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Dominating plant species around Sanganer area contaminated with effluents from textile dyeing and printing industries.

KEYWORDS: Sanganer, Croton bonplandanium, Amaranthus spinosus and Abutilon bidentatum.

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ABSTRACT *Different plant species were found at sites contaminated with textile dyeing and printing effluents. A total of 316 plant species belonging to 33 different plant families were found growing at the sites contaminated with textile dyeing and printing effluent. The plant species that were found to dominate the sites were Croton bonplandanium, Amaranthus spinosus and Abutilon bidentatum. The average density of plant Croton bonplandianum was found to be highest among all the plant species. The mean frequency of Amaranthus spinosus was 85%, Croton bonplandianum 80% and Abutilon bidentatum 48.33%. The species richness was higher for site 1 whereas the dominance was higher for site 2. The IVI was highest for Croton bonplandianum followed by Amaranthus spinosus and Abutilon bidentatum from rest of the other plant species found in the area. As these plant species are capable of surviving in the contaminated area they could be applied for the removal of pollutants through bioremediation.*

INTRODUCTION:

With the increase in human population there has ever been increasing demand for textiles. The attempts to make textiles more appealing have led to the constant demand for various textile dyes. Earlier dyes from natural sources were used but nowadays synthetic dyes are mostly in demand. Textile dyeing and printing industries are one of the major consumers of these synthetic dyes. However a large percentage of these textile dyes are lost in the effluent due to their lower fixation. Consequently the waste water from these industries contain dyes which is distinctly visible to the naked eyes. The effluents are discharged untreated into nearby water bodies or soil and even used for irrigating the agricultural fields thereby contaminating them and disturbing the growth and development of nearby flora and fauna. There have been numerous reports regarding the toxicity of these synthetic dyes. Textile dyes have been reported to reduce seed germination and growth of different crop plants (Ravi et al. 2013). The plants are capable of surviving in wide range of habitats from extreme cold to extreme hot, from acidic to alkaline environments and from desert to marshy lands as well as from fertile to polluted soil. Plants are exposed to different types of stress in these environments including, extreme drought, salinity, high and low temperatures, chemical pollution, radiation and oxidative stress, therefore the study of plants surviving in such unique environmental conditions is of vital importance. Such plants are not only capable of surviving and adapting themselves but also flourish and reproduce, showing their dominance in the contaminated area.

In the present study Sanganer town was selected as the study area due to the presence of large number of small and large scale textile dying and printing industries. These industries make immense use of synthetic dyes. Due to poor enforcement of relevant laws the waste water from these industries is discharged untreated into nearby water bodies or in adjoining soil. The waste water is highly colored visualizing the presence of these toxic synthetic dyes. Therefore a survey of the study area was conducted so as to determine the kind of vegetation that was able to thrive in such a harsh environment where survival for the other plant species becomes quite difficult.

MATERIALS AND METHODS:

Study Area:

Rajasthan is the largest state in India, consisting of 10.41% of the total area and 5.5% of the national population. Jaipur, the capital city, also popularly known as the Pink city, with geographical area of 11,143 sq. km forms east-central part of the State of Rajasthan. Its geo-coordinates are latitude 26° 1' 36" North and longitude 75 4' 32" East, administered by 13 tehsils and 13 blocks, Sanganer (study area) being one of the tehsils as well as a block. The plant samples for the study were collected from three distinct sites. Site 1, 2 and 3 were area points located nearby a pool of polluted water adjoining the dyeing and printing units at Gular Ka Banda, located in Sanganer region. The climate of the study area is semiarid. The mean maximum and minimum temperatures were 33.35^0 and 25.2^0 C respectively and the mean rainfall recorded (July- Aug.) was 207.8 mm.

Sampling of plant material:

The sampling of plant material (focusing on herbs) for the study was conducted on an identified area being referred to as site 1of approximately 25 m in length and 20m in width nearby a pool of contaminated water. This area was further divided into 20 quadrats of 5m*5m size. The site 2 and 3 were of approximately 25m in length and 5m in width nearby the pool of contaminated water. Each site was further divided into 10 quadrats of 5 m * 5m size. The sampling was done during the months of February-March, May- June and during September – October for phytosociological studies. The identification of the plant species was done according to the available herbarium specimens. The different biodiversity indices which were calculated during the present study are Margalef index, Shannon index, Equitability index, Berger-Parker dominance index, importance value index and Simpson index.

