ISSN: 2287-688X

Annals of
Plant Sciences

Volume 13, Issue 07 (2024) pp. 6423-6433

Research Article

Analysis of Surface Vegetation and Soil Characteristics along the Bank of Kali river in Meerut region

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Abstract

The present paper documents the findings of phytosociological attributes which have been carried out in dry tropical vegetation along Kali river bank in Meerut region of western Uttar Pradesh, India. The main objectives of this study were to understand characteristics of vegetation and soil along Kali river bank in Meerut region. Floristic composition, dominant species and estimation of diversity and Physico-chemical characteristics were investigated. 46 plant species belonging to 24 families in the form of 12 species of trees, 3 species of shrubs, 30 species of herbs and 1 species of climber are recorded. The dominant plant species based on abundance value in decreasing order were *Megathyrsus maximus, Cynodon dactylon, Parthenium hysterophorus, Physalis angulata* and *Ranunculus sceleratus*. Malvaceae, Fabaceae and Poaceae were the most dominant families with 5 species each. The estimated summer soil properties were moisture content 8%, Organic Carbon 0.66%, total N 0.022%, Available P 17.4 kg/ha, exchangeable K 180 kg/ha, available S 14.3 ppm, available Fe 5.28 ppm and available Cu 0.55 ppm. This study provides baseline information on the vegetation and soil of Kali river bank in Meerut region, which has implication for management of the degrading ecosystem around Kali river bank.

Keywords: *Phytosociological Attributes, Relative Dominance, Anthropogenic Disturbance, Kali River, Vegetation Composition.*

Introduction

The globalization and rapid modification of the natural habitats around in and around developed urban areas have been mainly suggested to accelerate the pace of invasion observed in the past century (Singhal, *et al*., 2016). once established in these Anthro-po-ecosystem, intruded alien flora plays a significant role in structural organization of plant community (Agrawal and Narayan, 2017); including those in riverine ecosystem. Plant species diversity is considered complex in nature here and its structure and composition differ from place to place because of varying climatic condition and topography (Raturi, 2012). Compared to the other ecosystems, tropical forest ones are the most complex which are highly dynamic and harshly exploited ecosystems of the biosphere (Bahuguna, 1999). Despite its direct services for sustainable human life, they are disappearing at an overall rate of 0.8 to 2 % per year (May & Stumpf, 2000, Sagar, *et al.* 2003). The dry deciduous forests are often considered the most disturbed and least protected ecosystems on the earth (Murphy & Lugo 1986). Even with a national policy aimed at conserving and improving nature, biodiversity is still declining. In addition to eutrophication, acidification and desiccation; habitat destruction, deforestation, human settlements, globalization, agricultural expansion, and other infrastructure change driven by economic development effects over the last century have accelerated the rapid decline of tropical forests throughout the world, which in turn has brought in the

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DOI: http://dx.doi.org/10.21746/aps.2024.13.7.2

negative impacts on biodiversity, climate change, ecological services, soil productivity and the livelihoods of forest dwelling as well as rural people (Myers, 1992, Raghubanshi & Tripathi, 2009). Biodiversity has become the issue of global attention because of growing awareness of its importance on the one hand, as ecosystem energy, and on the other hand, it allows building complex tropical networks and functions as insurance for ecosystem stability and resilience (Gaston & Spicer, 2004). Such studies may become a vital tool in the estimation of the level of adaptation to the environment and their ecological significance (Pascal & Pelissier, 1996).

Phytosociological analysis indicates the organization and structure of plant diversity which determines the distribution pattern of individuals among the species in a particular habitat. In connection to this, Warger & Morrel, (1976) noted that phytosociological analysis is important for understanding the functioning of any community. It provides useful basic data for ecology, geography, landscape science, conservation and environmental science because the data represent integrated units in vegetation systems (Fujiwara, 1987). Intensive studies concerning the phytosociology of the tropical forests of India and also other parts of the world (Tripathi & Singh, 2009, Bajpai, *et al*., 2012, Sahu, *et al*., 2012, Verma, *et al*., 2013, Srinivasa, *et al*., 2014, Pradhan & Rahman, 2015, Sundarapandian & Subbiah, 2015, Bajpai, *et al*., 2017, Iyagin & Adekunle, 2017, Masens, *et al*., 2017, Shiferaw, *et al*., 2018) have been highlighted.

