RESEARCH ARTICLE

Floral Diversity in the Vicinity of Sugar-Mill of Semikhera, Bareilly, UP, India

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Abstract

Sugar industry is a crucial agricultural sector, producing large amounts of effluent affecting the environment. In order to study the effect of sugar mill effluents on native floral diversity in the locale of Kisan Sehkari Sugar Mill, Semikhera, Bareilly (Uttar Pradesh), the physicochemical analysis of the mill's effluents and native soil was carried out. pH, EC, TDS, TS, BOD, COD, and metals were recorded. Order of the heavy metal concentrations in soil and sugar mill effluent was: Fe> >Mg>, Cu>, Zn>, Ni>, Cr>, Pb>, Cd, and Fe>Mg>Zn>Cr>Mn>Cu>Pb>Co>Ni>Cd respectively and pH, EC, TDS, BOD, and COD were also significantly above the permissible limit. Extensive field surveys were conducted thrice a year to explore floral diversity. Results found a total 88 species of vascular plants. The Fabaceae family was found to be dominant, followed by Asteraceae, Moraceae, Apocynaceae, Solanaceae, Euphorbiaceae, Poaceae, Myrtaceae, and Amaranthaceae. Additionally, two species of pteridophytes from the families of Pteridaceae and Thelypteridaceae were also collected. As per taxonomic studies, 82% of species belonged to dicotyledons, while only 14% were monocotyledons. The present study's results demonstrated that the effluents' physicochemical properties are significantly higher compared to a permissible level determined by CPCB (2017). Dominant species were above 70 %, common species were 40 to 70% and rare species below 40 %. Overall results indicate the possibility of eco-restoration of waste disposal sites of sugar mill areas with these native species growing luxuriantly without showing any toxic effect.

Keywords: Sugar mill, Effluents, Heavy metal, Floral diversity, Threat status.

Highlights

- The concentrations of heavy metals in both soil and sugar mill effluent were found to be above the permissible limit.
- The order of heavy metals in soil was Fe > Mg > Cu > Zn > Ni > Cr > Pb > Cd, while in sugar mill effluent, it was Fe > Mg > Cu > Zn > Ni > Cr > Pb > Co > Cd. The pH, EC, TDS, BOD, and COD levels were significantly higher than the allowed limit.
- As per taxonomic studies 82% of species belonged to dicotyledons, while only 14% were monocotyledons.
- In angiosperms, *Calotropis procera, Parthenium hysterophorus, Amaranthus retroflexus, Amaranthus deflexus, Tripidium benghalense*, *Terminalia arjuna, Tectona grandis, Ricinus communis, Solanum nigram, Saccharum officinarum, Cyanodon dactylon, Eclipta prostrata, Saraca indica, Typha latifolia, Cyperus eragrostis, Urena lobata, Senna occidentalis,* and *Canna generalis* are growing luxuriantly.

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Introduction

Uttar Pradesh covers an area of about 2,41,286 square kilometers, of which 21,291 are covered in trees and forest, making up only about 3% of the nation's total forest cover. This is because the majority of the province's land has been developed into agricultural land and is home to a substantial human population (Kishor *et al*., 2011). Located northwest of the country, Uttar Pradesh is India's fifth-largest and most populous state. Uttar Pradesh is bordered by Nepal to the north, Bihar to the east, Haryana to the west, Uttrakhand to the north, Madhya Pradesh to the south and southwest, Himachal Pradesh to the north, and Rajasthan to the west. This state is the first in population and the fifth largest in terms of area in the nation. It is situated between 77°3 and 84°39′E longitude and 23°52 to 31°28′N latitude. It covers a large region, and the state's plains differ significantly from the high mountains in the north (Sachan *et al*., 2015). India occupies the second position in the world in terms of sugar production, with approximately 650 sugar mills after Brazil (Marotrao, 2017). In India, the chief sugar-producing states are Maharashtra and Uttar Pradesh. In Uttar Pradesh, there are 28 sugar mills, of which 8 are in the eastern zone, 6 in the western zone, and the remaining 14 in the central zone. The sugar business greatly aids the Indian subcontinent's economic development, but the effluents that are emitted cause significant carbon-based pollution in both the marine and terrestrial environments (Kumar and Chopra., 2013, 2014). The primary threat to environmental health is the enormous amount of untreated effluent produced by sugar companies and its disposal (Kumar *et al*., 2017). These pollutants disrupt the ecology and alter the environment's chemical, physical, and biological aspects (Siddiqui *et al*., 2012, Kumar *et al*., 2014). Effluents generated by different sugar mills of India requires huge amount of space and money for dumping. These wastelands may be revegetated by planting some effluent-tolerant plants that are eco-friendly.

