Asia-Africa (2.3% each) respectively (Fig.3). Seed bank analyses in our study also corroborate results from other urban seed bank studies in being dominated by non-native flora (Overdyck and Clarkson 2012, Hahs and McDonnell 2013, Londe *et al*. 2017).

The present study on soil seed bank flora revealed a considerable scale of intrusion into the soil seed banks across various anthropic sites in urban regions in Indian dry tropics dominated by the weedy American alien herbs (68.1%) followed by other continents (31.9% Europe, Asia, and Africa). But presently, its vegetation is largely distinct from that in natural ecosystems because of alterations in resource availability, stress intensity, and disturbance as reported by Gupta and Narayan (2010, 2011) for such disturbed ecosystems in Indian dry tropics. Diverse studies have shown that the age, area of urban habitats, inhabitant density, and urban-rural gradient affected plant diversity in Asian, North American, South American, and European urban sites (Gustafson and Gardner

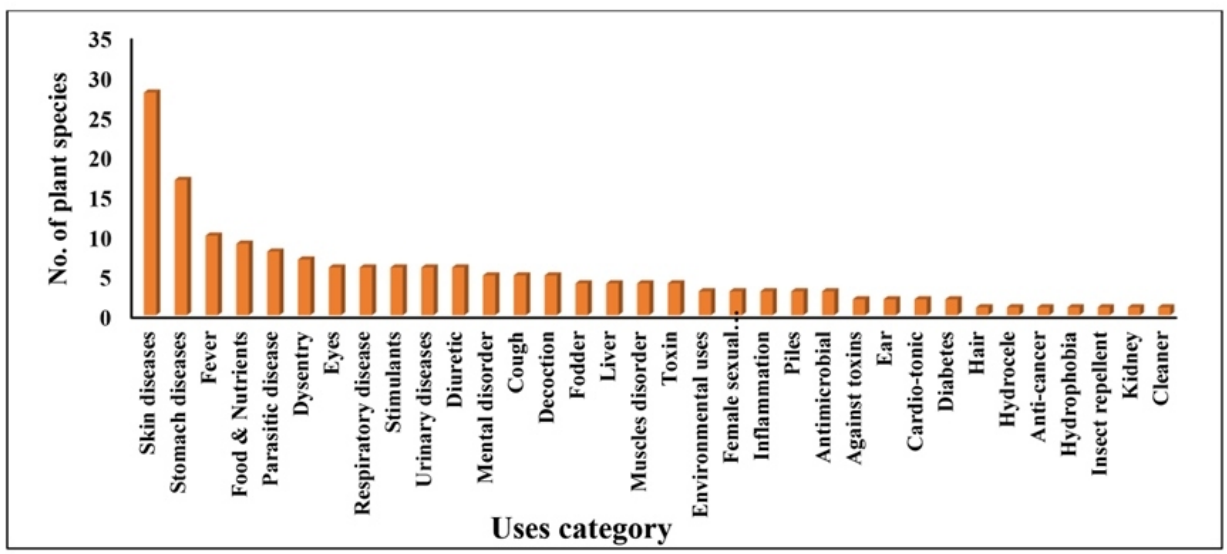

Figure 4: The graphical representation showing the number of plant species used in each category of different uses.

1996, Li *et al.* 2006, Godefroid and Koedam 2007).

As reported in this study too, many plant species flourished abundantly in the Indian dry tropics *viz. Achyranthes aspera, Alternanthera sessilis, Argemone mexicana, Oxalis corniculata,* and *Solanum nigrum* which have been used medicinally for a variety of diseases as reported by Chaudhary *et al.* (2011). Some alien grasses *viz. Echinochloa colonum* and *Megathyrsus maximus* were reported in seed bank studies and also considered useful in the study on standing vegetation of diverse habitats of Indian dry tropics at Meerut (Yadav *et al.* 2022).

In terms of various uses of alien species in various categories recorded and documented in the present study, the maximum number of them was found to be of utility in skin diseases (28), stomach problems (17), fever (10), food & nutrients (9), parasitic diseases (8), dysentery (7), diuretic, eyes, respiratory disorder (6 each), cough, decoction, mental disorder (5 each), environmental friendly, fodder, liver, muscles disorder, toxin (4 each), antimicrobial activities, female sexual disorder, inflammation, piles (3 each), anti-toxin, cardio-tonic, diabetes, ear (2 each) and others with single-use anticancer, cleaner, hair, hydrocele, hydrophobia, insect repellent and kidney disorder (Fig. 4).

