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Effect of Industrial Effluents on Mineral Uptake of Two Rabi Crops (*Triticum aestivum* and *Raphanus sativus*)

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ABSTRACT

The physico-chemical characteristics of effluents from two different industries, viz. textile and sugar factory, were assessed and the effect of various concentrations (0%, 25%, 50%, 75 % and 100%) on mineral uptake in *Triticum aestivum* and *Raphanus sativus* was determined. The study revealed that the germination % of wheat and radish was severely affected by these effluents at higher concentration, where a maximum germination was recorded at 25% effluent concentration. The uptake of iron, phosphate, zinc and copper was found in increasing order and was highest at 100% effluent concentration. The above study reveals the feasibility of using industrial effluent for growing vegetables and crops with proper dilution.

INTRODUCTION

Environmental pollution has been recognized as one of the major problems of the modern world. Effluents from industries contribute toward environmental pollution, particularly to the aquatic ecosystems. India is an agriculture based country and a major user of water resources for irrigation (Singh et al. 2005). But, there is a great demand of water for irrigation, while gallons and gallons of effluents are let out into water resources as untreated. The disposal of wastewater is a major problem faced by industries, due to the generation of high volume of effluent and with limited space for land based treatment and disposal. On the other hand, wastewater is also a resource that can be applied for productive uses, since wastewater contains nutrients that have the potential for use in agriculture, aquaculture, and other activities (Hussain et al. 2001). Sugar industry is one of the most important agrobased industries in India (Sanaraj & Stella 2014). In general, sugar mill effluents contain a significant concentration of suspended solids, dissolved solids, high BOD, COD, considerable amount of chlorides, sulphates, nitrates, calcium, magnesium and sugar concentration (Borale et al. 2004). Diverse sugar industry effluents disposed off in soil and water cause major pollution problems. The sugar industries play an important role in the economic development of India, but the effluents released produce a high degree of organic pollution in both aquatic and terrestrial ecosystems (Ayyasamy et al. 2008). Because sugar industry effluents are commonly used for irrigation, it is essential to determine how crops respond when exposed to industrial effluents. In this regard, efforts have been made to determine the effect of industrial effluents on seed germination of various crops such as paddy and mung (Worku & Sahu 2014), maize (Choudhury et al. 1987), rice (Singh et al. 1985), wheat (Agarwal et al. 1995), pine (Czabator 1962), green gram (Subramani et al. 1999) and catechu (Pandey & Sony 1994).

Textile and clothing (T&C) is one of the largest and oldest industries present globally (Gereffi 2002) and considered to be one of the biggest threats to the environment. Textile industries produces large amounts of liquid wastes that contain organic and inorganic compounds along with colour (Elliot et al. 1954).

The sugar industry also produces voluminous quantity of wastewater. The effluent has a high organic load along with various salts and nutrients including nitrogen and phosphorus.

The present study deals with the effect of these industrial effluents on certain physico-chemical properties of soil, germination and the mineral uptake by crops.

MATERIALS AND METHODS

Rohtak city consists of many water polluting industries in the vicinity. The effluent from main outlet of the industries was collected and analysed for various physico-chemical properties, according to the procedure outlined by APHA (1985).

Seed germination and seedling growth experiments were carried out on two Rabi crops, wheat and radish. Seeds were obtained from HAU Hissar and surface sterilised with 0.1% $HgCl_2$. Seeds were grown in Petri plates in triplicates for 10 days with varying effluent concentration of 25%, 50%, 75% and 100% (Prashanthi & Rao 1998). For mineral uptake, crops planted in pots, were harvested after the growing season up to 125 days approximately. Pots were supplied with varying effluent concentration (25%, 50%, 75%, 100%) and one with water acting as control. Daily 200 mL of effluent and water was supplied to the pots. After harvesting the crop, soil sample was taken, dried for the analysis of various parameters like conductivity, pH, organic carbon, phosphates, as per the procedure outlined by Jackson (1973). The heavy metal detection in the soil samples was done by AAS. The extractable sodium, potassium, calcium and magnesium were extracted with ammonium acetate buffer. Yield was studied after maturation of the crops.

RESULTS AND DISCUSSION

The physico-chemical characteristics of the sugar factory and cotton textile industry effluents are given in Table 1. Sugar factory plant is sulphitation plant. The physico-chemical characteristic of sugar factory effluent indicate that it is acidic in nature. From the above results it is clear that large amount of TSS is responsible for high BOD and COD of the effluent, which were found to be above permissible limit, i.e., BOD 50 mg/L and COD 250 mg/L (BIS 2010). The absence of DO indicates high organic nature of the effluent. The presence of heavy metals was not detectable. On the other hand physico-chemical characteristics of the cotton industry reveals that the sample was alkaline and contains considerable amount of calcium, magnesium, TSS, high COD and other basic nutrients above the permissible limits. The findings were supported by Shivappa et al. (2007) and Parivash (2010).