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In context to the above, the present study has aimed to assess the diversity of native flora in the vicinity of sugar mill effluents and its physicochemical properties.

Study Area

The study area is the vicinity of Kisan Sehkari Sugar Mill located in Semikhera, Bareilly (Uttar Pradesh) a city in Uttar Pradesh in northern India, located at 78°23′E, 28°10′N, with 2750 TCD capacity (Fig. 1). The climate in this region is also unpredictable, with summer highs of 44 °C and winter lows of 4 °C. Most of the soil is alluvial and clayey alluvial, and it has enough high-quality carbonic minerals. 1150 mm of precipitation fall on average per year in this area (Kishor *et al.*, 2011).

Materials And Methods

A comprehensive survey of Kisan Sehkari Sugar Mill Ltd. Semikhera, Bareilly, has been done thrice in a year i.e. winter, spring and monsoon (2021-22) to assess the native flora. Identification and processing of the collected specimens were done by following standard herbarium techniques (Jain *et al.*, 1977) and identification by the species available in the literature (Duthie, 1903-1922). The name of the collected plant species has been listed, as per ICBN (2007) and classified as Bentham & Hooker's system. Threat categories for each species have been decided according to current categories as per IUCN guidelines for global and regional level (2012).

Wastewater Collection

Samples of sugar mill wastewater were taken using plastic canes from the Kisan Sehkari Sugar mill's effluent disposal sites for the physicochemical analysis. Nitric acid and perchloric acid (10:1 v/v mixture) were added to 10 mL of sugar mill effluent for digestion, and the mixture was digested on an electrically heated plate for four hours at 150°C for the determination of heavy metals. After cooling, the resultant mixture was run through the Whatman No. 42 filter paper. The volume was reduced to 50 mL and used for analysis using pure water. Metals were examined using a spectrophotometer for atomic absorption.

Soil Sampling

Soil samples were taken from the vicinity of the Sugar mill. Five different sites of a radius 500 m were selected for sample collection. The soil surface samples (0–30 cm depth) were collected in hygienic polythene airtight bags. Each bag contained 3 to 4 kg sample and was brought to the laboratory of the University of Lucknow for further analysis. For the digestion of soil, samples were first air-dried for three days and further oven-dried at 107°C for 24 hours. The dried samples were ground using a pestle and mortar and then sieved with 75-micron pore size. Further soil sample (1-g) was added to a digestion tube with a capacity of 250 mL, along with 10 mL of concentrated nitric acid and 1-mL of perchloric acid. The mixture was cooked for 40 to 50 minutes to completely oxidize all easily oxidizable materials. After cooling, one milliliter of hydrogen peroxide was added, and the liquid was slowly heated until dense white

Table 1: Physicochemical properties of wastewater of Sugar mill

S. No.	*Parameter*	*Wastewater*	*CPCB (2017)*
1.	Temperature (°C)	27.06 ± 0.49	-
2.	Colour	Dark yellow	-
3.	Odor	Unpleasant smell	-
4.	Ph	3.26 ± 0.01	7.54±0.001
5.	EC (Ms cm^{-1})	2.48 ± 0.01	950
6.	TDS (mg L^{-1})	1234.59±7.80	70±0.00
7.	TS (mg L^{-1})	51874.9±79.80	-
8.	BOD (mg L^{-1})	450.20 ± 1.53	47.00±0.00
9.	COD (mg L^{-1})	765.54 ± 2.52	79.00±0.01
10.	Ca (mg L^{-1})	59.46 ± 0.56	-
11.	Metals (mg L^{-1})		
i.	Cd	0.04 ± 0.00	BDL
ii.	Cu	1.71 ± 0.06	0.19
iii.	Zn	8.07 ± 0.03	1.28
iv.	Fe	44.27 ± 0.53	1.45
v.	Cr	2.36 ± 0.21	0.01
vi.	Pb	0.30 ± 0.00	0.02
vii.	Mn	2.10 ± 0.17	0.15
viii.	Co	0.25 ± 0.33	-
ix.	Mg	11.37 ± 0.17	-
x.	Ni	0.19 ± 0.00	0.04