A perusal of literature reveals that phytosociological studies in different parts of India are well carried out (Sahu, *et al*., 2007, Ekka & Behera, 2011, Behura, *et al*., 2015, Nayak, *et al*., 2016, Paul, 2017). The present investigation aimed to document the structure of plant communities, composition and diversity of a tropical vegetation in relation to soil along the Kali river bank in Meerut region of India.

Material and Methods

Study Area

The area under study lies in the Indo-Gangetic Plains, located at the latitude 28°57" N and the longitude 77°40" E in Meerut district of Uttar Pradesh. The study was conducted during April 2018 to June 2021 along Kali river bank (KRB) which originates near Antwara in Muzaffarnagar district of Uttar Pradesh and flows through the districts of Hapur, Bulandshahar, Aligarh, Kasganj and finally joins with river Ganga in Kannauj district of Uttar Pradesh. It is a seasonal river that flows massively in monsoon season. It carries along dump of urban and industrial waste and sewage discharge. The bank has varying gradient of slopes and dimensions. The grazing animals frequently visited here.

Climate

The maximum temperature in the warmest months May and June and the minimum temperature in the coldest months December and January were 45.5°C and 4.5°C, respectively. Annual mean rainfall was 637 mm, of which 75% was received during July to September.

Data Collection

Phytosociological studies were carried out to overall spectrum of vegetation. Its study was carried out through fifty quadrat (each of size 1 m × 1 m) randomly laid across a stretch of 2 km along both sides of KRB following Mueller and Dombois (1974). The species density, frequency and abundance were quantitatively analysed following standard procedures (Curtis & McIntosh 1950, Philips 1959, Misra 1968). Names and families of listed plant species were updated by using "plants of the world online (POWO)" (https://powo.science.kew.org) taxonomic database. Plant samples were also identified or confirmed with available regional floras (Haines 1925, Sharma 1980, Saxena & Brahmam 1996).

Soil Analysis

Sixteen representative surface-soil samples (0-10 cm depth) were randomly collected from locations at KRB. These soil samples were air-dried, sieved through a 2 mm sieve and

estimated for different Physico-chemical characteristics of soil that included soil-moisture content, pH, total organic carbon (Walkley and Black method), total nitrogen (micro-Kjeldahl's method) according to Piper (1944), available Phosphorous and exchangeable Potassium through Allen, *et al.*, (1986).

Species Richness Indices

Species count (Number of species/area). In the present study, species count was measured as the number of species that occurred in quadrats sampled.

Information Statistic Indices (Krebs, 1989; Magurran, 2004)

Shannon-index (H') = - $\sum_{i=1}^{\infty}\left(\frac{n_i}{N} * \ln(\frac{ni}{N})\right)$

Shannon´s Evenness or Equitability index E = H' / ln S

Dominance Measure

Simpson index = $\frac{\sum_i n_i(n_i-1)}{N(N-1)}$

where H´= Shannon diversity index, n_i =portion of ith species, N= total number of individuals, E=evenness, S= species richness

Abundance to Frequency Ratio

The plant species distribution pattern was calculated using the abundance to frequency (A/F) ratio, which was introduced by Whitford (1949) as a degree of contagiousness. The ratio denotes regular (0.025), random (0.025-0.05), and contagious (>0.05) dispersions (Curtis and Cotton 1956).

Results

A total of 46 plant species distributed over 23 angiospermic were recorded. Of these, herbs were maximum in number (67%) followed by trees (26%) and shrubs (7%). Majority was comprised of annuals (54%), perennials (28%) and biennials (18%). The largest plant families were Fabaceae, Malvaceae, and Poaceae with equal number of species (Fig.1)

Table 1: Density and abundance of plant species along the Kali river bank in a dry tropical region of India.

