

Physico-Chemical Properties of Paper Mill Effluent and Its Ecological Impact on Local Flora

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Abstract: Enormous quantity of water is used for production of paper and accordingly huge amount of effluents are being generated, spread over surrounding environments with or without proper treatment. During present investigation an attempt was made to assess the physico-chemical properties of effluents discharged by Orion Paper Industries Limited situated at Village Dhenka of Bilaspur District, Chhattisgarh and to evaluate its ecological impact on local flora. Nineteen parameters of physico-chemical properties of effluent samples collected from different sites were assessed adopting the standard method. Plant communities of adjoining area thoroughly and seventeen species of herbaceous and shrubby plants were identified. The herbaceous vegetation, but floristically poor in species composition was observed. Evaluation of ecological impact of effluent revealed the less frequency of common species of the locality i.e. *Eclipta alba*, *Lippia nodiflora* however, relative frequency of *Croton spaciflorus*, *Asteranthus longifolia* and *Parthenium sp.* were observed maximum. A significant correlation was observed between different plant communities and the effluents properties of the polluted drains. *Croton spaciflorus*, *Asteranthus longifolia*, *Parthenium sp.*, *Cyanodon dactylon*, *Alternanthera sessilis*, *Echhornia crassipes* communities showed wide ecological amplitude and were found growing at diverse habitat conditions along the polluted disposal channels of the industrial sites.

Keywords: Ecology, Paper mill effluent, pollution, *Cynodon dactylon*, *Croton spaciflorus*, *Asteranthus longifolia*.

1. Introduction

Industrial pollution problems are the most dangerous threatening to human, animal as well as plants. With rapid industrialization the problem is being further accentuated. Almost all industries discharge their effluents into lakes, rivers and canals or drains without proper treatment or untreated. The volume of the industrial waste effluents is increasing several times as fast as that of sewage as the result of growing per capita output of goods and the increasing degree of processing per unit products. The polluted effluents of the industries are carried away through the drains or by surface flow. The vegetation close to these drains is adversely affected by the industrial effluents.

In the developing countries, the pollution of air, water and soil is based on the nature of raw materials and methods of processing used in the industry. The vegetation close to discharging drains is adversely affected by the industrial effluents. Many of the workers have described the damage to vegetation caused by the industrial waste effluents [1], [3], [4], [5], [8]. Water plants have been particularly affected [6], [7], [10], [11] had been researched.

2. Material and Methods

The samples were collected from two sites S-1 (effluent discharged site at industrial boundary) and S-2 (effluent discharged site at water reservoir, about 1km. away from site-1) of Orion Paper Industries Limited (formerly known as

Kanoi paper mill) situated at Village Dhenka of Bilaspur District, Chhattisgarh. Effluent sampled from the depth of about 50 cm. in plastics sample jars properly. Temperature and pH of the samples were recorded immediately and the samples then carried to the laboratory carefully. Standard methods^[2] were carried out for analyzing the chemical parameter like Turbidity, Conductivity, Total alkalinity, Total acidity, DO, BOD, COD, Chloride, Total hardness, Calcium, Magnesium, Nitrate Nitrogen, Nitrite nitrogen, Total Phosphate, Total dissolved solids and Total suspended solids.

The ecological studies were done at both of study sites, in order to study the floristic composition and phytosociological characters of un-cultivated plant community growing on the bank of drain carrying effluent and the adjoining fields by quadrat method. Relative density, frequency, dominance and IVI were determined using following formula -

Density and Frequency -

Density and Frequency were calculated according to formula as given below;

$$\text{Density} = \frac{\text{Total number of plants in the quadrat}}{\text{Number of quadrat examined}}$$

Values were expressed as number of plants / m²

$$\text{Frequency \%} = \frac{\text{Number of quadrat in which the species occurred}}{\text{Total number of quadrat examined}} \times 100$$

Dominant Flora:

Identification of dominant species was worked out by applying relative values of the frequency and density.

Relative Frequency:

To study the degree of dispersion of individual species in an area in relation to other species present in it, the Relative Frequency (R.F.) of different species was calculated using the following formula;

$$\text{Relative Frequency} = \frac{\text{Frequency of one species}}{\text{Frequency of all the species}} \times 100$$

Relative Density:

To know the numerical strength of a species in relation to the total number of individuals of all the species Relative Density was calculated as below;

$$\text{Relative Density} = \frac{\text{No. of individuals of the sp. of all the quadrates}}{\text{No. of individuals of all the sp. in all the quadrates}} \times 100$$

Table 1: Mean variation (Annual) of Different parameters of effluent at different study sites of Orion Paper mill