Selection of the plant material:

Healthy plants were selected, avoiding diseased or insect-damaged plants. Only individual plants which showed healthy leaves, flowers and fruit size were chosen. The present study focused on collecting plants that showed morphological variation.

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Data Analysis:
The phytosociological data were quantitatively analyzed for density and frequency according to Curtis and McIntosh (1951) and Muller Dombois and Ellenberg (1974) respectively. The relative values of density, frequency and abundance were determined following Phillips method (1959). Diversity indices were calculated as per the method given by Ludwig and Reynolds (1988).

Information statistic indices:
Shannon's Index or α diversity (H′) = $H' = -\Sigma_{i=1}^{s}$ (pi log2 pi)
or $H' = -\Sigma_{i=1}^{s}$ (ni/n) log2 (ni/n)
(Shannon and Weaver, 1963)

where: H′ = Shannon's diversity index.
pi = Proportion of total sample belonging to ith species.

pi's are population parameters, log2 =3.322 log10.

ni = Number of individuals of species i in the sample, n = Total number of all species

Dominance measures:

Simpson's Index (λ) = $\Sigma_{i=1}^{s} Pi^2$= (ni/N)

(Simpson, 1949)

where Pi is the proportional abundance of the ith species.

ni = Number of individuals of the ith species.

N = Total number of individuals of all species in the population.

Berger-Parker index = **$n_{max/}$ N**

(Berger-Parker, 1970)

Species richness indices:
Margalef's index of richness (R) = S−1/ ln (N)

(Margalef, 1958)

where S = The total number of species in a community.

N= Total number of individuals of a species.

RESULTS:
A total of 316 plant species belonging to 33 different plant families were found growing at the sites contaminated with textile dyeing and printing effluent. There were 160 different plant species at site 1, at site 2 there were 83 whereas at site 3 there were 73 plant species. The results also revealed that at the contaminated sites there were two dominant plant families Amaranthaceae and Euphobiaceae followed by Solanaceae, Poaceae, Acanthaceae and Rhamanaceae.

Distribution pattern of Abutilon bidentatum, Amaranthus spinosus and Croton bonplandianum at the contaminated sites:

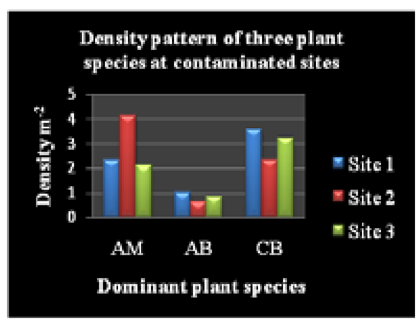
The mean density of *Amaranthus spinosus* was 2.83 m^{-2}, *Abutilon bidentatum* 0.8 m^{-2} and *Croton bonplandianum* 3.02 m^{-2} (Table-1). The density of *Abutilon bidentatum* was 1.0 m^{-2}, *Amaranthus spinosus* was 2.3 m^{-2} and of *Croton bonplandianum* was 3.55 m^{-2} at site 1, at site 2 density of *Abutilon bidentatum* was 0.6 m^{-2}, *Amaranthus spinosus* was 4.1 m^{-2} and of *Croton bonplandianum* was 2.3m^{-2} whereas density of *Abutilon bidentatum* was 0.8 m^{-2}, *Amaranthus spinosus* was 2.1 m^{-2} and of *Croton bonplandianum* was 3.20 m^{-2} at site 3 (Graph- 1). Thus mean density of the plant *Croton bonplandianum* was found to be higher than *Amaranthus spinosus* and *Abutilon bidentatum.*

On the other hand the mean frequency of *Amaranthus spinosus* was 85%, *Abutilon bidentatum* 48.33% and of *Croton bonplandianum* was 80% (Table-1). However at site 1 *Amaranthus spinosus* was 85%, *Abutilon bidentatum* was 55% and *Croton bonplandianum* was 80%. While at site 2 *Amaranthus spinosus* was 90%, *Abutilon bidentatum* was 40% and *Croton bonplandianum* was 70% whereas at site 3 *Amaranthus spinosus* was 80%, *Abutilon bidentatum* was 50% and *Croton bonplandianum* was 90%. *Amaranthus spinosus* was least at site 3 whereas *Abutilon bidentatum* and *Croton bonplandianum* were least at site 2 (Graph-2).Thus the plant *Amaranthus spinosus* was found to have the maximum mean frequency whereas mean density was found to be highest for plant *Croton bonplandianum*.

