International Journal of Chemical Studies 2018; 6(6): 994-997

International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 994-997

Received: 25-09-2018
Accepted: 29-10-2018

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Effect of distillery factory effluent on macro and micro nutrients in the crop barley variety-264

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Abstract
The effluent discharged distillery factory brought about deterioration in water quality. pH showed fluctuation. Other parameters *viz.* B.O.D., C.O.D., Chlorides, Free CO_2 exceeded tolerance limits. Brownish-black colour and poor transparency indicated poor water quality. T.S.S., T.D.S. and heavy metals like Cr, Pb, Zn, Fe and minerals like Na, K, Ca, and total Nitrogen concentration indicated organic and inorganic loading. Percentage of Ca, K, and Total Nitrogen, Crude Protein and Ether extract was significantly low in the seeds of effluent treated cultivar Barley var. 264. On the contrary, concentration of Na, Fe and Total Carbohydrates, were significantly higher.

Keywords: Distillery effluent, pollution, chemical composition, barley var. 264

Introduction
It is well known that the growth and development of the plant are majorly dependent on the availability of nutrients in the soil. Plants need a total of 16 elements for completion of a productive life cycle. Macro nutrients are required in large quantities by the plant while micro nutrients in lesser quantities both impact growth and function in the plants.
The indiscriminate disposal of wastes by large number of industrial units has led to rapid deterioration in the quality of aquatic environment at Bareilly. The effluent from Superior Industry Ltd. C.B. Ganj Bareilly disposed of through several drains which carry their pollution load into canals that ultimately causes pollution in river "Ram Ganga" flowing at 4.5 Km. west from Bareilly. Cultivators of adjacent villages irrigate their crops with the polluted water of the factory. This has resulted in colossal damge to their crops. Several workers have studied the effect of industrial effluents on growth, yield and chemical composition of various crops [1-4].
No efforts seem to have been made to study the water pollution caused by Superior Industry C.B. Ganj Bareilly and its irrigation impact on mineral bioaccumulation and metabolite concentration in different parts of crop plants. An attempt has, therefore, been made to fulfill the above objective.

Materials and Methods
The effluent disposed of from distillery factory was collected from its discharge points at weekly intervals and was analysed according to A.P.H.A. (1980) [5]. Quantitative estimation of heavy metals, viz. Cd, Cr, Cu, Pb, Ni, Fe, Zn, Co, Mn in the effluent was made by using Atomic absorption spectrophotometer (AAS 300 Parkin & Elmer). The data are presented in Table 1.
Chemical analysis of root, stem, leaf and seeds was done according to Piper (1966) [6]. Seeds of Barley var. 264 were separately sown in unglazed earthen pots (22 cm dia.) containing uniform density of garden loam soil mixed with farm-yard manure.
Thinning was done after one week of seedling emergence to permit one seedling to grow in each pot. The control and treatment sets were maintained with tap water and effluent, respectively.
Plants were harvested at the time of seed ripening after 135 days of sowing. Different parts, viz. root, stem, leaf and seeds were collected from the plants of control and treated sets and analyzed for Na, K, Total-N, Fe, Crude protein, ether extract and total carbohydrates. Values are expressed in terms of dry weight percentage. Mean values ± S.E. were recorded for each parameter. The soil used in the control and treated sets was the same and was found to have pH (7.3), Nitrogen (1.42 kg ha^{-1}), Potassium (290 kg ha^{-1}), EC_eEC (0.8 $mScm^{-1}$), Organic

Carbon (1.65%), Organic matter (4.2%), WHC (42.13%), moisture (9.6%), sand (56%), silt (14%) and clay (30%).

Result and Discussion

The data (table-1) indicated the brownish-black colour and poor transparency (2-3.5 cm) of the effluent. pH (4.2 to 9.4) is not conducive for inhabitation and survival of aquatic life. The concentration of TDS, TSS, DO, BOD, Total-N, Ca, Na, K, EC_e ($mScm^{-1}$), Total Hardness, Free CO_2,Cd, Cr, Cu, Pb, Ni, Fe, Zn, Co, Mn exceeded the permissible limits recommended by IS:2490.

Table 1: Physico-chemical parameters of effluent and Tap Water used in seed Germination and Irrigational Treatments (Nov. 2008, April 2009). All unless specified are mg/1

	Parameters	Effluent	Tap Water
1.	Colour	Brownish-black	Colour less
2.	pH	4.2-9.4	7.0-7.3
3.	Transparency (cm)	2.0-3.5	100
4.	T.D.S.	323-1120	96-152
5.	T.S.S.	169-187	17-29
6.	DO	1.7-5.6	10.0-13.3
7.	BOD. 5 days 20^0c	31.34-1291.67	2.5-3.0
8.	COD	61.0-1610.50	40-45
9.	Total-N	8.8-63.0	-
10.	Ca	66.5-89.2	1.3-4.6
11.	Na	15.9-21.5	2.0-2.4
12.	K	17.0-17.8	1.7-2.1
13.	EC_e ($mScm^{-1}$)	3.9-4.8	1.3-1.7
14.	Total Hardness (as $CaCo_3$)	41.3-529.3	98-120
15.	Free CO_2	70-250	1.2-2.5
16.	Cl	295-6060	19.4-23.2
17.	Heavy metals		
	Cd	0.02-0.3	-
	Cr	0.3-0.5	-
	Cu	0.5-0.8	-
	Pb	0.2-0.3	0.09
	Ni	0.3-0.5	-
	Fe	2.5-2.8	0.3
	Zn	3.0-5.5	1.2
	Co	0.3-0.5	-
	Mn	0.7-0.8	0.5

