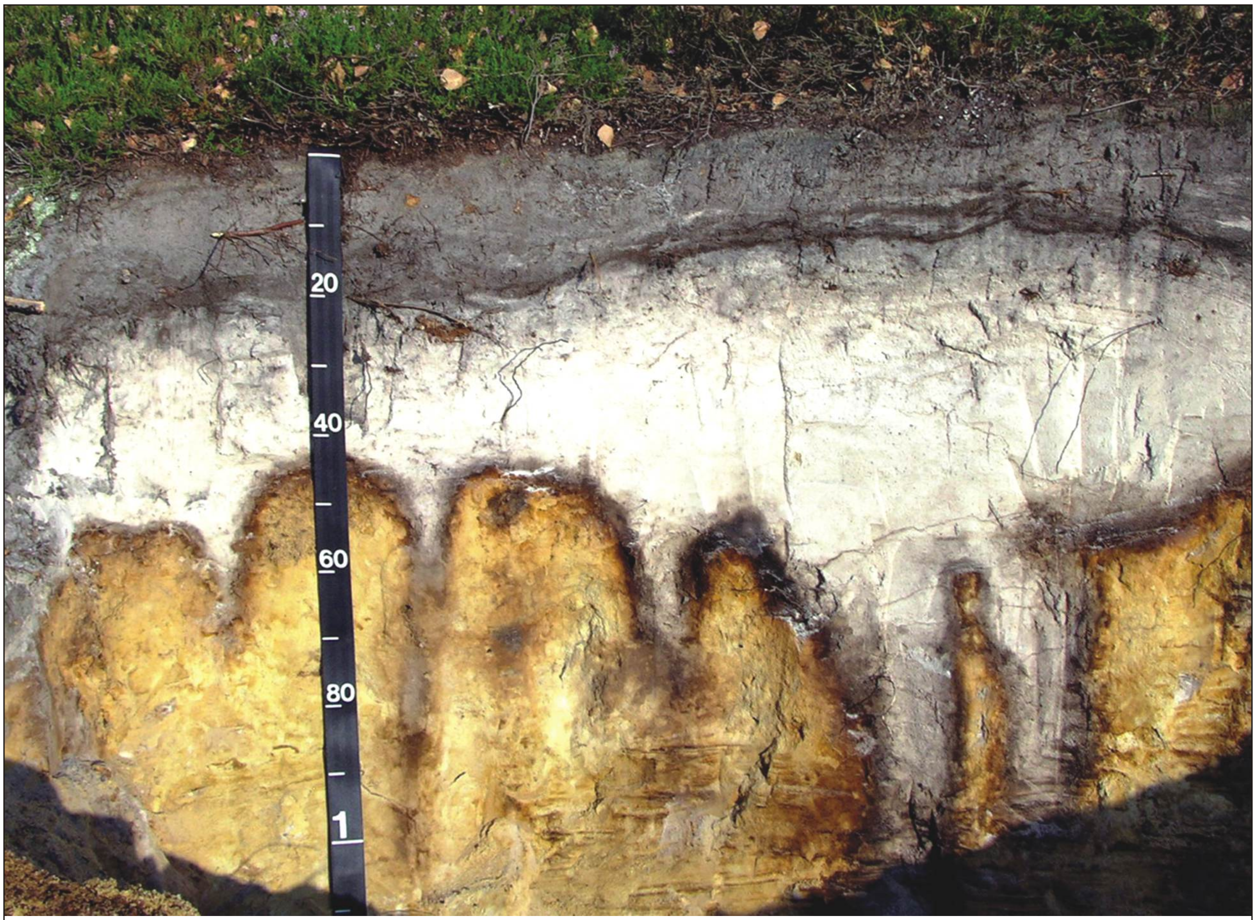

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Effect of Irrigation with Paper Mill Effluent on the Nutrient Status of Soil

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Abstract: The study was undertaken to investigate the impact of paper mill effluent irrigation on soil nutrient status. The soil was collected at five locations. At each location two near by fields were selected of which one was irrigated with paper mill effluent while other received normal irrigation water. The samples were collected for two depth 0-15 cm and 15-30 cm and were designated as d_1 and d_2, respectively. The study revealed a significant increase in EC (electrical conductivity), organic carbon, available K, exchangeable cation (Ca^{2+} and Mg^{2+}), exchangeable anion (Cl^- and HCO_3^-) along with micronutrient cation (Cu^{2+}) for both d_1 and d_2 depths under paper mill effluent water irrigation. Although increase in value for available N, P and S were recorded for both d_1 and d_2 depths but they were found to be statistically at par with that of control.