(Values are the mean± SD of three replicates.)

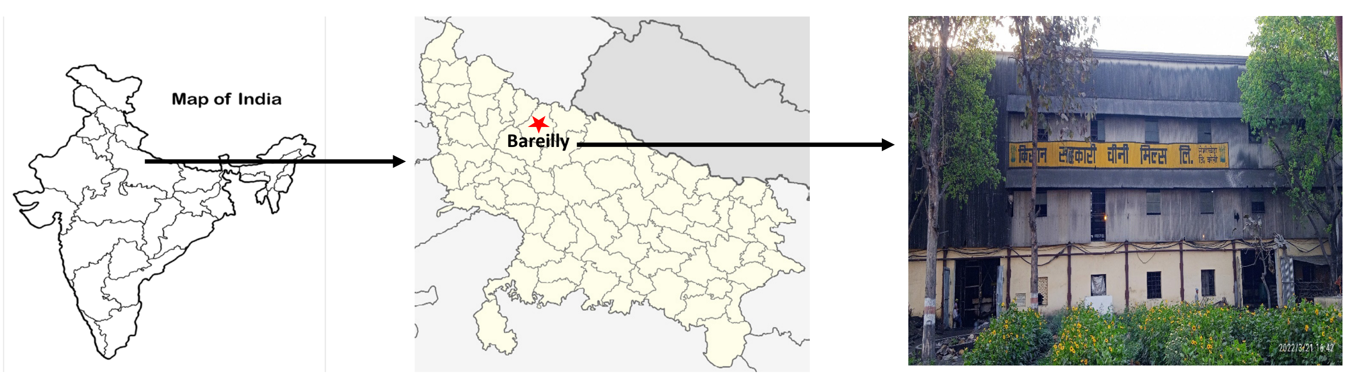

Fig. 1: Location map of Kisan Sehkari Sugar Mill in Semikhera, Bareilly (Uttar Pradesh)

vapors appeared. The mixture was then transferred to a 20 mL volumetric flask after cooling once more and filtering with Whatman No. 42 filter paper. With distilled water, the volume was adjusted to the proper level (Khan *et al*., 2019).

Physicochemical Properties Of Soil And Effluent

Temperature, pH, EC, and TDS of the samples were measured immediately for the physicochemical study of effluent and soil, while other parameters, such as TDS, TSS, BOD, COD, Ca, Mg, Fe, Zn, Cd, Cu, Cr, Mn, Co, Mg, Ni, and Pb contents, were assessed in the laboratory using Standard Methods (APHA., 2012; AOAC., 2005). HANNA H15222 was used to monitor pH, TDS, and EC. Before using and reading the chosen samples, all lab equipment was calibrated with its standard. An atomic absorption spectrometer was used to analyze Mg, Fe, Zn, Cd, Cu, Cr, Mn, Co, Mg, Ni, and Pb. Distilled water was used to make all of the standard solutions.

