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Effect of paper mill effluent on soil, growth and biochemical constituents of *Vigna radiata* (L.) Wilczek

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Studies on the effect of different concentrations of treated paper mill effluent on soil and growth, biochemical constituents and nodulation of green gram were carried out under potted condition. The growth parameters such as shoot, root lengths and biomass were increased upto 50% concentration of the effluent, thereafter all these attributes decreased sharply. Biochemical constituents such as chlorophyll and protein exhibited a slight increase in 25 and 50% concentration. The bacterial, fungal and nodules had also increased upto 50% concentration and decreased slowly. All the above said parameters were decreased at higher concentrations (75% and 100%). The physico chemical constituents of treated paper mill effluent showed higher BOD and COD values, dissolved oxygen was nil, NPK was low while the contents of sodium, calcium, sulphate and chloride were higher.

Key words : Green gram, Paper mill effluent, Phytotoxicity.

INTRODUCTION

Water is the most precious thing in the world. Nowadays, most of our water resources are gradually becoming polluted by addition of huge amounts of sewage, industrial and agricultural effluents. These effluents contain materials with varying properties from simple nutrients to highly toxic substances. The discharge of industrial effluents with varying amounts of pollutants has altered the water quality. Among the different major industries, the paper industry is a notorious polluter of the environment.

There are nearly 305 paper mills in India with an installed capacity of 3014 lakh tones. During paper production, the mills release a large amount of waste water containing various physical and chemical agents. They are discharged into land or nearby water bodies. The polluted water is being used for irrigation by near by farmers. It is necessary to study the impact of this effluents on crop system before they are recommended for agricultural irrigation. Several studies have been done on the impact of various industrial effluents on various crops (Lakshmi and Sundaramoorthy, 2001; Kaushik *et al.*, 2004). In the present investigation, attempt has been made to evaluate both the beneficial and adverse effects of using the paper mill effluent as irrigation water on the growth of legume *Vigna radiata* (L.) Wilczek.

MATERIALS AND METHODS

The treated effluent discharged from Seshasayee paper and boards Limited, Pallipalayam, Namakkal District, Tamil Nadu was used as irrigation water in the present study. The colour of the effluent sample was recorded by visual observation. The odour of the effluent sample was categorized by directly smelling the sample. The solid present in the effluent sample was determined by Therox *et al.*, 1943 method.

pH of effluent samples was directly determined using a standard Elico pH meter. The soil pH was determined in 1:5, [Soil : Water suspension]. Electrical conductivity was determined in a conductivity bridge and expressed as dsm^{-1}. For soil, it was determined from saturated paste extract. The dissolved oxygen (DO) in the samples were estimated by following idometric method described in standard methods for the examination of water and waste water (Anonymous, 1981). Dilution method was employed for Biological oxygen demand (BOD) determination (Anonymous, 1972). The chemical oxygen demand (COD) was estimated by Sundaresan, 1979.

Calcium and magnesium content in the sample were estimated following the titrimetric method of Strickland and Parsons (1972). Sodium and potassium were estimated by using flame photometer. Chloride in the samples was estimated following the titrimetric method described (Sundaresan, 1979). Total phosphorus was estimated (Pemberton, 1945) and estimation of total nitrogen (Jackson, 1973). Nitrate nitrogen was estimated following Phenol Di Sulphonic acid method described in standard methods for the examination of water and waste water (Anonymous, 1981). Sulphate was estimated by (Anonymous, 1981).

The healthy and uniform seeds of *Vigna radiata*

(L.) Wilczek obtained from Department of Pulses, Tamil Nadu Agricultural University, Coimbatore were surface sterilized with 0.1% $HgCl_2$ and washed thoroughly. Earthen pots (30 cm x 20 cm) filled with field soil (Ca 6 kg) were drenched with different concentrations, (25,50,75 and 100%) of the effluent and left as such for one week. These dilutions of effluent were made in distilled water. A control set of distilled water was also kept for comparison. Five replicates were taken for each set. The pots were sown with surface sterilized, healthy seeds of *Vigna radiata* KM_2 variety at the rate of 10 seeds per pot and watered with the respective effluent concentration. The plants were uprooted on 20th day after sowing. The measurement for length (shoot and root) and biomass were made. The number of root nodules in the root system was counted and expressed as individuals plant $^{-1}$. Chlorophyll was estimated as per Yoshida *et al.* (1976). Protein estimation was done following Lowry *et al.* (1951) method. Dilution plate method was employed for the enumeration of microbial population in the soil samples.

RESULTS AND DISCUSSION

Physico – chemical properties of paper mill effluent are given in Table 1. The analyse of paper mill effluent showed it to be alkaline in nature with dark brown in colour. It contained high amounts of suspended and dissolved solids. It showed a high value of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The presence of Calcium, Sulphate, Sodium and Chloride were higher. This is in conformity with the earlier findings of Lakshmi and Sundaramoorthy (2001); Rathore *et al.* (2000); Kalaichelvi (2001); Borole and Patil (2004). The pollution load of the effluent depends upon the nature of raw materials, chemicals used, the processes involved, and also the methods of treatments given to the effluent in the factory.

