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Phytosociological study and estimation of carbon sequestration of tree species from the Riparian area of the Sabarmati river in Gandhinagar Taluka, Gujarat

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Abstract
Riparian landscapes are a significant resource that provide all essential ecosystem functions. Urban riparian areas, primarily those with trees, have the potential to sequester carbon from the atmosphere and reduce the impacts of global warming. In the present study, tree communities along the Sabarmati River have been studied to evaluate their species diversity and carbon stocks. For the survey of vegetation, both the left and right riverbank areas were selected. For field analysis, a quadrat-cum transact approach was used; 16 plots of 20 x 20 sq. m. were laid, and within each quadrat species enumeration, tree height (TH) and girth at breast height (GBH) data were noted. Results revealed that the tree layer vegetation was represented by 16 species. With total density of 180 ind/ha. A total of 73 trees from 16 distinct species have been counted, with 62.18 tons of carbon sequestration potential (CSP). In the present study, *Azadirachta indica* had the highest CSP of 15667 kg and the lowest 118 kg CPS *of Aegle marmelos*. The present work highlights the potential role of urban riparian vegetation in sequestering carbon dioxide. Such studies on fractional floral diversity need to be assessed at the regional level to gather data on the existing condition of the river for effective management measures.

Keywords: Urban riparian zones, vegetation, carbon stocks, carbon sequestration potential

Introduction

Riparian zones are small corridors of land near streams, rivers, lakes, reservoirs, and wetlands. Due to the availability of watered conditions, humidity, and open area, the flora diversity present here is remarkable (Singh *et al*., 2021) [11]. The extensive use of the river area for agriculture practices and urbanization has resulted in disturbance of species richness (Aguiar & Ferreira 2005) [1]. Evaluation of the riparian vegetation and screening of native species are rare; because the area is so large, it is very challenging to analyse, requiring the application of phytosociology. In phytosociological research, an area is not analysed as whole but rather as a collection of numerous small plots (Shah, 2012) [10]. Compiling such information is used to understand population dynamics. Landscapes and vegetation are significant because they can act as sources as well as sinks of carbon dioxide (CO2), which is an abundant greenhouse gas and also has a large impact on global climate change (Ramachandran *et al*., 2007) [9]. Riparian vegetation has been reported as highly productive and rich in biomass, which plays a significant role in the global carbon cycle, but this aspect has yet to be explored properly (Kujur *et al*., 2021) [4]. In the present study, the vegetation structure of the Urban riparian zone of the Sabarmati River in Gandhinagar taluka has been analysed by various phytosociological attributes, and the potential of tree species to sequester carbon dioxide has been studied.

Materials and Methods

1. Study Area

The present investigation was carried out around the Sabarmati River site in Gandhinagar taluka. Sabarmati River, which is a perennial river originating from the Aravalli Hills and flows towards the south-west, covers various parts of Gujarat namely Banaskantha, Sabarkantha, Mehsana, Gandhinagar, Ahmedabad, Kheda and Anand. The geographical location of the Sabarmati River is between 22° 30’ to 24° 30’ North latitude and 72° 30’ to 73° 30’ East longitude.

2. Field survey and sampling

For this study, a random sampling method was followed. Four sites were selected near the riparian area of Sabarmati in Gandhinagar taluka, of which two were on the left side of the riverbank and two on the right side of the river. In the riparian area, line transects were laid perpendicular to the riverbank towards the land side in each of the four quadrats of 20m x 20m grid dimension. The distance between the two quadrats was kept at 50 m (Table 1).