Key words: Paper mill, effluents, soil nutrient status, available nutrients

INTRODUCTION

Pulp and paper industry is one of the notorious polluters of the environment. It has been categorized as one of the 17 most polluting industries in the country due to discharge of huge volumes of highly colored and toxic waste water in the environment (Martin, 1998). It ranks 3rd in the world in terms of fresh water withdrawal after primary metal and chemical industries in the world. It is estimated that about 273-455 m^3 of water is required per tonne of paper produced (Subrahmanyam, 1975), that consequently generates 300 m^3 of waste water (Subrahmaryam and Hanumanulu, 1976). Practically major portion of effluents emanating from various pulp and paper industries in India is being discharged into various rivers, thus polluting them. The land application of waste water is a preferred alternative for its disposal since, soil is believed to have a capacity for receiving and decomposing waste and pollutants (Young *et al*., 1981) where organic materials are stabilized through the activity of micro flora in the soil. Although a number of research papers are available on the impact of paper mill effluent on soil nutrient status but the picture is not clear. Some researchers (Achari *et al*., 1999; Chhonkar *et al*., 2000; Dhevagi *et al*., 2000) have reported an increase in the nutrient content of soil particularly N, P and K due to paper mill effluent irrigation, while Saha *et al*. (1995) and Sharma *et al*. (2000) have reported a decrease in soil available nitrogen. Similar is the case with soil pH and other micronutrients. It seems that nutrient status of the soil is affected by the characteristics of the emanating effluent, soil characteristics and the prevailing climatic conditions. The characteristics of the emanating paper mill effluent depends upon the nature of raw material, type of manufacturing process adopted and the extent of reuse of water employed in the plant (Chong, 1999; Saxena *et al*., 2000).

Hence, a study was conducted to access the impact of paper mill effluent irrigation on the nutrient status of the soil as to determine whether the plant available nutrients increased or decreased due to effluent irrigation.

MATERIALS AND METHODS

The paper mill whose effluent was used in the present study is located in Lalkuan, district Nainital, India, at distance of about 8 km from Govind Ballav Pant University of Agriculture and Technology. Geographically Pantnagar is located at 29° 5′ N latitude and 79° 3′E longitude at an altitude of 243.84 m above mean sea level. Physically it is located in the foothills of Himalayan range (Shivalik Hills) and fall under humid sub tropical climatic zone in a narrow belt called tarai. The soil samples were collected in the month of April from five locations, located nearby university campus along the paper mill effluent drain. At each location two fields were selected of which one was receiving paper mill effluent irrigation and the other was irrigated with normal water. The samples were collected from two depths (0-15 cm) and (15-30 cm), (designated as d_1 and d_2, respectively). The samples were collected with the help of bucket auger. The collected soil samples were air dried, ground and passed through a 2 mm sieve. The soil was analyzed for pH, EC, organic carbon, available nitrogen, available phosphorus, available potassium, available sulphur, exchangeable cations (Ca^{2+} and Mg^{2+}), exchangeable anions (Cl^- and HCO_3^-) and available micronutrients (Fe, Cu, Mn, Zn) following Page *et al*. (1982). In order to draw statistical inference, soil samples at five locations were taken as one unit and analysis was done by t-test to examine the changes in the chemical properties of soil along with nutrient status under the influence of paper mill effluent irrigation.

RESULTS AND DISCUSSION

Table 1 show the characteristics of paper mill effluent which was applied on soil for irrigation. The pH and EC value have been shown in Table 2. The soil at depth d_1 under effluent irrigation recorded a pH value of 7.49 whereas for unirrigated condition it was 7.60. The pH value of soil at (d_1) depth was lower in effluent irrigated soil because of the fact that effluent had a lower pH of about 7.37. However, statistically the pH value for both irrigated and unirrigated conditions were at par for both the depth. This is in tune with the findings of Chhonkar *et al*. (2000). The electrical conductivity (Table 2) of the soil (1:2 soil: water suspension) was found to be statistically superior under paper

Table 1: Characteristics of paper mill effluent used for irrigation

Characters	Values
pH	7.37
EC (ds/m)	1.89
Organic carbon (%)	1.68
Total solids (mg L^{-1})	1960.00
Total dissolved solids (mg L^{-1})	1400.00
Total suspended solids (mg L^{-1})	560.00
Calcium (mg L^{-1})	275.20
Magnesium (mg L^{-1})	40.10
Sodium (mg L^{-1})	94.40
Potassium (mg L^{-1})	158.10
Carbonate (mg L^{-1})	30.50
Bicarbonate (mg L^{-1})	389.00
Sulphate (mg L^{-1})	198.00
Chloride (mg L^{-1})	147.00
Nitrogen (mg L^{-1})	34.00
Phosohorus (mg L^{-1})	4.70
Iron (mg L^{-1})	8.30
Copper (mg L^{-1})	0.076
Manganese (mg L^{-1})	0.036
Zinc (mg L^{-1})	0.616
BOD (mg L^{-1})	950.00
COD (mg L^{-1})	2900.00

