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Impact of long-term paper mill effluent irrigation on agricultural soil and crop plant

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SUMMARY

The effects of long-term effluent irrigation on agricultural soil and growth, biochemical constituents and yield of black gram were carried out under potted condition. The physico chemical properties of (pre and post harvest) soil samples studied *viz*., bulk density, soil respiration, water holding capacity, pH, EC, chlorides, nitrates, nitrogen, phosphorous, potassium and organic carbon registered increases with the increasing years of effluent irrigation of the soil. 2 years effluent irrigated soil supported higher growth rate such as shoot, root lengths and biomass and biochemical constituents such as chlorophyll, protein and soluble carbohydrates. However, significant decreases were observed in 15 years effluent irrigated soil. Maximum yield and seed nutrients were recorded in 2 and 5 years irrigated soil. Where as 15 years effluent irrigated soil showed significant decrease in yield and seed nutrients.

Key words : Black gram, Long term irrigation, Paper mill effluent, Microbial population

Water resource, the most vital of all resources, is adversely affected by increasing industrialization, urbanization and other developmental activities. Of these, the effluents discharged from industries normally considered as the major pollutant of soil. Among the different major industries, the paper industry is a notorious pollutor of the environment.

In India there are more than 305 paper mills with an installed capacity of 2.04 x 10^6 tonnes of paper per annum which discharges waste water at the rate of 305 to 450 m^3t^{-1} paper produced. Seshasayee Paper and Boards Limited paper mill, Pallipalayam, Tamil Nadu discharged 30 to 40 MLd^{-1} of effluent everyday. The effluent is stored in a lagoon and used as irrigation water 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 (Mariappan and Rajan, 2002; Malla and Mohanty, 2005)

In the present investigation, attempt has been made to evaluate both the beneficial and adverse effects of long-term paper mill effluent irrigation on soil and growth of *Vigna mungo*(L) Hepper.

MATERIALS AND METHODS

The long-term effects of effluent irrigation were studied in the agricultural fields which have received treated but undiluted paper mill effluent as irrigation water for varying periods, *viz*., 2, 5, 10 and 15 years. Soil obtained from A_1 (0-10cm) layer in these fields were filled in earthern pots. The field soil which never received effluent irrigation earlier served as control.

Soil physical characters *viz*., bulk density and maximum water holding capacity were determined by keen Raczkowski box. Soil pH was directly determined using a standard Elico pH meter. Chloride in the soil sample was estimated following titrimetric method described by Sundaresan (1979). Total phosphorus was estimated by Pemberton (1945) method,and total nitrogen by Jackson (1973) method. Nitrate nitrogen was estimated following phenol Di sulphonic acid method described by Anonymous (1981). Organic carbon was estimated by Piper (1944) method.

The healthy and uniform seeds of *Vigna mungo* (L.). Hepper were surface sterilized with 0.1% $HgCl_2$ and washed thoroughly. The pots were sown with healthy surface sterilized seeds at the rate of 10 seeds per pot and watered regularly. The plants were uprooted on 20th day after sowing. The measurement for length (Root and shoot) and biomass were made. Chlorophyll was estimated as per Yoshida *et al*. (1976). Protein estimation was done following Lowry *et al*. (1951) method. Total soluble carbohydrates was done following Clegg (1956) method. Yield parameters *viz*., pod length, number of seeds per pod, 1000 seeds weight, number of pods per plant and grain yield per plant were made. Seed protein was estimated using Lowry *et al*. (1951), total soluble carbohydrates by Clegg (1956) and reducing sugars by

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Nelson (1944) method.

RESULTS AND DISCUSSION

Physico-chemical properties of pre and post larvest soil samples are given in Table 1 and 2.

Among the physical parameters studied, the bulk density of the soil registered progressive decreases with the increasing years of effluent irrigation while the reverse was true with water holding capacity. In the case of soil respiration maximum activity was observed in 2-years effluent irrigated soil and the minimum in the 15-years effluent treated one. All the chemical parameters *viz*., pH, EC, chlorides, nitrates, nitrogen, phosphorous, potassium and organic carbon registered pronounced increases with the increasing years of effluent irrigation of the soil. Post-harvest soil samples exhibited similar trend as that of pre-sowing samples. Similar observations has been made by a number of earlier investigators (Kannan and Oblisami, 1990; Kannapiran, 1995; Sundaramoorthy *et al*., 2007).