Conclusion

This study revealed a heavy scale of intrusion of alien species in soil seed banks dominated by the weedy American alien herbs followed by European, Asian, and African into urban ecosystems in Indian dry tropics. Despite being a threat to the indigenous urban biodiversity in Indian dry tropical ecosystems, their medicinal and other economically beneficial characteristics have implications for their cautious utilization that would reduce the pressure on indigenous medicinal plant species.

References

Abbasi A M, Khan M A, Ahmed M and Zafar M 2010 Herbal medicines used to cure various ailments by the inhabitants of Abbottabad district, North West Frontier Province, Pakistan. *Indian Journal of Traditional knowledge* **9(1)** 175-183.

Adjanohoun EJ 1983 Medicine traditionelle et pharmacopée. Contributions aux etudes ethnobotaniques et floristiques à Maurice (Ile Maurice et Rodrigues). *Agence de Cooperation Culturelle et Technique (ACCT)*, Paris, France. **1** 214-3.6

Aggarwal S, Gupta V and Narayan R 2012 Ecological study of wild medicinal plants in a dry tropical peri-urban region of Uttar Pradesh in India. *International Journal of Medicinal and Aromatic Plants* **2** 246-253.

Agrawal S and Narayan R 2017 Spatio-temporal organization and biomass dynamics of plant communities in a dry tropical peri-urban region: deterministic role of alien flora in anthropo-ecosystems. *Current Science* 53-62.

Bakshi DNG, Sensarma P, Pal DC 1999 A lexicon of medicinal plants in India, Naya Prakash, Calcutta, pp. 424-25.

Bhatia H, Sharma Y P, Manhas R K and Kumar K 2014 Ethnomedicinal plants used by the villagers of district Udhampur, J & K, India. *Journal of Ethnopharmacology* **151(2)** 1005-1018.

Bunalema L, Obakiro S, Tabuti J R S and Waako P 2014 Knowledge on plants used traditionally in the treatment of tuberculosis in Uganda. *J. Ethnopharmacol* **151** 999-1004.

Carag H and Buot Jr IE 2017 A checklist of the orders and families of medicinal plants in the Philippines. *Sylvatrop, The Technical Journal of Philippine Ecosystems and Natural Resources*. **27** 49-9.

Chaudhary N and Narayan R 2013 Medicinal uses of some wild plants from a dry tropical peri-urban region in India. *Journal of Pharma Research* **2(9)** 1-5.

Chaudhary R, Oh S and Lee J 2011 A ethnomedicinal inventory of knotweeds of Indian Himalaya. *Journal of Medicinal Plant Research* **5(10)** 2095-2103.

Duthie J F 1960 Flora of Upper Gangetic Plain and the adjacent Siwalik and Sub-Himalayan Tracts. Published by Botanical Survey of India, Calcutta 3.

EMA 2012. Assessment Report on *Eucalytus globulus* Labill., *Eucalyptus polybractea* RT Baker and/or *Eucalyptus smithii* RT Baker, Aetheroleum.

Gaur R D 1999 Flora of the District Garhwal North West Himalaya. Trans Media Srinagar Garhwal, UP, India.

Gioria M and Pysek P 2016 The legacy of plant invasions: changes in the soil seed bank of invaded plant communities. *Bioscience* **66** 40-53.

Gioria M, Jarosik V and Pysek P 2014 Impact of

invasions by alien plants on soil seed bank communities: emerging patterns. Perspectives in Plant Ecology. *Evolution and Systematics* **16(3)** 132-142.

Gioria M, Pysek P and Moravcova L 2012 Soil seed banks in plant invasions: promoting species invasiveness and long-term impact on plant community dynamics. *Preslia* **84** 327-350.

Godefroid S and Koedam N 2007 Urban plant species patterns are highly driven by the density and function of built-up areas. *Landsc. Ecol.* **22** 1227-1239.

Gupta S and Narayan R 2006 Species diversity in four contrasting sites in a peri-urban area in Indian dry tropics. *Tropical Ecology* **47(2)** 229-242.
Gupta S and Narayan R 2010 Brick kiln industry in long-term impacts biomass and diversity structure of plant communities. *Current Science* **10** 72-79.

Gupta S and Narayan R 2011 Plant diversity and dry-matter dynamics of peri-urban plant communities in an Indian dry tropical region. *Ecological research* **26(1)** 67-78.

Gurib-Fakim A 1990 Medicinal Plants of Mauritius. *Int. J. Crude Drug Res*. **28:** 297-308

Gurib-Fakim A, Sewraj MD, Gueho J and Dulloo E 1996 Medicinal plants of Rodrigues. *International Journal of Pharmacognosy*. **34(1)** 2-14.