Table 2 revealed the physico chemical and biological characteristics of soil samples. All the studied parameters *viz.*, pH, EC, nitrates, phosphorus and potassium of the treated soils registered increases over their controls irrigated with plain water and the increases were linearly related to the concentrations of the effluent. Similar observations has been made by a number of investigators (Mishra *et al*., 1992; Kannapiran, 1995; Sundaramoorthy *et al*., 2007). The bacterial and fungal populations were significantly higher in 50% effluent treated soil and higher concentrations registered pronounced decreases.

The data presented in Table 3 revealed the effect of different concentrations (25, 50, 75 and 100%) of paper mill effluent on growth, biochemical constituents and nodulation of green gram. The shoot length, root length and biomass were in the range of 9.48 to 13.48 cm, 3.80 to 4.72 cm and 0.126 to 0.229 g, respectively. All the growth parameters were higher in 50% effluent irrigated

Table 1: Physico-chemical characteristics of the treated paper mill effluent

Sr. No.	Parameters	*Observations	** ISI tolerance limit
1.	Colour	Dark brown	-
2.	Odour	Phenolic (objectionable)	-
3.	pH	7.9 ± 0.06	5.5 – 9.0
4.	Electrical Conductivity (dSm^{-1})	1.7 ± 0.03	-
5.	Suspended solids	1001 ± 0.57	-
6.	Dissolved solids	1210 ± 5.70	2-100 maximum
7.	Dissolved oxygen	0.0 ± 0.0	-
8.	Biochemical Oxygen Demand (BOD) (5 days at 20°C)	160.0 ± 0.33	500 maximum
9.	Chemical Oxygen Demand (COD)	386.2 ± 0.66	-
10.	Nitrogen	15.2 ± 0.88	-
11.	Phosphorus	1.3 ± 0.05	-
12.	Potassium	9.5 ± 0.05	-
13.	Calcium	140.0 ± 0.57	-
14.	Magnesium	68.0 ± 0.57	-
15.	Sodium	792.0 ± 1.33	-
16.	Sulphate	510.0 ± 0.33	1000 maximum
17.	Chloride	139.3 ± 0.10	600 maximum

* All values except colour, odour, pH and electrical conductivity are expressed in mg/l. Each value is mean ± SE at three individual observations.

** Tolerance limits for individual effluents discharged on land for irrigational purpose IS : 3307 : 1965.

Table 2 : Effect of various concentrations of treated paper mill effluent on the Physico–chemical characteristics and biological characteristics * of the soil samples

Effluent concentration (%)	Parameters					Bacterial population (x 10^6 cfu g^{-1})*		Fungal population (x 10^3 ppg g^{-1}) *	
	pH	Electrical conductivity (dsm^{-1})	Nitrates (mg/kg)	Total phosphorus (mg/kg)	Total potassium (mg/kg)	Plant Age (Days)			
						0	20	0	20
Control	8.00 c	0.14 f	18.0 f	0.077 d	0.14 d	12.20 c	13.20 d	2.80 d	3.0 defg
25	8.22 b	0.23 e	24.3 d	0.079 cd	0.21 b	16.40 b	22.20 c	4.40 c	4.80 bcd
50	8.24 b	0.25 d	26.0 c	0.078 cd	0.21 b	20.20 a	26.40 abc	5.00 bc	5.60 abc
75	8.28 b	0.33 b	33.6 b	0.089 b	0.22 b	16.20 b	22.80 c	2.00 def	2.40 fg
100	8.42 a	0.36 a	44.8 a	0.102 a	0.23 a	11.20 c	12.60 d	1.20 f	1.60 g

* Based on five determinations for each treatment.
values with same alphabets in each sampling day in the columns do not differ significantly from each other ($p < 0.05$).

Table 3: Effect of various concentrations of treated paper mill effluent on the growth, biochemical constituents and nodulation of green gram

Effluent concentration (%)	Shoot length (cm)*	Root length (cm) *	Biomass (g $plant^{-1}$) *	Chlorophyll (µg g^{-1} fresh leaf weight) *	Protein (mg g^{-1} leaf dry weight) *	Nodules ($Plant^{-1}$)*
Control	11.38 c	4.10 fghi	0.150 fgh	2.35 d	57.8 cde	8.80 bcde
25	11.82 c	4.44 cde	0.187 de	2.50 c	55.4 f	9.00 bcde
50	13.48 ab	4.72 bc	0.229 bc	2.58 ab	58.4 c	11.40 ab
75	11.44 c	4.22 efgh	0.143 ghi	2.19 e	47.6 h	7.20 cdef
100	9.48 d	3.80 i	0.126 hi	1.88 f	34.8 i	5.00 f

* Based on five determinations for each treatment.
values with same alphabets in each sampling day in the columns do not differ significantly from each other ($p < 0.05$).

soil. The results are in conformity with the findings of Lakshmi and Sundaramoorthy (2001); Kumawat *et al.* (2001); Mariappan and Rajan (2002).

In the present investigation, 25% and 50% effluent concentrations significantly enhanced the chlorophyll and protein content in the leaves of *Vigna radiata*. All the above said parameters were decreased at higher concentrations (75% and 100%). The decreases in the total chlorophyll and protein contents indicating various host tissue injury in the leaves of *Vigna radiata*. Increasing trend of chlorophyll contents at lower concentrations is due to the favourable effect of optimum level of nutrients required for biosynthesis of chlorophyll pigments. This is in agreement with the reports of Malla and Mohanty (2005) and Samyuktha (2005). The same trend was observed in nodulation (Kannan and Oblisamy, 1990 a; Rajeswari, 2003).

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