Effect of industrial effluent on seed germination: Germination test was conducted with seeds of wheat and radish with different effluent concentrations (25%, 50%, 75%, 100%). The germination % was recorded up to 10th day. The seed germination was 100% in control for *Raphanus sativus* as well as *Triticum aestivum*. Percentage germination decreases from 96.6% to 86.6% in 50%, 75%,100% effluent concentration in accordance with the results obtained by Doke et al. (2011).

Effect of effluent on plant characteristics: Dried plant material was taken and analysed for calcium, magnesium, sodium, potassium, phosphorus, iron, zinc and copper. In sugar mill effluent treated crop, calcium, magnesium and potassium content was higher in 25% concentration than that of control. The calcium content in wheat was recorded 5.811% in 25% concentration and 5.611% (control), and in radish 5.79% in 25% concentration. The sodium content was recorded a decrease with increase in effluent concentration ranging from 0.958-1.015% in *Triticum aestivum*, and 0.003-1.060% in *Raphanus sativus*. The micronutrients like iron ranged from 0.4874-0.4884 mg/100g in wheat and 0.4808-0.4818 mg/100g in radish. The reported increased values except sodium may be due to the presence of soluble salts and organic matter which was found to be high in sugar mill effluent, and the decrease in sodium uptake by the plant may be due to the lower pH of the effluent. Our results are contrary to the results obtained by Kaushik et al. (1996), where they reported higher uptake of sodium in the sugar mill effluent. It has been revealed that the plants have observed more potassium and magnesium failed to uptake the required amount of the sodium and hence are deficient in sodium content despite soil having adequate sodium. The results have been depicted in Table 2.

As shown in Table 3, in cotton textile industry the nutrient uptake by plants at 25% concentration was at par with control and then decreases with increase in effluent concentration. The calcium content varied from 5.37% to 5.63% in wheat and 5.41% to 5.5% in raddish. The magnesium content ranged from 2.11-2.30% in *Triticum aestivum* and 2.28-2.36% in *Raphanus sativus*. The sodium and potassium content varied from 1.21-1.27% and 1.06-1.11% in *Triti-*

Table 1: Physico-chemical characteristics of the discharged effluents.

S.No	Characteristics	Sugar mill	Cotton industry
1	pH	4.2	8.9
2	E.C(μmhos/cm)	2990	8200
3	BOD(mg/L)	800	300
4	COD (mg/L)	3116	1000
5	DO (mg/L)	NIL	6.3
6	Calcium (mg/L)	120	248
7	Magnesium (mg/L)	76.2	128
8	Alkalinity (mg/L)	240	300
9	Acidity (mg/L)	10.8	0.4
10	TSS (mg/L)	365	900
11	Phosphate (mg/L)	3.7	1.2
12	Sulphate (mg/L)	266	120
13	Chloride (mg/L)	47	20
14	Iron (mg/L)	ND	ND
15	Zinc (mg/L)	ND	ND
16	Copper (mg/L)	ND	ND
17	Chromium (mg/L)	ND	ND
18	Cadmium (mg/L)	ND	ND
19	Lead (mg/L)	ND	ND

Table 2: Effect of sugar industry effluent on plant characteristics.

Crops	Concentration	Ca%	Mg%	K%	Na%	PO_4%	Fe (mg/100g)	Zn (mg/100g)	Cu (mg/100g)
	Control	5.611±0.261	2.13±0.505	1.164±.194	1.015±.213	0.89±.159	0.4874±0.161	0.2848±0.118	0.3404±0.056
	25%	5.811±0.182	2.23±0.522	1.396±.195	0.992±0.179	0.96±0.172	0.4872±0.159	0.2849±0.135	0.3406±0.082
Wheat	50%	5.571±0.252	2.17±0.235	1.249±.183	0.981±0.182	0.97±0.183	0.4876±0.144	0.2854±0.147	0.3408±0.103
	75%	5.511±0.250	2.17±0.231	1.187±.177	0.981±0.182	1.01±0.206	0.4879±0.153	0.2857±0.113	0.3411±0.117
	100%	5.490±0.530	2.07±0.516	1.148±.170	0.958±0.167	1.05±0.216	0.4884±0.132	0.2862±0.156	0.3416±0.092
	Control	5.571±0.552	2.26±0.256	1.187±.230	1.060±.218	0.91±0.180	0.4808±0.136	0.2907±0.107	0.3354±0.126
	25%	5.791±0.573	2.34±0.268	1.303±.158	1.043±.235	0.97±0.195	0.4812±0.169	0.2909±0.128	0.3357±0.066
Radish	50%	5.571±0.552	2.26±0.255	1.218±.119	1.020±.210	0.99±0.230	0.4813±0.147	0.2911±0.123	0.3359±0.043
	75%	5.450±0.531	2.31±0.288	1.164±.143	1.003±.219	1.02±0.213	0.4815±0.173	0.2916±0.146	0.3359±0.072
	100%	5.393±0.484	2.20±0.240	1.125±.149	1.003±.223	1.04±0.218	0.4818±0.178	0.2916±0.173	0.3351±0.068

Table 3: Effect of cotton industry effluent on plant characteristics.