Gustafson E J and Gardner R H 1996 The effect of landscape heterogeneity on the probability of patch colonization. *Ecology* **77** 94-107.

Hahs A K and McDonnell M J 2013 Composition of the soil seed bank in remnant patches of grassy woodland along an urbanization gradient in Melbourne, Australia. *Plant Ecol.* **214** 1247-1257

Horo S and Topno S 2015 Lesser known wild leafy vegetables consumed by "Ho" tribes of W. Singhbhum district, Jharkhand, India. *J. Med. Plants* **3** 155-159.

Huang Q Q, Wu J M, Bai Y Y, Zhou L and Wang G X 2009 Identifying the Most Noxious Invasive Plants in China: Role of Geographical Origin, Life Form and Means of Introduction. *Biodiversity conservation* **18** 305-316.

Jain S K 1991 Dictionary of Indian folk medicine and ethnobotany. Deep Publication.

Joshi K and Rawat D S 2011 A Preliminary Investigation on Alien and Native Elements in the Flora of Pantnagar, Uttarakhand, India. *The Journal of Indian Botanical Society* **90(1&2)** 66-74.
Jovel EM, Cabanillas J and Towers GN 1996 An ethnobotanical study of the traditional medicine of the Mestizo people of Suni Mirano, Loreto, Peru. *Journal of ethnopharmacology* **53(3)** 149-156.

Kanjilal U N 1928 Forest flora of the Chakrata, Dehradun, and Saharanpur Forest Divisions, Uttar Pradesh. (Revised by Gupta BL, 3rd Ed.). Govt. of India Press, New Delhi.

Khanna K K 2009 Invasive alien angiosperms of Uttar Pradesh. *Biological Forum* **1(2)** 34-39.

Khuroo A A, Rashid I, Reshi Z, Dar G H and Wafai B A 2007 The alien flora of Kashmir Himalaya. *Biological Invasions* **9(3)** 269-292.

Kolodziejek J and Patykowski J 2015 Effect of Environmental Factors on Germination and Emergence of Invasive Rumex confertus in Central Europe. *The Scientific World Journal* 1-11.

Kudoh H, Nakayama M, Lihova J and Marhold K 2007 Does invasion involve alternation of germination requirements? A comparative study between native and introduced strains of an annual Brassicaceae, Cardamine hirsuta. *Ecol. Res.* **22** 869-875.

Kumar N S and Bihari S K 2015 Diversity, Uses and Origin of Invasive Alien Plants in Dhenkanal district of Odisha, India. International Research. *Journal of Biological Science* **4(2)** 21-27.

Kumar P, Dangwal LR, Uniyal P and Lal T 2022 Ethno-medicinal uses of some aquatic plants in district Haridwar, Uttarakhand. *International Journal of Botany Studies* **7(1)** 388-393.
Li W, Ouyang Z, Meng X and Wang X 2006 Plant species composition in relation to green cover configuration and function of urban parks in Beijing, Chile. *Ecol. Res.* **21** 221-237

Londe V, Caldas de Sousa H and Kozovits A R 2017 Exotic and invasive species compromise the seed bank and seed rain dynamics in forests undergoing restoration at urban regions. *J For Res.* **28** 1019-1026.

Madawala H M S P, Ekanayake S K and Perera G A D 2016 Diversity, composition and richness of soil seed banks in different forest communities at Dotalugala Man and Biosphere Reserve, Sri Lanka. *Ceylon Journal of Science* **45(1)**.

Mishra R 1968 Ecology Work Book. Oxford and IBH Publishing Co New Delhi, India.

Mullick JB Reddy KVR, Saha S, Bashir T, Hore S and Sil SK 2018 In vitro toxicity studies on the extract of medicinal plant Evolvulus nummularius as a potent microbicidal candidate. *Journal of Drug Delivery and Therapeutics* **8** 229–236.

Namrata S, Kumar YU, Jana GK and Ramashish T 2014 Pharmacognostic, phytochemical and physiochemical study of Evolvulus nammularius (convolvulaceae). *International Journal of Pharmacognosy and Phytochemical Research* **6** 874–878.

Negi P S and Hajra P K 2007 Alien Flora of Doon Valley, North West Himalaya. *Current Science* **92(7)** 968-978.
Overdyck E and Clarkson B D 2012 Seed rain and soil seed banks limit native regeneration within urban forest restoration plantings in Hamilton City, New Zealand. *New Zealand Journal of Ecology* 177-190.