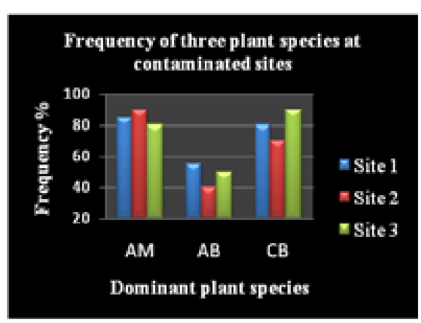
Table 1: Density (D) and Frequency (F) of *Amaranthus spinosus, Abutilon bidentatum* and *Croton bonplandanium* at the contaminated sites.

Site	Amaranthus spinosus		Abutilon bidentatum		Croton bonplandanium	
	D (m^{-2})	F %	D (m^{-2})	F %	D (m^{-2})	F %
Site 1	2.3	85	1.0	55	3.55	80
Site 2	4.1	90	0.6	40	2.3	70
Site 3	2.1	80	0.8	50	3.2	90
Mean	2.83	85	0.8	48.33	3.02	80

Graph 1: Density pattern of three plant species at the contaminated sites.



Graph 2: Frequency pattern of three plant species at the contaminated sites.



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The dominant plant families:

The plant families which were dominant at the study area were Amaranthaceae and Euphobiaceae followed by Solanaceae, Poaceae, Acanthaceae and Rhamanaceae. There have been reports regarding the growing potential of these two families at sites contaminated with toxic and hazardous pollutants. These have also been reported to be good hyper-accumulators of heavy metals, thereby are ideal for phytoremidiation.

Abundance of Abutilon bidentatum, Amaranthus spinosus and Croton bonplandianum as compared to other plant species at the contaminated sites:

The IVI of *Croton bonplandianum* was 189.38, *Amaranthus spinosus* was 133.75 and of *Abutilon bidentatum* was 64.16 at site 1 (Table-2). However at site 2 IVI of *Croton bonplandianum* was 131.16, *Amaranthus spinosus* was 221.81 and of *Abutilon bidentatum* was 34.59. While at site 3 IVI of *Croton bonplandianum* was 180.51, *Amaranthus spinosus* was 125.44 and of *Abutilon bidentatum* was 54.30. Thus the plant *Croton bonplandianum* had the maximum IVI followed by *Amaranthus spinosus*, *Abutilon bidentatum* and then the rest of the other plant species found at the contaminated sites under study.

Table 2: Relative Density (RD), Relative Frequency (RF), Relative Abundance and IVI of top ten dominant plant species in the contaminated area:

Plant Species	Site 1				Site2				Site 3			
	RD	RF	RA	IVI	RD	RF	RA	IVI	RD	RF	RA	IVI
Amaranthus spinosus	28.75	28.33	76.67	133.75	49.40	31.03	141.38	221.81	28.77	26.67	70.00	125.44
Chenopodium album	1.86	5.00	5.00	11.86	2.41	6.90	6.90	16.21	1.37	3.33	3.33	8.03
Euphorbia hirta	3.75	6.67	10.00	20.42	7.82	6.90	10.34	25.06	4.11	6.67	10.0	35.84
Parthenium hysterophorus	3.13	5.00	8.33	16.46	4.82	6.90	13.79	25.51	5.48	6.67	13.33	25.48
Ricinus communis	0.66	1.67	1.67	4.00	-	-	-	-	-	-	-	-
Abutilon bidentatum	12.50	18.33	33.33	64.16	7.23	6.67	20.69	34.59	10.96	16.67	26.67	54.3
Artemisia scoparia	1.25	3.33	3.33	7.91	2.41	6.90	6.90	16.21	-	-	-	-
Solanum nigrum	3.13	3.33	8.33	14.79	2.41	3.45	6.90	12.76	4.11	6.67	10.0	20.78
Croton bonplandanium	44.38	26.67	118.33	189.38	27.71	24.14	79.31	131.16	43.84	30.00	106.67	180.51
Verbesenia encelioides	0.66	1.67	1.67	4.00	-	-	-	-	1.37	1.33	3.33	6.03

Dominance-diversity structure:

On the basis of following table-3 it can be suggested that site-1 was found to be much more diverse than site 2 and 3 in terms of species count. Both Margalef index and Shannon index (species richness indices) was higher for site 1.In contrast, the dominance measures Berger-Parker and Simpson index of site 2 exhibited higher dominance. In terms of species equitability Index was higher for site 3. The species richness was higher for site 1 whereas the dominance was higher for site 2.