Table 2: Effect of paper mill effluent irrigation on pH and EC of soil

	pH		EC (dS/m)	
Treatment	d_1	d_2	d_1	d_2
Irrigated	7.49	7.79	0.49	0.37
Unirrigated	7.60	7.68	0.28	0.22
t-value	0.37 ns	0.46 ns	2.69*	3.22*

*- Significant at 5% probability level; ns: not significant

Table 3: Effect of paper mill effluent irrigation on soil available nutrient status

	%OC		Available N (kg ha^{-1})		Available p (kg ha^{-1})		Available K (kg ha^{-1})		Available S (kg ha^{-1})	
Treatment	d_1	d_2	d_1	d_2	d_1	d_2	d_1	d_2	d_1	d_2
Irrigated	1.32	1.04	206.22	157.65	18.87	15.03	171.93	135.90	69.91	47.09
Unirrigated	0.74	0.58	165.72	144.12	14.05	8.92	116.59	99.72	37.31	31.73
t-value	0.54*	4.28*	2.05ns	0.76ns	1.01ns	1.48ns	3.45*	2.48*	1.39ns	1.29ns

* Significant at 5% probability level; ns: not significant

Table 4: Effect of paper mill effluent irrigation on water soluble cations and anions

	Ca (meq/100 g)		Mg (meq/100 g)		Cl^- (meq/100 g)		HCO_3^- (meq/100 g)	
Treatment	d_1	d_2	d_1	d_2	d_1	d_2	d_1	d_2
Irrigated	13.57	13.69	4.41	4.18	0.36	0.34	0.54	0.46
Unirrigated	8.21	7.68	2.11	2.47	0.22	0.18	0.28	0.30
t-value	2.60*	2.71*	2.79*	2.75*	4.08*	4.81*	4.11*	3.99*

* Significant at 5% probability level; ns: not significant

Table 5: Effect of paper mill effluent irrigation on soil micronutrients

	Fe (mg kg^{-1})		Cu (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})	
Treatment	d_1	d_2	d_1	d_2	d_1	d_2	d_1	d_2
Irrigated	36.66	26.51	3.65	3.91	20.77	21.53	1.88	1.21
Unirrigated	28.33	29.67	2.50	2.78	20.79	18.85	1.79	0.94
t-value	1.27ns	0.42ns	2.86*	2.74*	0.004ns	0.43ns	0.13ns	1.91ns

* Significant at 5% probability level; ns: not significant

mill effluent irrigated condition for both the depths. The EC value of soil at (d_1) depth was 44.1% higher in effluent irrigated soil where as the same for soil at (d_2) depth was 41.1%. High values of EC indicate enrichment of soil with the soluble cations and anions such as Na, K, Mg, Cl^- and SO_4^{2-} through continuous use of effluent. Similar results were also reported by Prashanti *et al.* (1999).

The organic carbon and available potassium content (Table 3) was statistically superior for the effluent irrigated condition as compared to that of controlled condition. The organic carbon content of soil for d_1 depth was 43.4% higher whereas that for d_2 depth was it 43.8% higher under effluent irrigated condition. The increase in organic carbon content of the effluent irrigated soils may be ascribed to the continued addition of organic matter through effluent. An increase of 32.8 and 26.6% in available K content were recorded for both d_1 and d_2 soil depths under effluent irrigation. The increase might be due to the addition of nutrients through effluent which contained an average of 158.1 mg L^{-1} of K^+ ion. Similar results have been reported by Achari *et al.* (1999). Although the available content of nitrogen, phosphorus and sulpur were higher for both d_1 and d_2 soil depths under effluent irrigation but they were found to be statistically at par. The exchangeable cations (Ca^{2+} and Mg^{2+}) as well as anions (Cl^- and HCO_3^-) were found to be significantly higher for both d_1 and d_2 soil depth under effluent irrigated conditions (Table 4). This was because of the richness of effluent water with cation and anions as evident by the higher values of electrical conductivities of effluent water.

Among micronutrients (Fe, Cu, Mn and Zn), Cu ion concentration was found to be significantly higher for effluent irrigated soils than that of control (Table 5). The Cu ion concentration was found to be 31.5 and 28.8% higher for d_1 and d_2 soil depths, respectively under effluent irrigated condition. This may be due to presence of high amount of organic matter. A significant and positive correlation between organic matter and exchangeable copper exists. The Cu ion concentration was found to be significantly higher for d_2 because of the formation of organic Cu complexes with fulvic acid and their downward mobility.

CONCLUSIONS

Use of paper mill effluent water for irrigation had a substantial effect on soil properties. The EC, organic carbon, available K, exchangeable cation (Cu^{2+} and Mg^{2+}), exchangeable anions (Cl^- and HCO_3^-) and Cu ion concentration were found to be significantly higher as compared to control. The high increase in salt concentration was of particular concern as it may lead to salinity hazard in long term use.

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