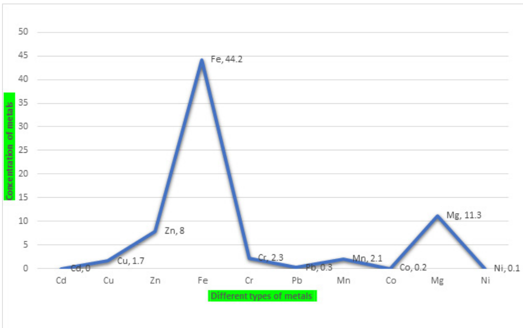

Fig. 2: Graphical representation of analysis of heavy metals in wastewater

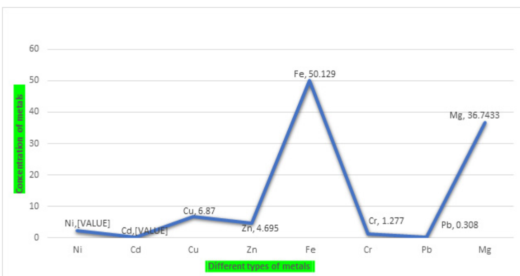

Fig. 3: Graphical representation of analysis of heavy metals in soil

Result And Discussion

Statistical Physicochemical Analysis Of Sugar Mill Wastewater

Table 1 lists the mean and standard deviation (SD) values of the various parameters of the effluent from a sugar mill. The values of various parameters in the 100% effluent viz., temperature (27°C), pH(3.26), EC (2.48 Ms cm^{-1}), TDS (1234.59 mg L^{-1}), TS (51874.9 mg L^{-1}), BOD (450.20 mg L^{-1}), COD (765.53 mg L^{-1}), Ca (59.45 mg L^{-1}), Cd (0.04 mg L^{-1}), Cu (1.71 mg L^{-1}), Zn (8.07 mg L^{-1}), Fe (44.27 mg L^{-1}), Cr (2.36 mg L^{-1}), Pb (0.30 mg L^{-1}), Mn (2.10 mg L^{-1}), Co (0.25 mg L^{-1}), Mg (11.36 mg L^{-1}), Ni (0.19 mg L^{-1}) indicated that the contamination from the sugar mill wastewater is extremely high and could harm the site's flora and animals (Fig. 2). The findings were according to Kumar and Chopra (Kumar *et al*., 2018 a,b).

Statistical Physicochemical Analysis of Soil of Sugar Mill

The various soil properties at the sugar mill's mean and standard deviation values are presented in Table 2. The values of parameters are pH (7.78), EC (1.95 Ms cm^{-1}), WHC (50%), Na (20.32 mg Kg^{-1}), K (168.12 mg Kg^{-1}), Ca (18.72 mg Kg^{-1}), Ni (2.22 mg Kg^{-1}), Cd (0.08 mg Kg^{-1}) Cu (6.87 mg Kg^{-1}), Zn (4.69 mg Kg^{-1}), Fe (50.12 mg Kg^{-1}), Cr (1.27mg Kg^{-1}), Pb (0.36 mg Kg^{-1}) and Mg (36.74 mg Kg^{-1}) shows high toxicity in soil (Fig. 3).