Table 1: Brife description of Sampling Locations

Transact Number	GPS Coordinates	No. of Quadrat (20x20m)	Area Studied (Sq.m)
T-1	23.183485, 72.655825	4	1600
T-2	23.187455, 72.66065	4	1600
T-3	23.197866, 72.660641	4	1600
T-4	23.208153, 72.675546	4	1600

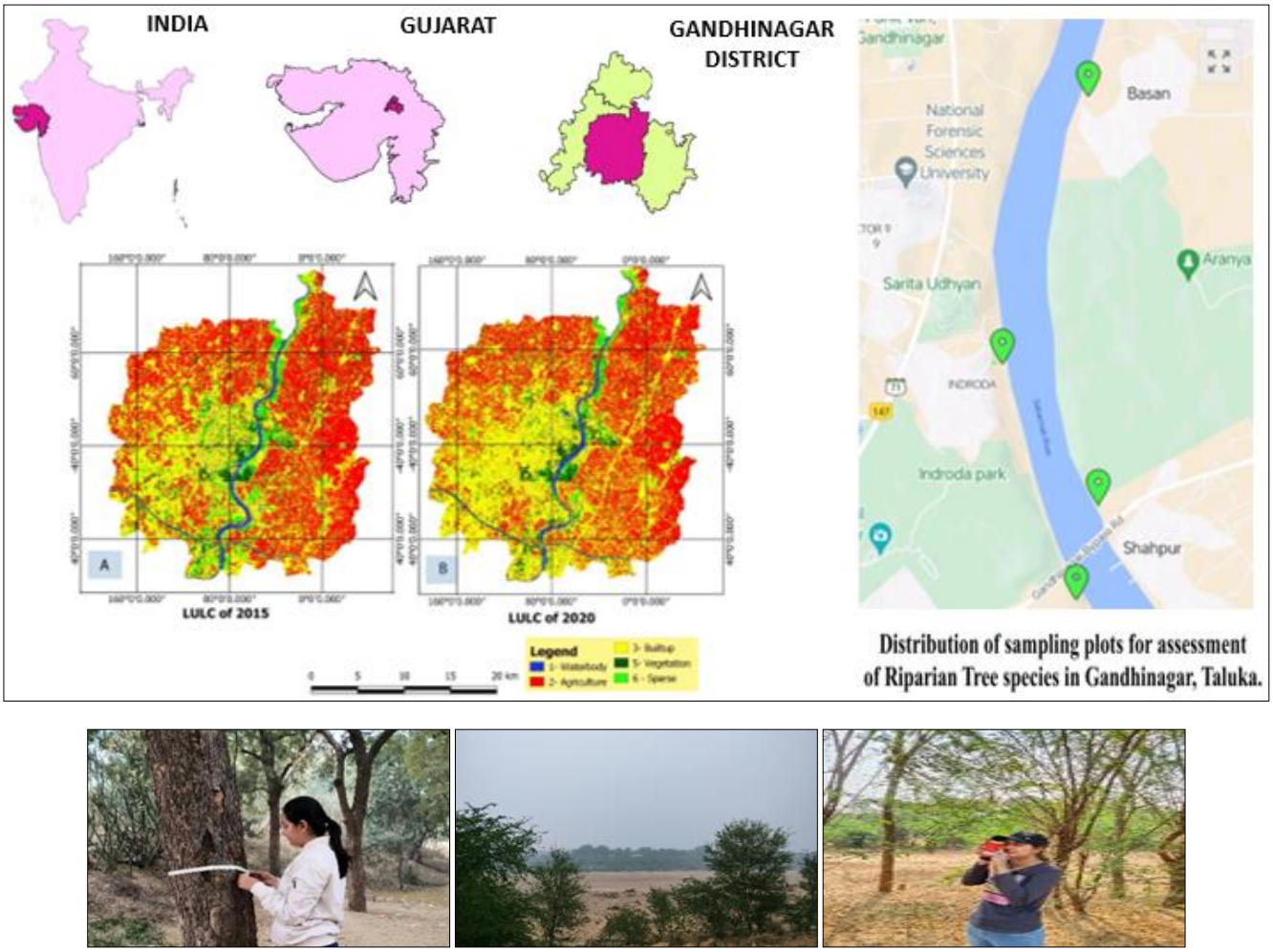

Fig 1: Location map, sampling sites and field photographs in Gandhinagar Taluka

Tree species were analysed from the above-mentioned square grid, in which the number of tree species and count were documented. The girth at breast height (i.e., 1.37 m above the ground) of all the trees in each quadrat was measured and recorded individually. The height of the tree was measured with the help of a HEXA Altimeter.