The effect of the years of effluent irrigation on growth and biochemical constituents of black gram under pot condition are presented in Table 3. The root length, shoot length and biomass was increased in the 2-years effluent irrigated soil, where as the 10 and 15 years effluent treated soils retarded plant growth. According to Oblisami and Palaniswami (1991) even after 15-years of effluent irrigation, the plant growth was not affected significantly.

In the present investigation insignificant decreases in chlorophyll, and protein recorded only in 10 and 15 years

Table 1 : Impact of the years of effluent irrigation on the physico-chemical characteristics* of the soil prior to seed sowing

Sr. No.	Parameters	Years of effluent irrigation				
		Control	2	5	10	15
1.	Bulk density (g/cc)	1.280 a	1.250 a (-6)	1.062 a (-17)	0.96 a (-25)	0.870 a (-32)
2.	Water holding capacity (%)	36.58 a	39.83 b (+8)	40.50 c (+10)	46.20 d (+26)	47.34 e (+29)
3.	Soil respiration (mg CO_2 released / h / 25 g soil)	0.220 a	0.257 a (+25)	0.220 a (0)	0.200 a (-9)	0.110 a (-50)
4.	pH	7.20 a	7.46 b (+3.6)	7.74 (+0.07)	8.00 d (+11)	8.30 e (+15)
5.	Electrical conductivity (dSm^{-1})	0.28 a	0.26 a (-7)	0.30 a (+7)	0.46 a (+64)	0.58 a (+107)
6.	Chlorides (mg / kg)	107.3 a	128.0 b	153.0 c (+42)	192.0 d (+78)	218.0 e (+103)
7.	Nitrates (mg / kg)	22.0 a	32.8 b (+49)	32.8 b (+49)	35.6 c (+6)	43.2 d (+96)
8.	Kjeldahl nitrogen (mg / kg)	98.5 a	103.8 b (+5)	115.3 c (+17)	122.9 d (+24)	135.2 e (+37)
9.	Total phosphorus (mg / kg)	0.07 a	0.08 b (+14)	0.08 b (+14)	0.09 c (+28)	0.10 d (+42)
10.	Total potassium (mg / kg)	0.15 a	0.17 b (+13)	0.19 c (+26)	0.22 d (+46)	0.24 e (+60)
11.	Organic carbon (%)	0.28 a	0.29 a (+3)	0.30 a (+7)	0.33 a (+17)	0.35 a (+25)

* Based five determinations for each treatment. The effluent treatment were given seven days period to soil analysis.
Values with the same superscript in each row do not differ significantly from each other (P<0.05).

Table 2 : Impact of the years of effluent irrigation on the physico-chemical characteristics* of post-harvest soil sample

Sr. No.	Parameters	Years of effluent irrigation				
		Control	2	5	10	15
1.	Bulk density (g/cc)	1.283 a	1.208 a (-5.8)	1.060 a (-17)	0.958 a (-25)	0.872 a (-32)
2.	Water holding capacity (%)	36.55 a	39.85 b (+9)	40.54 c (+10)	46.18 e (+26)	47.36 g (+29)
3.	Soil respiration (mg CO_2 released / h / 25 g soil)	0.220 a	0.285 a (+29)	0.225 a (+2)	0.220 a (0)	0.098 a (-55)
4.	pH	7.12 a	7.54 b (+5)	7.78 cd (+9)	7.88 ef (+10)	8.36 ga (+17)
5.	Electrical conductivity (dSm^{-1})	0.27 a	0.30 b (+11)	0.36 c (+33)	0.48 d (+77)	0.58 e (+114)
6.	Chlorides (mg / kg)	102.2 a	115.6 d (+13)	140.3 d (+37)	166.1 f (+62)	217.2 h (+112)
7.	Nitrates (mg / kg)	23.8 a	32.2 b(+35)	38.8 d (+63)	47.4 f (+99)	53.0 h (+122)
8.	Kjeldahl nitrogen (mg / kg)	98.0 a	103.6 b (+5)	104.8 d (+7)	122.6 f (+25)	134.4 h (+37)
9.	Total phosphorus (mg / kg)	0.07 a	0.08 ab (+14)	0.08 ab (+14)	0.09 ab (+28)	0.10 bc (+42)
10.	Total potassium (mg / kg)	0.15 a	0.17 ab (+13)	0.20 bcd (+33)	0.22 cd (+46)	0.24 d (+60)
11.	Organic carbon (%)	0.27 a	0.28 a (+3)	0.31 a (+14)	0.32 a (+18)	0.34 a (+25)