Pellissier V, Roze F, Aguejdad R, Quenol H and Clergeau P 2008 Relationships between soil seed bank, vegetation and soil fertility along an urbanisation gradient. *Appl. Veg. Sci.* **11** 325-334

Pysek P 1998 Alien and native species in Central European urban floras: a quantitative comparison. *Journal of Biogeography* **25(1)** 155-163.

Pysek P, Manceur A M, Alba C, McGregor K, Pergl J, Stajerova K, Chytry M, Danihelka J, Kartesz J, Klimesova J, Lucanova M, Moravcova L, Nishino M, Sadlo J, Suda J, Tichy L and Kuhn I 2015 Naturalization of central European plant species in North America: species traits habitats propagule pressure residence time. *Ecology* **96** 145-157.

Rao PK, Hasan SS, Bhellum BL and Manhas RK 2015 Ethnomedicinal plants of Kathua district, J&K, India. *Journal of ethnopharmacology*. **171** 12-27.

Rao R, R and Murugan R 2006 Impact of exotic adventives weeds on native biodiversity in India: implications for conservation. In: Invasive Alien Species and Biodiversity in India, eds Rai LC & Gaur JP Banaras Hindu University, Banaras. 93-109.

Rathva D, Pal P, Parmar D, Upadhyay S and Upadhyay U 2020 A Basic Review on Eucalyptus Oil. *International Journal of Pharmaceutical Research and Applications*. **5(2)** 771-781.

Raunkiaer C 1934 The life forms of Plants and Statistical Plant Geography. Clarendon Press, Oxford.
Reddy C S 2008 Catalogue of Invasive Alien Flora of India. *Life Science Journal* **5(2)** 84-89.

Rengifo-Salgado E and Vargas-Arana G 2013 Physalis angulata L. (Bolsa Mullaca): a review of its traditional uses, chemistry and pharmacology. *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas* **12(5)** 431-445.

Sharma L K 1980 Floristic studies of district Bulandshahr and morphological studies of *Dasmodium* Desv. and *Alysicarpus* Neek, With special reference to fruit structure. Ph. D. thesis, Meerut University, Meerut, India.

Singh A 2015 Folk medicinal uses of the leaves of plants of Banaras Hindu University main campus, India. *Journal of Advances in Biological and Basic Research* **1(2)** 66-68.

Singh B, Sultan P, Hassan Q P, Gairola S and Bedi Y S 2016 Ethanobotany traditional knowledge, and diversity of wild edible plants and fungi: a case study in the Bandipora district of Kashmir Himalaya, *India. J Herbs Spices Med Plants* **22(3)** 247-278.

Singh K P, Shukla A N and Singh J S 2010 State-level inventory of invasive alien plants, their source regions and use potential. *Current Science* **99** 107-114.

Singh PS 2021 Traditional Medicinal Plants. AkiNik Publications New Delhi.

Ssegawa P and Kasenene J M 2007 Medicinal plant diversity and uses in the Sango Bay area, southern Uganda. *J. Ethnopharmacol*. **113** 521-540.
Tarnam Y A, Ilyas M M and Begum T N 2014 Biological potential and phytopharmacological screening of Gomphrena species. *Int J Pharm Res Rev* **3(1)** 58-66.

Thompson K and Grime J P 1979 Seasonal variation in the SB of herbaceous species in ten contrasting habitats. *Journal of Ecology* **67** 893-921.

Tognetti P M, Mazia N and Ibanez G 2019 Seed local adaptation and seedling plasticity account for Gleditsia triacanthos tree invasion across biomes. *Ann. Bot.* **124** 307-318.

Wu S H, Hsieh C F and Rejmanek M 2004a Catalogue of the naturalized flora of Taiwan, Taiwania **49** 16-31.

Wu S H, Hsieh C F and Rejmanek M 2004b Plant invasions in Taiwan: Insights from the flora of casual and naturalized alien species. *Diversity and Distributions* **10** 349-362.

Yadav C, Lomas K M, Kumar A, and Narayan R 2022 Ecological Importance and Economic Uses of Selected Native and Invasive Alien Grasses across Five Diverse Anthropo-Ecosystems in the Indian Dry Tropics. *Annals of Plant Sciences* **11 (7)** 5252-5269.

Yadav K R and Verma N 2021 Study of alien plants species from Bareilly College, Bareilly campus, U.P. (India). *Plant Archives* **21** 287-293.

Zerbe S, Choi I K and Kowarik I, 2004 Characteristics and habits of non-native plant species in the city of Chonju, southern Korea. *Ecological Research* **19** 91-98.