Data Analysis

Riparian vegetation structure and composition were quantified by various phytosociological attributes like frequency, density, abundance, and important value index. The diversity indices of riparian sites were determined by the standard equations of Michael 1990 (Shannon-Wiener diversity index), Simpson 1949 (Simpson's index), Pielou 1966 (Evenness index), and Margalef 1958 (Species richness index). Total carbon storage (TCS) and carbon dioxide sequestration potentials of tree species were calculated (Jithila & Prasadan, 2018) [3].

Using PAST 4.03 software, the diversity indices were computed based on the number of individuals in each species, and linear regression plots were created between total biomass, C stock, tree height, and GBH.

Results

1. Phytosociological Attributes

In the quadrate plot sampling conducted during the study, 108 unique trees and 16 different tree species were recorded. Among the tree species, the highest density was measured in *Vachellia nilotica* (38.3 ind/ha), followed by *Prosopis juliflora (*36.7 ind/ha) and *Azadirachta indica* (35 ind/ha). The minimum density of 1.7 ind/ha was observed in *Leucaena leucocephala* (Table). The frequency varied from 6.3% to 68.8% for individual tree species. The importance value index (IVI) of individual tree species ranged from 6.5 to 48.9, with the highest for *Vachellia nilotica* and the lowest for *Leucaena leucocephala*, respectively (Table 2).

Table 2: phytosociological characteristics of tree species found in the Sabarmati River's riparian zone in Gandhinagar Taluka, Gandhinagar District, Gujarat

Sr. No	Botanical Name	D (ind/ha)	F (%)	A	RD (%)	RF (%)	RA (%)	IVI
1.	*Vachellia nilotica* (L.) P.J.H. Hurter & Mabb.	38.3	68.8	0.005	21.3	19.6	7.9	48.9
2.	*Prosopis juliflora* (Sw) DC	36.7	43.8	0.008	20.4	12.5	11.9	44.8
3.	*Azadirachta indica* A. Juss.	35	62.5	0.005	19.4	17.9	8.0	45.3
4.	*Syzygium cumini* (L.) Skeels	11.7	18.8	0.006	6.5	5.4	8.8	20.7
5.	*Ziziphus mauritiana* Lam.	11.7	18.8	0.006	6.5	5.4	8.8	20.7
6.	*Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson	10	18.8	0.005	5.6	5.4	7.6	18.5
7.	*Ficus religiosa* L.	5	18.8	0.003	2.8	5.4	3.8	11.9
8.	*Moringa oleifera* Lam.	5	12.5	0.004	2.8	3.6	5.7	12.0

9.	*Senegalia senegal* (L.) Britton	5	18.8	0.0025	2.8	5.4	3.8	11.9
10.	*Aegle marmelos* (L.) Correa	3.3	6.3	0.005	1.9	1.8	7.6	11.2
11.	*Butea monosperma* (Lam.) Kuntze	3.3	12.5	0.003	1.9	3.6	3.8	9.2
12.	*Cassia fistula* L.	3.3	6.3	0.005	1.9	1.8	7.6	11.2
13.	*Ficus racemosa* L.	3.3	12.5	0.003	1.9	3.6	3.8	9.2
14.	*Prosopis cineraria* (L.) Druce	3.3	12.5	0.003	1.9	3.6	3.8	9.2
15.	*Tamarindus indica* L.	3.3	12.5	0.0025	1.9	3.6	3.8	9.2
16.	*Leucaena leucocephala* (Lam.) de Wit	1.7	6.3	0.003	0.9	1.8	3.8	6.5
F= Frequency, D= Density, A= Abundance, RD (%) = Relative Density (Percent), RF (%) = Relative Frequency (Percent), RA (%) = Relative Abundance (Percent), IVI=Importance value index, A/F-=Abundance-to-frequency ratio								