Parameters	Sites of collection	
	S-1	S-2
Temperature (°C)	29.08 ±5.47	25.42±5.38
pH	7.5±0.14	7.1±0.11
Turbidity (NTU)	18.61±1.85	11.99±2.48
Electric Conductivity (dSm ⁻¹)	0.83±0.11	0.62±0.06
Total Alkalinity (mg L ⁻¹)	208.1±64.18	161.1±64.13
Total Acidity (mg L ⁻¹)	31.9±8.20	40.6±9.36
DO (mg L ⁻¹)	1.07±0.53	1.26±0.55

Relative Dominance:

Relative dominance as basal coverage value of a species with respect to the sum of the basal coverage of rest of the species in an area was calculated as follows;

$$\text{Relative Dominance} = \frac{\text{The basal area of the sp. in all the quadrates}}{\text{Total basal area of all the sp. in all the quadrates}} \times 100$$

For determining an individual species, canopy of the species was clipped off and diameter of the stem emerging out of the ground was measured with the help of calipers.

Important Value Index-

In order to have an overall picture of an ecological importance of a species with respect to the community structure, the percentage of the relative frequency, relative density and dominance was added together and the sum value was called as Important Value Index (IVI).

$$\text{IVI} = \text{R. D.} + \text{R. F} + \text{R. Dominan}$$

3. Result and Discussion

BOD (mg L ⁻¹)	185.8±46.33	98.83±30.49
COD (mg L ⁻¹)	512.1±147.08	404.0±172.97
Chloride (mg L ⁻¹)	390.9±47.87	205.0±32.14
Total Hardness (mg L ⁻¹)	232.4±45.02	183.7±39.19
Calcium (mg L ⁻¹)	89.5±21.50	75.5±19.88
Magnesium (mg L ⁻¹)	34.7±6.46	26.3±4.76
Nitrate Nitrogen(mg L ⁻¹)	49.7±6.80	31.5±5.41
Nitrite Nitrogen(mg L ⁻¹)	39.2±5.96	20.6±5.15
Phosphate(mg L ⁻¹)	27.5±3.98	20.4±1.95
TDS (mg L ⁻¹)	1862.3±434.6 2	1150.3±159.1 2
TSS (mg L ⁻¹)	531.9±115.53	365.8±49.60

Table 2: Phytosociological attribute of plant species growing at different sites of Orion Paper mill in winter season

Sl. No.	Plant species	Study Sites							
		S-1				S-2			
		Relative frequency	Relative Density	Relative Dominance	Importance Value Index	Relative frequency	Relative Density	Relative Dominance	Importance Value Index
1	Achyranthus aspera	9.43	8.42	4.58	22.43	9.5	3.6	2.77	15.87
2	Alternanthera sessilis	7.55	12.63	4.99	25.17	8.1	13.1	5.65	26.85
3	Astercantha longifolia	5.66	8.42	7.56	21.64	10.8	9.0	8.75	28.55
4	Bidance pilosa	5.66	6.32	1.68	14.47	10.8	7.7	3.31	21.81
5	Calotropis procera	5.66	3.16	11.36	20.18	-	-	-	-
6	Cassia tora	11.32	9.47	15.12	35.91	8.1	4.5	7.78	20.38
7	Commelina benghalensis	-	-	-	-	5.4	12.6	12.26	30.26
8	Croton sparciflorus	13.20	10.53	4.16	27.89	5.4	4.1	3.12	12.62

9	Cyanodon dactylon	11.32	9.47	1.68	22.47	9.5	4.1	0.44	14.04
10	Cyperus rotundus	-	-	-	-	4.1	9.0	1.73	14.83
11	Echhornia crassipes	-	-	-	-	6.8	8.1	27.82	42.72
12	Eclipta alba	3.77	3.16	2.24	9.18	-	-	-	-
13	Euphorbia hirta	5.66	8.42	2.33	16.41	2.7	2.3	0.67	5.67
14	Lippia nodiflora	-	-	-	-	2.7	7.2	2.16	12.06
15	Marselia sp.	-	-	-	-	4.1	3.6	0.69	8.39
16	Parthenium sp.	11.32	12.63	27.46	51.41	8.1	7.6	15.53	31.23
17	Xanthium stramerium	9.43	7.37	16.01	32.81	4.1	3.6	7.31	15.01

(Data taken during the month of October-November)

Table 3: Phytosociological attribute of plant species growing at different sites of Orion Paper mill in summer season