S.N.	Species	D	A	RA	A/F	Distribution pattern
1	*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs	12.7	12.7	10.1	0.13	Contagious
2	*Cynodon dactylon* (L.) Pers.	7.0	8.8	6.9	0.11	Contagious
3	*Parthenium hysterophorus* L.	5.2	5.8	4.6	0.06	Contagious
4	*Saccharum spontaneum* L.	2.5	5.0	3.6	0.10	Contagious
5	*Physalis angulata* L.	1.9	4.8	3.8	0.12	Contagious
6	*Ranunculus sceleratus* L.	2.8	4.7	3.7	0.08	Contagious
7	*Chenopodium album* L.	4.5	4.5	3.6	0.05	Contagious
8	*Senna occidentalis* (L.) Link.	2.7	4.5	3.6	0.08	Contagious
9	*Cannabis sativa* L.	3.7	4.1	3.3	0.05	Contagious
10	*Argemone mexicana* L.	2.3	3.8	3.0	0.06	Contagious
11	*Cyperus rotundus* L.	2.9	3.6	2.9	0.05	Contagious
12	*Amaranthus viridis* L.	2.5	3.6	2.8	0.05	Contagious
13	*Solanum nigrum* L.	1.9	3.2	2.5	0.05	Contagious
14	*Malvastrum coromandelianum* (L.) Garcke	2.2	3.1	2.5	0.04	Random
15	*Abutilon indicum* (L.) Sweet	1.8	3.0	2.4	0.05	Contagious
16	*Achyranthes aspera* L.	2.1	3.0	2.4	0.04	Random
17	*Oxalis corniculata* L.	2.4	3.0	2.4	0.04	Random
18	*Rumex dentatus* L.	1.8	3.0	2.4	0.05	Contagious
19	*Croton bonplandianus* Baill.	2.0	2.9	2.3	0.04	Random
20	*Ricinus communis* L.	1.4	2.8	2.2	0.06	Contagious
21	*Corchorus olitorius* L.	1.1	2.2	1.7	0.04	Random
22	*Senna tora* (L.) Roxb.	1.3	2.2	1.7	0.04	Random

23	*Triticum aestivum* L.	1.3	2.2	1.6	0.04	Random
24	*Vigna unguiculata* (L.) Walp.	1.3	2.2	1.7	0.04	Random
25	*Ziziphus mauritiana* Lam.	1.3	2.2	1.7	0.04	Random
26	*Euphorbia hirta* L.	1.0	2.0	1.6	0.04	Random
27	*Triumfetta rhomboidea* Jacq.	0.6	2.0	1.6	0.07	Contagious
28	*Urena lobata* L.	1.0	2.0	1.6	0.04	Random
29	*Melia azedarach* L.	0.9	1.8	1.4	0.04	Random
30	*Carissa macrocarpa* (Eckl.) A.DC.	1.0	1.7	1.3	0.03	Regular
31	*Psidium guajava* L.	1.0	1.7	1.3	0.03	Regular
32	*Cassia fistula* L.	0.8	1.6	1.3	0.03	Regular
33	*Phyllanthus amarus* Schumach. & Thonn.	0.8	1.6	1.3	0.03	Regular
34	*Mesosphaerum suaveolens* (L.) Kuntze	0.6	1.5	1.2	0.04	Random
35	*Dichanthium annulatum* (Forssk.) Starf	0.7	1.4	1.1	0.03	Regular
36	*Ficus religiosa* L.	0.5	1.3	1.0	0.03	Regular
37	*Morus alba* L.	0.5	1.3	1.0	0.03	Regular
38	*Typha angustifolia* L.	0.5	1.3	1.0	0.03	Regular
39	*Azadirachta indica* A. Juss.	0.6	1.2	1.0	0.02	Regular
40	*Calotropis procera* (Aiton) W.T. Aiton	0.6	1.2	1.0	0.02	Regular
41	*Dalbergia sissoo* Roxb. ex DC	0.6	1.2	1.0	0.02	Regular
42	*Datura stramonium* L.	0.4	1.0	0.8	0.03	Regular
43	*Ficus benghalensis* L.	0.1	1.0	0.8	0.10	Contagious
44	*Holoptelea integrifolia* (Roxb.) Planch	0.3	1.0	0.8	0.03	Regular
45	*Populus deltoides* W. Bartram ex Marshall	0.3	1.0	0.8	0.03	Regular
46	*Ziziphus jujuba* Mill.	0.2	1.0	0.8	0.05	Contagious