2. Carbon Biomass

The present study estimated the carbon sequestration of 73 trees belonging to 16 species (Table 3). The estimated total AGB of the trees was 26.893 tons, and the total BGB was 6.992 tons. The total biomass was 33.885 tons, and the total carbon storage by the trees was 16.943 tons. The total carbon dioxide sequestration potential is 62.18 tons. In the present study, *Azadirachta indica* had the highest CSP of 15667kg and the highest average GBH and carbon biomass, followed by *Vachellia nilotica's* (15423kg) CSP. The lowest CPS was that *of Aegle marmelos*, 118 kg.

Table 3: Sequestration of tree species found in the Sabarmati River's riparian zone in Gandhinagar Taluka, Gandhinagar District, Gujarat

Sr. No	Botanical Name	AGB	BGB	TB	TCS	CSP
1.	*Azadirachta indica* A. Juss.	6776	1762	8538	4269	15667
2.	*Vachellia nilotica* (L.) P.J.H. Hurter & Mabb.	6671	1734	8405	4203	15423
3.	*Corymbia citriodora* (Hook.) K.D. Hill & L.A.S. Johnson	5335	1387	6722	3361	12335
4.	*Syzygium cumini* (L.) Skeels	2941	765	3706	1853	6801
5.	*Ziziphus mauritiana* Lam.	1727	449	2175	1088	3992
6.	*Butea monosperma* (Lam.) Kuntze	1181	307	1488	744	2731
7.	*Acacia nilotica* (L.) Delile	588	153	741	371	1360
8.	*Ficus religiosa* L.	429	112	541	270	992
9.	*Cassia fistula* L.	265	69	334	167	613
10.	*Ficus racemosa* L.	219	57	275	138	505
11.	*Senegalia senegal* (L.) Britton	194	50	244	122	448
12.	*Tamarindus indica* L.	184	48	231	116	425
13.	*Leucaena leucocephala* (Lam.) de Wit	138	36	173	87	318
14.	*Prosopis cineraria* (L) Druce	108	28	136	68	250
15.	*Prosopis juliflora* (Sw) DC	88	23	111	55	203
16.	*Aegle marmelos* (L.) Correa	51	13	64	32	118
Sum Total (Kg)		26893	6992	33885	16943	62180
AGB= Above ground biomass, BGB= Below ground biomass, TB=Total Biomass, TCS= Total Carbon Storage, CSP= Carbon Sequestration Potential						

3. Diversity Indices

The study came with an index of dominance of 0.1452, and the Shannon index value was 2.23 for the riparian area of the Sabarmati River. The greater value of the index of dominance exhibits lower species diversity, and vice versa, on a scale of 0 to 1 (Misra, 1989). The evenness index (e) was 0.59, and the Margalef (1958) species richness index (d) was 3.21in the study area.

4. Regression analysis

The linear regression in Fig 2 showed that there was a significant positive relation between the tree GBH and CO_2 sequestration with r2 = 0.628. Hence, the GBH can be used to predict the CO_2 sequestration rate of the tree species.