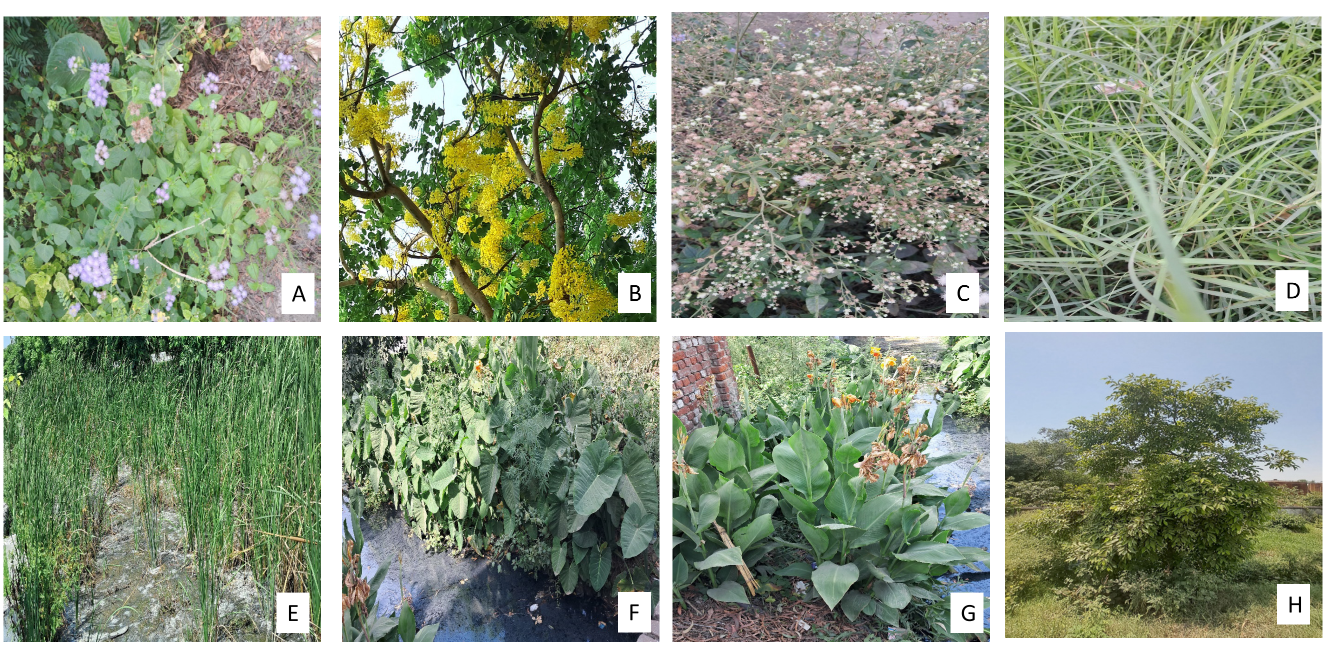

Fig. 4: Floral diversity in the vicinity of sugar mill; (A) *Ageratum conyzoides*, (B) *Cassia fistula*, (C) *Parthenium hysterophorus*, (D) *Cynodon dactylon*, (E) *Typha latifolia,* (F) *Colacasia esculenta*, (G) *Canna generalis*, (H) *Syzygium cumini*

Table 2: Physicochemical properties of soil of Sugar mill vicinity.

S. No.	*Parameter*	*Soil*
1.	pH	7.79 ± 0.01
2.	EC (Ms cm^{-1})	1.95 ± 0.06
3.	WHC (%)	50 ± 4.08
4.	Na (mg Kg^{-1})	27.61 ± 5.96
5.	K (mg Kg^{-1})	169.44 ± 7.58
6.	Ca (mg Kg^{-1})	17.89 ± 2.36
7.	Metal (mg Kg^{-1})	
i.	Ni	2.22 ± 0.24
ii.	Cd	0.08 ± 0.00
iii.	Cu	6.87± 0.11
iv.	Zn	4.70 ± 0.11
v.	Fe	50.12 ± 2.48
vi.	Cr	1.28 ± 0.31
Vii	Pb	0.37 ± .31
viii.	Mg	36.74 ± 8.07

(Values are the mean± SD of three replicates.)

Floral Diversity In The Vicinity Of Sugar Mill

During the examination, 88 different native plant species were gathered from the area around the sugar mill. Out of 88 species, 86 plant species belonged to angiosperms and 2 species belonged to ferns with their family (Table 3 and Figs 4-7), IUCN status and dominating status according to local field observation. The data shows that 40 families are present in the site, in which the most diverse plant families are Fabaceae and Asteraceae. (9) followed by Apocynaceae (7), Moraceae (7), Euphorbiaceae (6), Poaceae (4), Myrtaceae (3), Solanaceae (3) and Amaranthaceae(3). Two terrestrial ferns, *Pteris vittata* and *Thelypteris dentata*, were also growing in shady places. Among angiosperms, some plant species i.e., *Saccharum officinarum*, *Tripidium bengalense, Cynodon dactylon, Senna occidentalis, cannabis sativa, Ricinus communis, Terminalia arjuna, Urena lobata, Amaranthus retroflexus, Calotropis procera, solanum nigrum, Tectona grandis, Parthenium hysterophorus, Eclipta prostrata, Saraca indica, Typha latifolia, Cyperus eragrostis,* and *Canna generalis* were found luxuriantly growing in the area (Fig. 8). As per statistical analysis, 82% of species belong to dicot, 14 % of species belong to monocot, and 3% of species belong