Table 3: Diversity estimates of three dominant plant species at the contaminated sites:

Diversity Indices	Site 1	Site 2	Site 3
Species Count	160	83	73
Margalef index	1.77	1.58	1.63
Shannon-index	2.18	2.06	2.17
Equitability Index	0.66	0.69	0.72
Berger-Parker dominance index	0.44	0.49	0.44
Simpson index	0.59	0.65	0.57

DISCUSSION:

Plants are essential for maintaining balance in the nature. Plants occupy a vital place in survival of mankind on earth, as they are not only the main source of food but also a store house of numerous valuable chemicals and compounds which are utilized for medicinal purposes. They are also capable of surviving and adapting themselves to different environmental conditions. The survey of the area, which was contaminated with untreated effluent discharged by the textile dyeing and printing industries, was conducted. The survey revealed that there were different plant species that were able to survive in polluted soil and water contaminated with synthetic textile dyes. A total of 316 plant species belonging to 33 different plant families were found growing at the sites contaminated with textile dyeing and printing effluents. There were 160 different plant species at site 1, at site 2 there were 83 whereas at site 3 there were 73 plant species. The results also revealed that at the contaminated sites there were two dominant plant families Amaranthaceae and Euphobiaceae followed by Solanaceae, Poaceae, Acanthaceae and Rhamanaceae. This indicates the growing potential of these two families at sites contaminated with toxic and hazardous pollutants. These have also been reported to be good hyper-accumulators of heavy metals, thereby are ideal for phytoremidiation.

The plant species that were found to dominate the sites contaminated with textile dyeing and printing effluent were *Croton bonplandanium, Amaranthus spinosus* and *Abutilon bidentatum,*. The mean density of *Amaranthus spinosus* was 2.83 m^{-2}, *Abutilon bidentatum* 0.8 m^{-2} and *Croton bonplandianum* 3.02 m^{-2}.The mean frequency of *Amaranthus spinosus* was 85%, *Abutilon bidentatum* 48.33% and *Croton bonplandianum* 80%. Thus the plant *Amaranthus spinosus* was found to have the maximum mean frequency whereas mean density was found to be highest for plant *Croton bonplandianum*. *Amaranthus spinosus* was least at site 3 whereas *Abutilon bidentatum* and *Croton bonplandianum* were least at site 2. Both Margalef index and Shannon index (species richness indices) was higher for site 1. In contrast, the dominance measures Berger-Parker and Simpson index of site 2 exhibited higher dominance. In terms of species equitability Index was higher for site 3. On the above basis species richness was higher for site 1 whereas the dominance was higher for site 2. Odum (1969) also reported a negative correlation between diversity and dominance as observed in the present study. The IVI was highest for *Croton bonplandianum* (189.38) at site1 followed by *Amaranthus spinosus* (133.75) and Abutilon bidentatum (64.16), at site 2 *Amaranthus spinosus* (221.81) followed by *Croton bonplandianum* (131.16) and Abutilon bidentatum (34.59) whereas at site 3 *Croton bonplandianum* (180.51) followed by *Amaranthus spinosus* (125.44) and Abutilon bidentatum (54.3), higher from rest of the plant species found in the area. The plant *Croton bonplandianum* had the maximum IVI followed by *Amaranthus spinosus*, *Abutilon bidentatum* and than rest of the other plant species found at the contaminated sites under study. Thus these three plant species were found to dominate the contaminated area as compared to rest of the other plant species. Consequently, these three plant species were not only capable of surviving and adapting themselves but also flourish and reproduce, showing their dominance in the contaminated area.

CONCLUSION:

The results of the present study clearly indicated that some plant species were able to survive under contaminated environment where the survival of the rest of the plant species was difficult. However during the present study, *Croton bonplandanium, Amaranthus spinosus* and *Abutilon bidentatum* were the plants species that were not only capable of surviving and adapting themselves but also flourished and reproduced showing their dominance in the contaminated area. As these plant species are capable of surviving in the contaminated area they could be applied for the removal of pollutants through bioremediation. Thus the study suggested immense potential of these plant species for their application in bioremediation of the environment contaminated with the pollutants.

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