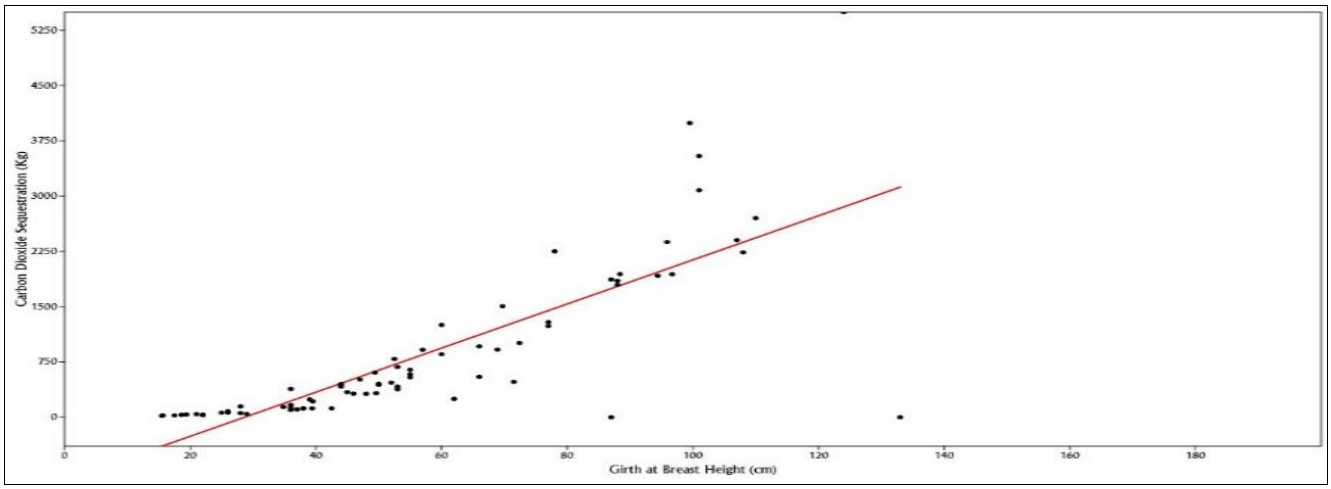

Fig 2: Relation between the tree GBH and CO_2 sequestration

The linear regression in fig 3 showed that there was a moderate relation between the tree Above ground biomass and tree height with 49% (r^2 0.49) of the variability.

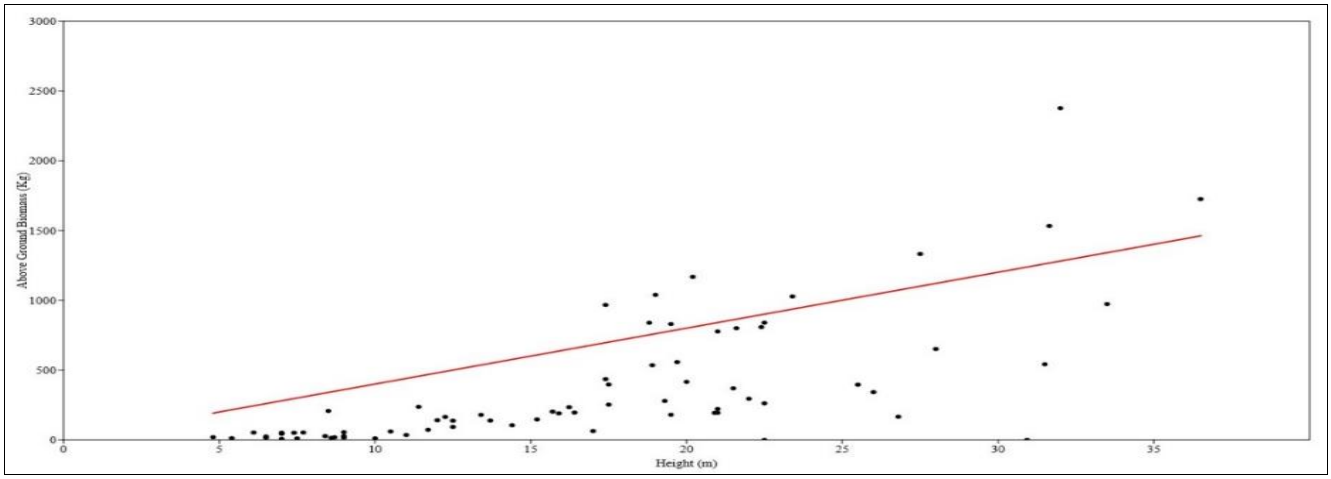

Fig 3: Relation between the tree Height and AGB

Conclusion

The present work highlights the potential role of urban riparian vegetation diversity and sequestering carbon dioxide. From such studies, effective tree species could be identified for plantation in the respective riparian sites, thus allowing the regeneration of indigenous species present in the sites.

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