* Based five determinations for each treatment. ** + indicates amendment and – non – amendment.
Values with the same superscript in the two rows under each parameter do not differ significantly from each other (p<0.05)

Table 3 : Impact of the years of irrigation (paper mill effluent) on growth and biochemical constituents of *Vigna mungo* (L.) Hepper under pot condition

Years of effluent irrigation	Root length (cm)	Shoot length (cm)	Biomass (g $plant^{-1}$)	Chlorophyll (µg g^{-1} fresh leaf weight)	Protein (mg g^{-1} leaf dry weight)	Soluble carbohydrate(mg g^{-1} leaf dry weight)
Control 2	7.2 abc	10.8 abf	0.174 abd	2.00 a	78.0 abd	108.2 abc
2	7.2 abc	16.0 ce	0.188 abd	2.33 a	79.0 ab	114.1 acde
5	6.8 bc	14.8 c	0.178 bd	2.05 a	68.3 e	110.9 bce
10	6.6 c	10.6 bf	0.148 de	1.87 a	64.2 e	102.8 ef
15	5.6 d	9.2 f	0.102 f	1.54 a	54.0 f	82.7 g

Table 4 : Impact of the years of irrigation using treated paper mill effluent on the yield and seed characteristics of *Vigna mungo* (L.) Hepper under pot condition

Sr. No.	Parameters	Years of effluent irrigation				
		Control	2	5	10	15
Yield						
1.	Pod length (cm)	3.90 ab	4.16 ab	3.64 ac	3.24 cd	2.34 de
2.	Number of seeds / Pod	5.6 ab	6.63 c (+ 17.9)	5.8 b (+3.6)	4.0 e (-28.6)	1.4 g (-75)
3.	1000 seed weight (g)	47.6 ab	47.8 acd (+0.42)	47.2 b (-0.19)	45.6 e (-4)	44.2 f (-7-1)
4.	Number of pods / plant	39.0 ab	47.0 c (+20.5)	35.0 b (-10.2)	24.0 ef (-38)	17.0 f (-56)
5.	Grain yield / plant (g)	12.2 a	16.8 b (+37)	10.0 d (-5.6)	5.4 f (-55)	2.4 h (-80)
Seed nutrients						
6.	Protein (mg/g)	263.0 a	264.0 a (+0.3)	254.0 c (-3)	234.0 d (-11)	213.0 e (-19)
7.	Total soluble carbohydrate (mg/g)	242.0 ab	247.0 cd (+2)	237.0 e (-2)	227.0 f (-6)	205.0 g (-15)
8.	Reducing sugars (mg/g)	95.0 ab	104.0 d (+9)	99.0 bc (+4)	90.0 f (-5)	82.0 g (-13)

* Based on observation of five plants / five determination for each treatment
Values with same superscript in each sampling day in the columns do not differ significantly from each other (P<0.05).

effluent irrigated soils, where as, soluble carbohydrate level registered significant decreases in 5 years effluent treated soil. The extent of injury suffered by *V. mungo* is reflected in its accumulation of biochemical constituents in the leaf tissue. The results are in confirmity with the findings of Samyuktha *et al*. (2005) and Malla and Mohanty (2005).

The data presented in Table 4 revealed the effect of long-term effluent irrigation on yield of black gram.Effluent irrigation for varying periods supported higher yields with respect to number of seeds per pod and grain yield per plant. Two years effluent irrigated soil significantly increased all the parameters (Yield and seed nutrients). Where as significant decreases were noted with 10 and 15 years effluent irrigated soil. Sandana (1995) made similar observation in tomato.

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