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Analysis of effluents released from the paper industry: Approach of its impact on agricultural soil

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Abstract
In the present study effluents and soil samples from the nearby paper industry collected in Bhimavaram Mandal of Andhra Pradesh and analyzed for various physio-chemical parameters like pH, TDS, TSS, TRC, TVS, TS, BOD, COD, DO. The inferences were drawn on the basis of analysis. In general, a considerable decrease in the concentration of total suspended and dissolved solids, chloride, calcium, sodium, manganese and cobalt occurred during the flow of effluents downstream. The lateral seepage of paper industrial effluent to agricultural lands increased the soil pH and electrical conductivity (EC). At shorter distances from point source, the lateral seepage of effluent increased exchangeable Na and extractable Cr, Zn, Mn, Pb and Ni in soil.

Keywords: Analysis, effluents, COD, TOC, dissolved solids

1. Introduction
Paper and pulp production industries are one of the most disreputable polluters of the nature. They are listed as one of the most polluting industries due to discharge of huge volumes of highly toxic effluents into the environment causing pollution of soil, air and water [1]. The most important problem which the paper industry is facing today is the disposal of remarkable volumes of waste water. This waste water is rich in dissolved solids such as chlorides and sulphates of Na, Ca, suspended organic materials and trace metals like Hg, Pb, and Cr etc. The paper industry effluent characteristically contains colour, very high level of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), due to presence of lignin and its derivatives from the raw cellulosic materials, chlorinated compounds, suspended solids, fatty acids, tannins, resin acids, sulphur and sulphur compounds, etc [2]. The dark colour of the effluent exhibits the toxic effects on the biotic and inhibits the photosynthetic activity by reducing the sunlight [3]. Most of these industries discharged their insufficiently treated waste into the rivers or streams, which makes serious problem to aquatic life and flora-fauna. Subsequently, these toxic elements may cause severe problems to human beings and animals by entering into the food chains [4]. Untreated industrial effluents contain higher amounts of Cd, Pb, Zn, Cu, Mn and Fe and enhance the concentration of the heavy metals in irrigated surface soils [5]. The present investigation was undertaken with the objective of examining the characteristics of effluents from paper industry and to study the impact on soil properties of agricultural fields.

2. Materials and Methods
Collection of samples: The paper mill effluent samples were collected from three locations downstream the main drain of paper industry located in Bhimavaram Mandal. The samples were collected at a distance of about 0.5 km (S1), 4.0 km (S2) and 8 km (S3) from the discharge point. For assessment reason, one sample (S4) was collected from tube well irrigation water nearby unpolluted site. The samples were collected in the plastic containers which were refrigerated at 4°C prior to further treatment. The samples were analyzed using standard methods of analysis of water and waste water [6]. In order to study the effect of lateral seepage of effluent on soil properties, at each sampling site of Paper mill surface three soil samples were collected away from the effluent drain and away from the drain (0.5, 4 and

8 km) respectively. Soil samples were air-dried in shade and crushed using a local motor and sieved. Processed soil samples were stored in plastic containers and analyzed.

Analysis: Effluent samples collected from different locations were analyzed as per the standard procedures [7]. Soil samples were analyzed by AAS by the method of Tandon (1993) [8] with minor modifications.

3. Results and Discussion

The properties of paper industry effluents and tube well water are presented in Table 1.

Table 1: Analysis of physical parameters of effluents at different sampling sites downstream the main drain.

Parameters	Effluent sample from discharge point				Tolerance limits for irrigation
Location	S1	S2	S3	Tube-well water (S4)	
pH	7.42	7.5	7.68	7.49	5.5-9.0[a]
EC (dg/m)	1.45	1.82	1.51	0.41	2.0-10.0[b]
BOD (mg/L)	312	4.19	308	62	100[a]
COD (mg/L)	4957	4050	3152	230	250[a]
TSS (mg/L)	462	266	200	Traces	200[a]
TDS (mg/L)	1280	1100	1020	150	1000[a]
TS (mg/L)	1988	1450	1327	162	--------

CPCB (1975)[a] [9], Paliwal& Yadav (1976)[b] [10].

Table 2: Chemical analysis of some cations and anions in effluents of paper industries at different locations.

Content (mg/L)	Effluent sample from discharge point				Tolerance limits for irrigation
Samples	S1	S2	S3	Tube-well water (S4)	
Chloride	357.6	278	190.5	6.8	600[a]
Nitrate-N	2.58	5.96	5.90	3.48	-----
Calcium	2548	2380	2182	1233	------
Sodium	953	809	852	15	60[a]
Manganese	0.27	0.21	0.13	0.002	0.2-10.0[a]
Cadmium	0.005	ND	ND	ND	0.01-0.05[C]
Zinc	0.06	0.006	0.01	0.02	2.0-10.0[C]
Lead	0.091	0.068	0.059	ND	5.0-10.0[C]
Chromium	0.008	0.002	ND	ND	0.1-1.0[C]
Nickel	0.020	0.008	0.015	0.003	0.2-2.0[C]

CPCB (1975)[a], Paliwal& Yadav (1976)[b], Ayers &Westcot (1976)[C] [11].