A- Abundance; RA – Relative Abundance; F- Frequency; D- Density (individuals/m²)

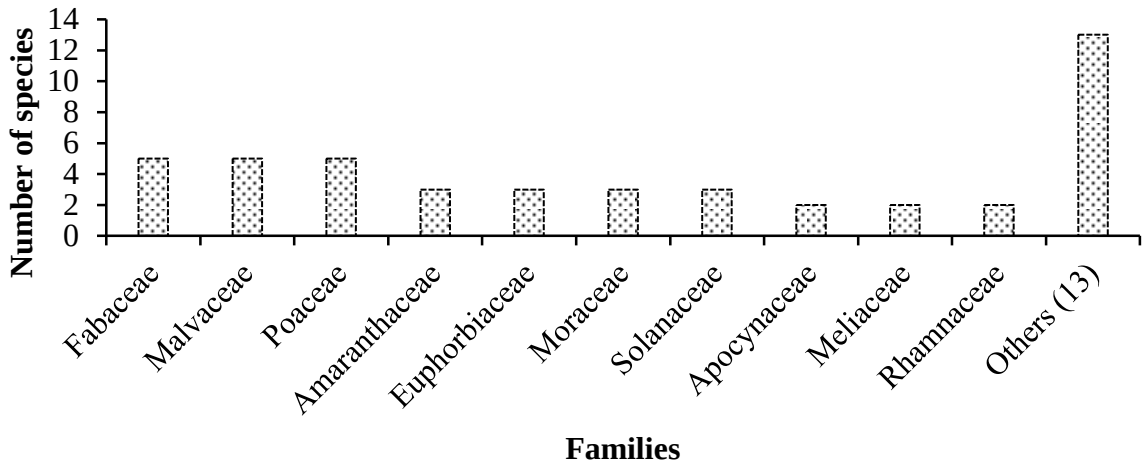

Figure 1. Dominant plant families in Kali river bank vegetation in dry tropical urban region of Meerut.

Top dominants in the term of abundance were *Megathyrsus maximus, Cynodon dactylon, Parthenium hysterophorus, Saccharum spontaneum, Physalis angulate, Ranunculus sceleratus, Chenopodium album, Senna occidentalis, Cannabis sativa* and *Argemone mexicana* who account for about 46 % of total relative abundance. *Megathyrsus maximus* had highest density 12.7/m² followed by *Cynodon dactylon* (7/m²) and exotic invasive weed *Parthenium hysterophorus* (5.2/m²).

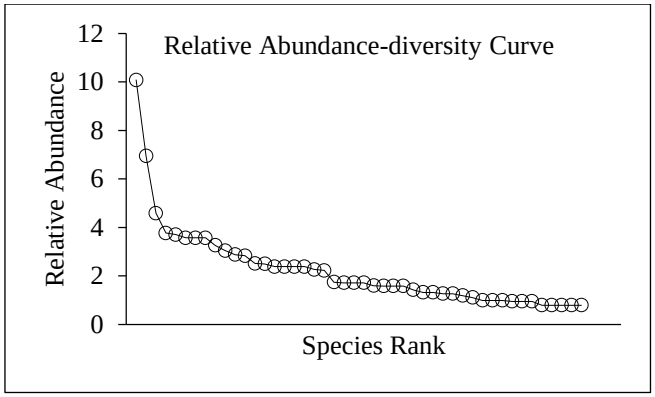

Figure 2: Dominance -diversity structure of standing vegetation along Kali river bank in a dry tropical region of Meerut.