Sl. No.	Plant species	Study Sites							
		S-1				S-2			
		Relative frequency	Relative Density	Relative Dominance	Importance Value Index	Relative frequency	Relative Density	Relative Dominance	Importance Value Index
1	Achyranthus aspera	11.48	10.20	6.64	28.32	10.77	6.57	6.88	24.22
2	Alternanthera sessilis	6.56	9.18	3.62	19.36	9.23	13.14	8.81	31.18
3	Astercantha longifolia	9.84	13.27	3.15	26.26	7.69	11.67	12.23	31.59
4	Bidance piloba	-	-	-	-	6.15	8.03	3.03	17.21
5	Calotropis procera	11.48	7.14	20.71	49.33	6.15	2.92	5.99	15.06
6	Cassia tora	8.20	6.12	8.32	22.64	6.15	5.11	9.04	20.30
7	Commelina benghalensis	-	-	-	-	7.69	10.95	9.28	27.92
8	Croton sparciflorus	13.11	13.27	6.82	33.20	10.77	6.57	6.88	24.22
9	Cyanodon dactylon	14.75	12.24	1.58	28.57	9.23	6.57	1.10	16.90
10	Cyperus rotundus	3.08	5.84	1.53	10.45	-	-	-	-
11	Eclipta alba	3.28	5.10	2.01	10.39	-	-	-	-
12	Lippia nodiflora	-	-	-	-	4.62	5.84	2.20	12.66
13	Parthenium sp.	9.84	14.29	25.83	49.96	12.31	13.14	23.25	48.70
14	Xanthium stramerium	11.48	9.18	21.32	41.98	6.15	3.65	10.21	20.01

(Data taken during the month of April - May)