Crops	Concentration	Ca%	Mg%	K%	Na%	PO_4%	Fe (mg/100g)	Zn (mg/100g)	Cu (mg/100g)
	Control	5.63±0.237	2.20±0.245	1.127±.250	1.11±.160	0.874±.085	0.4856±0.405	0.2889±0.008	0.3562±0.413
	25%	5.61±0.257	2.18±0.166	1.28±.290	1.18±0.108	0.874±0.195	0.4863±0.449	0.2892±0.001	0.3565±0.443
Wheat	50%	5.39±0.248	2.14±0.233	1.24±.188	1.07±0.209	0.861±0.288	0.4864±0.410	0.2896±0.083	0.3569±0.240
	75%	5.37±0.483	2.13±0.163	1.21±.143	1.06±0.144	0.859±0.205	0.4865±0.245	0.2896±0.142	0.3573±0.476
	100%	5.37±0.483	2.11±0.153	1.21±.280	1.06±0.088	0.859±.118	0.4867±0.218	0.2899±0.133	0.3573±0.193
	Control	5.59±0.513	2.36±0.121	1.30±.180	1.060±.410	0.815±0.065	0.4921±0.088	0.2931±0.229	0.3610±0.254
	25%	5.63±0.522	2.36±0.158	1.30±.148	1.05±.435	0.837±0.177	0.4923±0.019	0.2932±0.044	0.3612±0.163
Radish	50%	5.51±0.573	2.30±0.160	1.29±.224	1.05±.185	0.825±0.125	0.4926±0.134	0.2934±0.198	0.3612±0.137
	75%	5.47±0.316	2.26±0.128	1.28±.177	1.04±.224	0.811±0.415	0.4926±0.125	0.2938±0.118	0.3608±0.188
	100%	5.41±0.210	2.28±0.130	1.27±.128	1.04±.098	0.807±0.188	0.4928±0.123	0.2941±0.130	0.3613±0.208

cum aestivum, and 1.27-1.30% and 1.04-1.06% in *Raphanus sativus*. The copper content varied from 0.3562-0.3573 mg/100g in *Triticum aestivum*, and 0.3610-0.3613 mg/100g in *Raphanus sativus*. The effluent treatment caused a considerable difference in the uptake of various nutrients by the seedlings in all the crops. The uptake of calcium, magnesium and potassium was highest at 25% effluent concentration in all crops. In wheat, the calcium uptake was also higher in 50% effluent concentration, in comparison to control. While when compared to others, crops at 50% effluent concentration, the uptake of nutrients was equal to the control value. Magnesium and potassium concentration was more than the control value up to 75% concentration in most of the crops. Sodium uptake was found to be less than control value at all the concentration for all the crops. The uptake of iron, phosphate, zinc and copper was found in increasing order and was highest at 10% effluent concentration. The macronutrients uptake such as calcium, magnesium, potassium either increased up to 25% effluent concentration in comparison to control. Although the increased value showed marginal difference, at higher concentrations these values were in decreasing order for both the crops. The uptake of sodium was higher at 25% effluent concentration in comparison to control in wheat as reported in findings by Kumar et al. (2010), whereas in raddish, at 25% concentration, the value was slightly less than the control. The uptake of phosphate was found to be in the decreasing order in both the crops with the increase in effluent concentration. The micronutrient iron, zinc and copper uptake show marginally increased values in the increasing order of the effluent concentration. The results of Adhikary (2014) supports these findings.

CONCLUSIONS

Industrial wastewaters usually contain considerable amounts of salts which may serve as nutrients for plants. These waters can be utilized for irrigation purposes after proper dilution. On the other hand, soils also have a great capacity for receiving and decomposing waste and pollutants and the use of industrial effluent for irrigation as an alternative to other disposal methods could be attractive. In developing countries including India, farmers irrigate their crops with industrial effluents having high level of several toxic metals due to the non-availability of alternative sources of irrigation water.

The research work to lessen the deleterious effects of industrial effluents on life and surrounding, and to evaluate suitable treatments prior to its disposal is generally recommended. This will enable to recycle and reuse the valuable constituents of wastewater for productive purposes in agriculture. In the present investigation, sugar mill effluent was highly alkaline with high conductivity and a high level of BOD. It was noted from study that the maximum germination was in both the crops at 25% effluent concentration. The uptake of iron, phosphate, zinc and copper was found to be in increasing order, the highest at 100% effluent concentration. The reported increased values except sodium may be due to the presence of soluble salts and organic matter which was found to be high in sugar mill effluent. Sugar mill effluent and cotton industry effluent may be utilized as an additional potential source of liquid fertilizer up to 25% concentration. The concentration should be reduced to beneficial levels of nutrients such as nitrogen, potassium and magnesium etc. by diluting with ordinary water.

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