Dominance (in term of abundance)- diversity structure of KRB vegetation exhibited major share of abundance between two species (*Megathyrsus maximus* and *Parthenium hysterophorus*) as evinced by geometrical pattern of abundance share in the initial segment of the curve and much larger number of tail-ending species with equitable share of abundance amongst them (Fig.2). however, dominance, when assessed in term of relative density, indicated sharp decline of curve after the top dominant *Megathyrsus maximus* and *Cynodon dactylon* being sub-dominant, and equitable share among the tail-ending species (Fig.3)

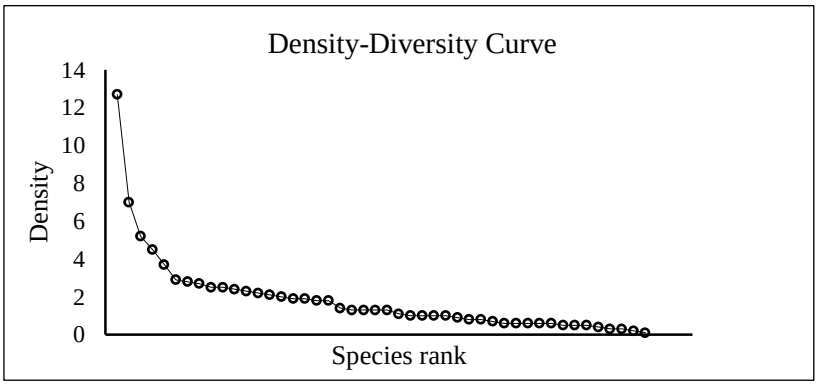

Figure 3: Density (individuals/m^2) along kali river bank in Meerut region, Uttar Pradesh.

Table 2: Diversity estimates of the vegetation in summer seasons along polluted Kali river bank in Meerut region.

Diversity indices	**Summer vegetation**
Species count	46.00
Shannon-index	3.38
Evenness	0.88
Simpson index	0.044

Diversity estimate in term of information statistic-index (Shannon index) was 3.38 that incorporated both evenness and species count. Dominance measure (Simpson´s index) was 0.044. The species count of 46 at KRB exhibited.

Table 3: Physico-chemical characteristics of soils at Kali River bank (mean ± SE) in an Indian dry tropical peri-urban region

Soil characteristics	Mean ± SE
Summer soil Moisture content (%)	8.6 ± 0.80
pH	7.65 ± 0.09
Organic C (%)	0.60 ± 0.08
Total N (%)	0.022 ± 0.002
Available P (kg/ha)	17.43 ± 1.92
Exchangeable K (kg/ha)	280.0 ± 11.8
Available S (ppm)	14.32 ± 0.53
Available Fe (ppm)	5.28 ± 0.46
Available Cu (ppm)	0.55 ± 0.04

Soil of KRB exhibited 8.6 % of moisture content in summer, 0.6 % soil organic carbon, 0.022 % total nitrogen and available P 17.43 (kg/ha). Exchangeable K was 280 (kg/ha), available S 14.3 (ppm), available Fe 5.28 (ppm) and Cu 0.55 (ppm).