Table3: Analysis of soil samples collected at different sites from the main effluent drain.

Character	Location of soil samples		
	0.5 km	4 km	8 km
pH (1:2)	8.75	7.42	7.10
EC (1:2)	0.32	0.3	0.36
Organic C (g/kg)	18.0	15.6	17.7
Manganese (mg/kg)	8.1	8.6	11.9
Cadmium(mg/kg)	0.01	ND	0.01
Zinc(mg/kg)	1.9	1.5	2.1
Lead(mg/kg)	2.1	1.7	2.5
Chromium(mg/kg)	ND	ND	0.1
Nickel(mg/kg)	0.11	0.09	0.14

The pH of the effluent samples from Paper Mill varied from 7.42 - 7.68. The increase in pH value of the effluent with distance might be due to dilution with municipal waste water. Considering the Indian Standards limit on pH of effluents (5.5 to 9.0) for their irrigation use (CPCB, 1975)[9], the pH values of all effluent samples fell well within the permissible limit. Similar pH values of the effluents discharged from paper and pulp industry were reported earlier by Jitendra *et al*., 2014 [4]. The electrical conductivity of paper mill effluent varied from 0.41 to 1.82 dS m^{-1} at 25°C. The highest value of EC observed near the source was because of high amounts of dissolved salts which decreased progressively with distance due to dilution as well as adsorption of metal ions.The BOD value of effluent are in the range of 308 to 419 mg/L whereas, COD varied in the range of 3152- 4957 mg/L. The observed values of BOD and COD in the effluents were higher than the recommended value of 100 mg BOD L^{-1} and 250 mg COD L^{-1} as prescribed by CPCB (1975). High COD value might be due to the presence of oxidisable organic compounds in the effluent [12]. The high COD value decreases the fertility of the soil and causes soil pollution and also has detrimental effect in the environment after long period [13]. The values of total solids (TS), total dissolved solids (TDS) and total suspended solids (TSS) in effluents were higher in contrast to the tube well water and generally decreased with the increasing distance from the outlet. Considering 200 mg total suspended solids L^{-1} and 1000 mg total dissolved solids L^{-1} as the threshold values for irrigation use (CPCB, 1975), the effluent water from both paper and pulp industries was not suitable for irrigation, except for the location15 km away from the site of origin.

The concentrations of soluble cations and anions in effluent and tubewell water are given in Table 2. Among anions, the amount of chloride ions in the effluents regularly decreased with the distance but chloride ion was higher even at the beyond location maybe due to supplementary of municipal waste water. No regular pattern of increase or decrease with the distance was noted in the case of nitrates. Among cations, the concentrations of ammonium, Ca, Na, Mn and Co decreased with the increase in distance for effluent, perhaps due to their dilution or precipitation. Rest of the cations (Mg, Zn, Cd, Pb, Ni and Cr) did not show any regular pattern of increase or decrease in their concentrations. The concentration of Na cation in effluents at all sites was much higher than the permissible limit (60 mg L^{-1}) while the concentrations of other observed cations or anions were present in concentrations lower than their permissible limit for use in irrigation.

Some properties of soil samples collected at from different distance from the main drain are shown in Table 3. It is

evident from the analysis that the soil sample nearby to the main drain had higher value of pH and EC than the soil sample collected from 8 km away from the effluent drain. However, pH of the soil near the drain was lesser than pH of the soil lying away from the drain. The soil sample collected away from 0.5 km from discharge point, from the main drain had the higher contents of extractable Zn, Mn, Pb and Ni as compared to the soil. The differences in the content of rest soil extractable nutrients/pollutants were not much. Earlier reports [14, 4] also confirmed a significant increase in soil EC, exchangeable cations and micronutrient cations in the soil irrigated by the effluent of paper industries.

4. Conclusion

The paper industries are growing at faster rate and generating various varieties of paper**.** But at the same time recycling paper mill also add pollution because of release of high quantity of waste water effluents during its production. On the basis of above discussion it is concluded that TSS, BOD and COD in effluents released by the paper factories were above the permissible limits and the lateral seepage of effluent increased exchangeable Na and extractable Zn, Mn, Pb and Ni in surface (0-15 cm) soil and the contents of micronutrients especially, at shorter distances from the point source. Hence proper strategies should be used to treat the effluents prior to its disposal to the environment.

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