Fig. 5: (A) *Thevetia peruviana*, (B) *Acmella caulirhiza*, (C) *Argemon maxiacana*, (D) *Terminalia arguna*, (E) *Calotropis procera,* (F) *Morus alba*, (G) *Tectona grandis*, (H) *Pteris vittata*

Fig. 6: (A) *Senna multijuga*, (B) *Cannabis sativa*, (C) *Oxalis latifolia*, (D) *Achyranthus aspera*, (E) *Ricinus communis,* (F) *Rauvolfia tetraphyla*, (G) *Murraya paniculate*, (H) *Hibiscus rosa-sinensis*

Table 3: List of Plants Growing in the vicinity of Sehkari Sugar mill, Semikhera

S. No.	*Family*	*Plant's name*	*Status at the site*	*IUCN status*
1.	Annonaceae	*Polyalthia longifolia*	C	NE
2.	Menispermaceae	*Tinospora cordifolia*	R	NE
3.	Papavaraceae	*Argemone maxicana*	C	NE
4.	Malvaceae	*Abutilon indicum*	R	NE
		Urena lobata	D	LC
		Hibiscus rosa-sinensis	C	NE
5.	Oxalidaceae	*Oxalis latifolia*	C	NE
6.	Rutaceae	*Murraya koenigii*	C	LC
		Murraya paniculata	C	NE
7.	Meliaceae	*Azadirachta indica*	C	LC
8.	Anacardiaceae	*Mangifera indica*	C	DD
9.	Fabaceae	*Adenanthera pavonine*	C	LC
		Dalbergia sissoo	C	LC
		Desmanthus virgatus	R	LC
		Senna multijuga	C	LC
		Senna occidentalis	D	LC
		Cassia fistula	R	LC
		Saraca indica	D	LC
		Desmodium triflorum	C	LC
		Medicago polymorpha	C	LC
10.	Combretaceae	*Terminalia arjuna*	D	NE
11.	Myrtaceae	*Syzygium cumini*	C	LC
		Eucalyptus tereticornis	R	LC
		Psidium guajava	C	LC
12.	Cucurbitaceae	*Coccinia grandis*	C	NE
13.	Araliaceae	*Polyscias fruiticosa*	R	NE
14.	Asteraceae	*Ageratum conyzoides*	C	LC
		Parthenium hysterophora	D	NE
		Lactuca serriola	C	LC
		Eclipta prostrate	D	LC
		Acmella caulirhiza	C	LC
		Tagetes erecta	C	DD
		Helianthus annuus	C	LC
		Launaea nudicaulis	C	NE
		Tridax procumbens	C	NE
15.	Apocynaceae	*Calotrpois procera*	D	NE
		Nerium oleander	C	LC
		Plumeria alba	R	LC
		Tabernamontana divaricate	C	NE
		Rauvolfia tetraphylla	C	LC
		Cascabella thevetia	R	NE
		Alstonia scholaris	R	LC
16.	Boraginaceae	Heliotropium indicum	C	NE
17.	Convolvulaceae	Ipomoea grandifolia	C	LC
18.	Solanaceae	*Withania somnifera*	C	DD
		Solanum nigrum	D	NE
		Lycopersicon esculentum	R	NE
19.	Bignoniaceae	*Tebebuia aurea*	C	NE
20.	Acanthaceae	*Justicia gendarussa*	C	NE
21.	Lamiaceae	*Tectona grandis*	D	NE
		Ocimum sanctum	C	NE
22.	Nyctaginaceae	*Bougainvillea glabra*	C	LC
23.	Amaranthaceae	*Amaranthus deflexus*	D	NE
		Amaranthus retroflexus	D	NE
		Achyranthus aspera	C	NE
24.	Petiveraceae	Rivina humilis	C	NE
25.	Aristolochiaceae	*Aristolochia macrophyla*	R	NE
26.	Elaeagnaceae	*Elaeagnus umbellate*	C	LC
27.	Euphorbiaceae	*Croton*	C	NE
		Ricinus communis	D	NE
		Euphorbia hirta	C	LC
		Phyllanthus reticulatus	C	LC
		Euphorbia heterophylla	C	LC
		Euphorbia milli	C	NE
28.	Phyllanthaceae	Phyllanthus emblica	R	LC
29.	Cannabaceae	*cannabis sativa*	D	NE
30.	Moraceae	*Ficus religiosa*	R	NE
		Ficus septic	C	LC
		Ficus virens	C	LC
		Ficus benjamina	R	LC
		Ficus benghalensis	C	NE
		Artocarpus heterophyllus	C	NE
		Morus alba	R	LC
31.	Asphodelacece	*Aloe vera*	C	NE
32.	Cannaceae	*Canna generalis*	D	NE
33.	Commelinaceae	*Tradescantia pallida*	C	NE
		Commelina diffusa	C	NE
34.	Arecaceae	*Dypsis lutescens*	R	NT
		Roystonea regia	R	LC
35.	Typhaceae	*Typha latifolia*	D	LC
36.	Araceae	*Colacasia esculenta*	D	NE
37.	Poaceae	*Saccharum officinarum*	D	NE
		Tripidium bengalense	D	NE
		Digitaria ciliaris	C	NE
		Cynodon dactylon	D	NE
38.	Cyperaceae	*Cyperus eragrostis*	D	LC
39.	Pteridaceae	*Pteris vittata*	R	LC
40.	Thelypteridaceae	*Thelypteris dentata*	R	LC