Discussion

During the study period, a total of 46 plant species belonging to 23 families of vascular plants were recorded. This finding of the present study is comparable to that of other ecosystems under tropical climates. Singhal, *et al*., (2016) reported a total of 33 plant species along Kali river bank in Bulandshahar region of Uttar Pradesh with highest density of *Cynodon dactylon* (L.) Pers (248/m^2) *Parthenium hysterophorus* L. (51/m^2). Krishnamurthy, *et al.,* (2010) reported 46 species from a tropical dry deciduous forest in Bhadra Wildlife Sanctuary, Karnataka. Sahu, *et al*., (2012) recorded 57 species in dry deciduous forest of Eastern Ghats. Studies of Thakur, (2015) in tropical dry deciduous forest in Sagar district reported total 36 trees, 8 shrubs and 34 herbs. Pradhan & Rahaman, (2015) recorded a total of 65 species belong to 36 families from three tropical dry deciduous forests of Birbhum District in West Bengal. Working on phytosociology of Hulikal state forest Vinayaka & Krishnamurthy, (2016) reported a total of 231 plant species out of which 96 were trees followed by 53 herbs, 51 shrubs and remaining 31 climbers. Sukumaran, *et al*., (2018) recorded 36 trees, 18 shrubs, 26 herbs and 22 climbers in Muppuram sacred grove of Kollencode, Tamil Nadu.

In the present study, *Megathyrsus maximus* was the dominant species having maximum abundance followed by *Cynodon dactylon, Parthenium hysterophorus, Physalis angulata* and *Ranunculus scelertus* (Table 1). The density of *Megathyrsus maximus* was the highest followed by *Cynodon dactylon, Parthenium hysterophorus, Chenopodium album* and *Cyperus rotundus.* The families with the large number of species (5) present in the study area were Malvaceae, Poaceae and Fabaceae (5). thirteen families are monospecific such as Papaveraceae, Cannabaceae, Cucurbitaceae, Cyperaceae, Ulmaceae, Lamiaceae, Phyllanthaceae, Ranunculaceae, Polygonaceae, Salicaceae, Typhaceae, Oxalidaceae and Myrtaceae. Similar result has been reported in other studies of India (Kassam, *et al.,* 2011, Khan, *et al*., 2011, Mehra, *et al*., 2014, Bajpai, *et al*., 2016) and also other parts of the world (Jones, 2000, Maurer, *et al.,* 2006, Chowdhury & Koike, 2010). Although species diversity along the bank of Kali river in Meerut region was grater then the riverine vegetation of the same river at Bulandshahar segment, yet, it is much poor compared to forest ecosystems in Indian dry tropics, evinced by the result of other workers in forest ecology. This is imperative relatively higher Shannon diversity index in present study (3.38) compared to that reported by Singhal, *et al*., (2016) for Bulandshahar segment of Kali river bank. Dominance of floristic elements belonging to Poaceae and Laguminaceae reflects a tropical similarity as suggested by Agrawal and Narayan, (2016, 2006). Infect, predominance of herbaceous

species reflects the ecologically opportunistic characteristic of these species under disturbance regimes (Yadav and Narayan, 2023), especially the annuals, as evinced by > 50% of their presence in the present study. The ecological disturbance, reflecting edaphic stress is intelligible from low soil N (0.022%) and C: N ratio of >27. Infect, this anthropic aspect ostensibly due to industrial and domestic dumps into the stream of Kali river, which has caused the dark colour of water in the river. Seasonality character of this river´s raises the residence level of pollutant load it carries, especially in rainy season, as well as eroding off the soil nutrients from the slope point of river bank, causing a range of ecological stress on river bank vegetation. Increasing prominence of invasive weed *Parthenium hysterophorus* in KRB vegetation is indicative of anthropic state of KRB areas, which appear harbouring the alien flora. However, native Cynodon *dactylon* competing with alien flora, with better anchorage capacity is reflective of its management and conservation implication.

In conclusion, KRB vegetation structure in Meerut region of Kali river bank depicts alteration of soil characteristics and vegetation structure under anthropic conditions.

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Source of support: Nil;
Conflict of interest: The authors declare no conflict of interests.

Cite this article as:
Kumar, N., A. Kumar., Anjali and R. Narayan. "Analysis of Surface Vegetation and Soil Characteristics along the Bank of Kali river in Meerut region." *Annals of Plant Sciences.*13.07 (2024): pp. 6423-6433.