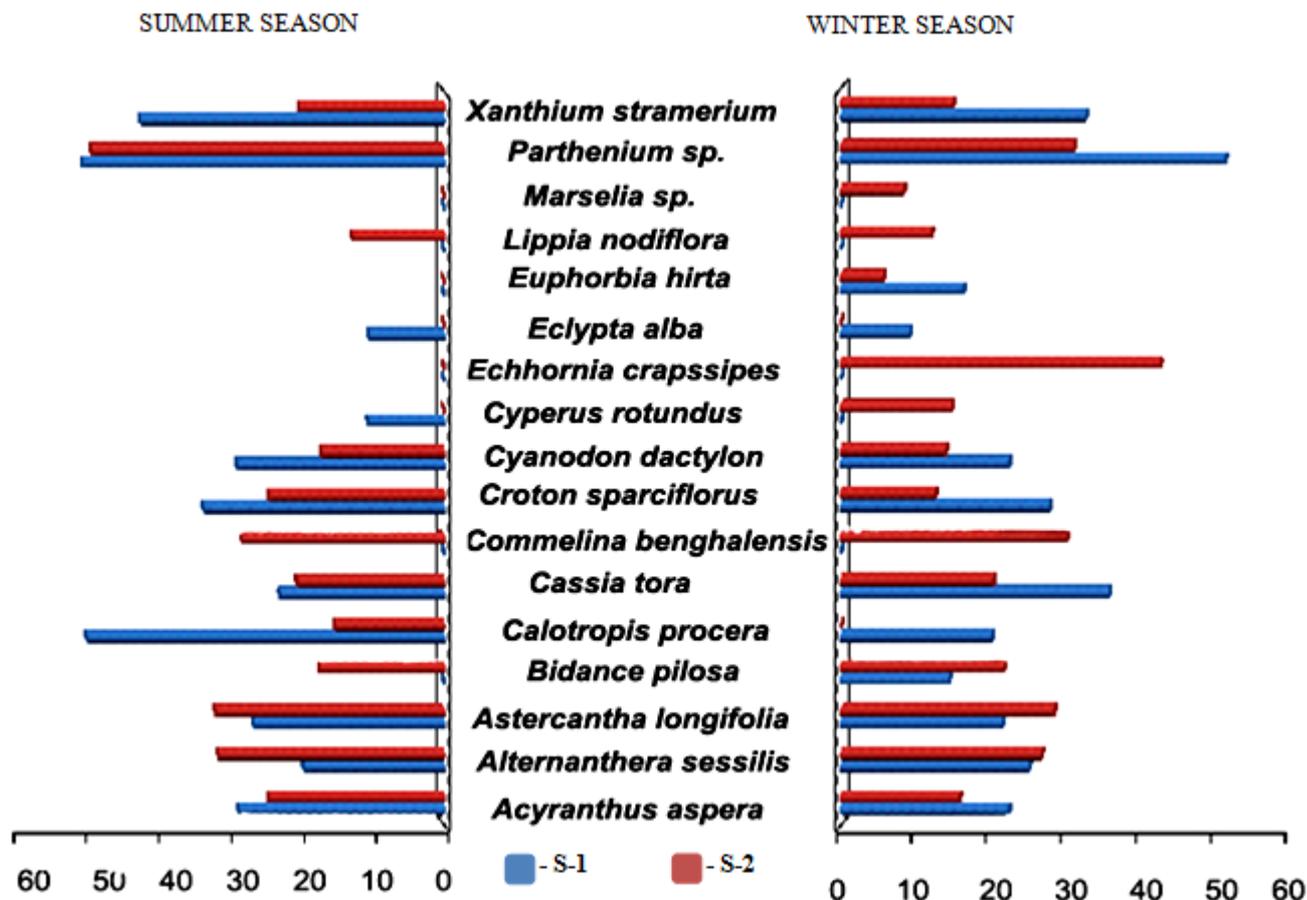


Plate I: Showing the IVI of different species during summer and winter season at the study site S-1 & S-2 of Orion Paper mill.

The quality and the concentrations of potentially toxic elements in effluent are summarized in Table -1. Effluents from both sites were slightly alkaline. In S-1 Dissolved Oxygen is less (1.07 mg/L) because there are more organic wastes in it & to remove these waste microbes requires more oxygen so BOD level is higher and in effluents of S-2 the value of Dissolved Oxygen is higher and BOD is lower in comparison to S-1. Total alkalinity of effluent of S-1 is higher (208.1 mg/L) than S-2(161.1mg/L). Chloride content was lower in S-2 (205.0 mg/L) than S-1(390.9mg/L). where hardness of S-1 was higher than S-2. Almost all parameter's values were haigher in effluent collected from S-1 in comparison to S-2.

Floristic composition (herbaceous) of two sampling sites (site- S-1 and site - S-2) for Orion paper mill was studied in during winter & summer season and observed data of Relative frequency, Relative density, Relative dominance and IVI of species have been represented in Table – 2 & 3. The entire observation has been presented by bar diagram in Plate –I. Significant variations in the floristic composition at different sites in two seasons are elucidated.

As per the observed floristic data present in the table –2 & 3 of winter & summer season from the study sites of Orion paper mill respectively. In winter season – Croton sparciflorus and Asteranthus longifolia have maximum Relative frequency at site S-1 and site S-2 respectively; whereas the higher value of Relative density is of Alternanthera sessilis at both sites, Parthenium sp. and Echhornia crapssipes have maximum Importance Value Index at site- S-1 and site S-2

respectively. In this season, the Relative dominance shown by Parthenium sp. at site S-1 and Echhornia crapssipes at site S-2, however, lowest Relative frequency and IVI represented by Eclipta alba and Relative density & Relative dominance represented by Calotropis procera & Bidance pilosa respectively at site S-1, whereas at site S-2 Relative frequency, Relative density and IVI shown by Euphorbia hirta, Relative dominance by Cyanodon dactylon .

In summer season – Cyanodon dactylon and Parthenium sp. have maximum Relative frequency at site S-1 and site S-2 respectively, whereas the higher value of Relative density, Relative dominance and IVI is of Parthenium sp. at both site, however, lowest Relative frequency Cyperus rotundus and Lippea nodiflora at site S-1 and site S-2 respectively, Relative density Eclipta alba and Calotropis procera at site S-1 and site S-2, Relative dominance represented by Cyperus rotundus & Cyanodon dactylon respectively at site S-1 and site S-2and IVI shown by Eclipta alba and Lippea nodiflora at site S-1 and site S-2.

Findings of present study reveal the existence of different community of plants along the drain carrying paper mill effluent. Such variation in community of plants may be attributed to variation in the habitats, each consist of a different environmental condition within the smaller area of investigation. High IVI indicates tolerance of species to the environment in which IVI has been measured. The variation in IVI between the sites indicates variation in the nature of specific dominant species.

Throughout experimental sites under the stress of effluents exhibited a narrow spectrum of flora with a distinct tendency for single species dominance, it elucidates natural selection under those species which have more efficient means to recover and propagate after stress. S-1 and S-2 sites showed variation in the dominant flora, such as *Parthenium* sp., *Echhornia* *crassipes*, and *Asteranthus longifolia* in all the two seasons. Variations in these species may be due to poor establishment and lack of competitive powers. Floral composition at site S-1 and S-2 showed more mosaicism in plant species as compared to plants growing on in all the three seasons. This is evident from the number of total species presence at each site. This mosaicism of plant communities within a climatic region is determined by the combination of a number of factors such as microclimatic and biotic conditions which produce the most common and vegetation pattern.

From the result of present research work, as discussed above, it become clear that variations in the floristic composition of the sites (S-1 and S-2) is associated with variations in Physico-chemical characteristics of the effluent that is controlled by effluent and change in seasons. In light of present investigation it can be said that paper effluents may be utilized for agriculture practices by means of planned management towards proper treatment before releasing and dilution after discharge from the industries.

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