D= Dominant; (>70%); C=Common (40-70%); R=Rare (<40%)

Fig. 7: (A) *Ficus benjamina*, (B) *Helianthus annuus*, (C) *Bougainvillea glabra*, (D) *Tabebuia aurea*

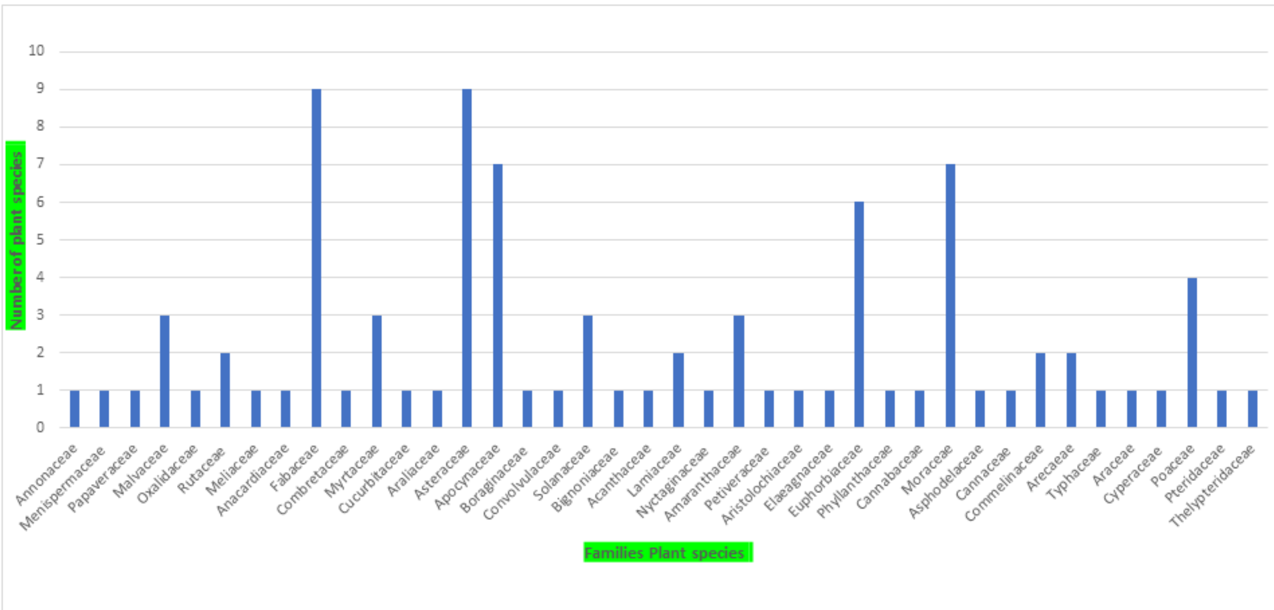

Fig. 8: Family-wise graphical representation of plant found in the site

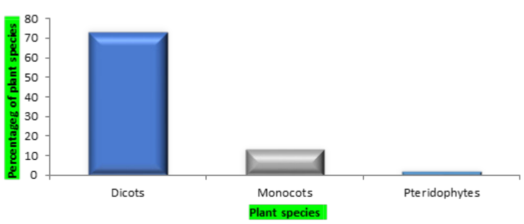

Fig. 9: Graphical representation of analysis of number of Angiosperms and Pteridophytes

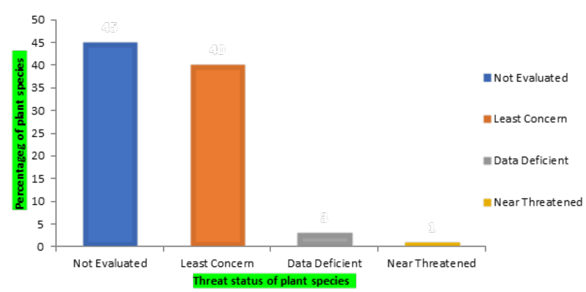

Fig. 11: Graphical representation analysis of threat status of plant species found in site

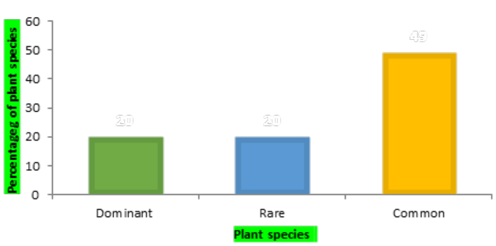

Fig. 10: Graphical representation of analysis of number of common, rare and dominant plant species

to Pteridophytes (Fig. 9) whereas Dominant species are 22%, Common species are 55% and rare species are 22% (Fig. 10), respectively. Also, data on the IUCN status at the global level is represented as 50% Not Evaluated, 44% Least Concern, 3 % Data Deficient, and 1% Near Threatened (Fig. 11).

Conclusion

The study concludes that a total 88 species of vascular plants were growing naturally in the target area in which 86 species belonged to the angiosperms consisting of 40 families, and only two from pteridophytes, i.e., *Pteris vittata* and *Thelyteris dentata*. In angiosperms, *Calotropis procera, Parthenium hysterophorus, Amaranthus retroflexus, Amaranthus deflexus, Tripidium benghalense, Terminalia arjuna, Tectona grandis, Ricinus communis, Solanum nigram, Saccharum officinarum, Cyanodon dactylon, Eclipta prostrata, Saraca indica, Typha latifolia, Cyperus eragrostis, Urena lobata, Senna occidentalis,* and *Canna generalis* are growing luxuriantly. The physicochemical analysis of soil and sugar mill wastewater revealed significant hazardous pollutants in the effluents generated but no symptoms of toxic effects on the vegetation growing in the vicinity of disposal sites. However, they damage the ecosystem around them due to their poisonous impacts. It suggests that the dominating flora is resistant to the hazardous effects of the sugar mill effluent, including *Terminalia arjuna* and others. The results of the physicochemical study showed the pattern of heavy metal concentration in soil and sugar mill effluent are in the following order: Fe>Mg>Cu>Zn>Ni>Cr>Pb>Cd and Fe>Mg>Zn>Cr>Mn>Cu>Pb>Co>Ni>Cd, respectively.

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Author Contribution

Prof. Alka Kumari supervised this research overall and provided conceptual advice and all required suggestions during the preparation of the manuscript. Priyanshi Singh carried out the fieldwork and analyzed the data and manuscript writing. The other two authors, Aanchal Verma and Pratibha, were also involved in data analysis and helped with manuscript preparation.

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Declaration Of Interest

The authors affirm that they have no known financial or personal conflicts that would have appeared to have an impact on the research presented in this study.

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