Calcium

There was overall decrease in the concentration of calcium in all the components of Barley var. 264. The percentage decrease in the root, leaf, seed and stem being 76.67 %, 84.16%, 85.88% and 89.76% respectively (Table 2-5). Calcium in the form of Calcium Pectate is an important constituent of middle lamella. Its poor Concentration vegetative parts of the treated plants could be due to its poor intake as Ca^{++} ions through plasma membrane. Precipitation of calcium as Calcium Hydroxid and Calcium Carbonates in the soil seems to be important causative factor responsible for its restricted availability. Its deficiency resulted in thin week stems, poor development of leaves and poor Calcium content in seeds [7].

Sodium

Sodium concentration increased significantly in all the four parts, maximum increase (592.30%) being in the case of root followed by seed (315.78%), stem (252.38%) and leaf (242.85%) (Tablws 2-5). Higher Na content the stem of treated crops may be attributed to rapid intake of Na^+ ions [8] in the soil solution inhibit the entry of K^+ ions. However, Sodium ions in association with Cl^- ions cause particles of plasma membrane to separate and enhance permeability [9]. Accumulation of Na^+ ions in association with weak and strong anions alter the pH of the solution and affect crop growth [10].

Potassium

Potassium content was poor in all the component parts. Decrease was maximum (95.68%) in stem of the treated crop followed by seed (78.87%), root (75.00%), and leaf (48.05%) (Tables 2-3). Potassium occurs in the plant cells only in the ionic form as micronutrient. Its poor availability was observed in the form of deficiency symptoms, viz., mottled chlorosis of leaves, necrotic areas of the tip and margins of leaves and shortening of internodes. As an activator of enzyme ALA dehydrase it has been reported to play an important role in the biosynthesis of chlorophyll. Potassium has a marked effect on the weight of the seeds hence maximum reduction in the seeds may be attributed to its deficiency. Low pH has been reported to cause Potassium deficiency and adversely affects Nitrogen metabolism [11].

Table 2: Chemical constituents of root and stem in Barley var. 264 as affected by industrial effluent.

Parameters%	Root		Stem	
	Control Mean ±SE	Treatment Mean ±SE	Control Mean ±SE	Treatment Mean ±SE
Ca	0.06 ± 0.03	0.01 ± 0.008	0.21 ± 0.13	0.02 ± 0.01
Na	0.01, 0.007	0.09 ± 0.05	0.02 ± 0.01	0.07± 0.02
K	0.12 ± 0.07	0.03 ± 0.02	0.13 ± 0.07	0.06 0.03
Fe	0.02, 0.0001	0.02, 0.001	0.07± 0.05	0.02 ± 0.02
Total-N	1.28 ± 0.74	1.36± 0.78	1.51± 0.87	1.40 ± 0.30
Crude Protein	8.0 ± 4.62	8.50± 4.91	9.43± 0.10	8.75 ± 0.10
Total Carbohydrates	82.46±47.61	81.43±47.02	82.70±47.78	82.93±0.83
Ether extract	0.09± 0.06	0.07±0.04	1.14 ± 0.66	1.03 ± 0.50

Iron

Percentage increase in iron content in seeds, stem, leaf and root was 191.17%, 171.60%, 119.78% and 12.00%, respectively (Tables 2-3) Iron content in the effluent was also much higher than recommended tolerance limit. Due to low pH of the effluent for major span of crop growth iron become excessively soluble and beyond its judicious micronutrient limit it exerted toxic effect on frredoxin which plays key role in nitrogen metabolism [12]. Inhibition in growth has also been found to be associated with suppression of the activity of several enzymes like peroxidase, catalase and of cytochrome. Bio-accumulation of Fe in plants at low pH is amply documented [13].

Table 3: Chemical constituents of leaf and seed in Barley var. 264 as affected by industrial effluent.

	Leaf		Seed	
Parameters%	**Control Mean ±SE**	**Treatment Mean ±SE**	**Control Mean ±SE**	**Treatment Mean ±SE**
Ca	0.12 ± 0.07	0.01 0.01	0.08, 0.05	0.01, 0.07
Na	0.02±0.01	0.02 ± 0.05	0.01± 0.06	0.07± 0.10
K	0.15 0.09	0.09, 0.04	0.95, 0.54	0.10± 0.06
Fe	0.009±0.01	0.02± 0.01	0.003 ± 0.02	0.02 ± 0.01
Total-N	1.82±1.05	1.48± 0.85	3.58± 0.51	2.31 ± 1.30
Crude Protein	11.37±26.57	9.25± 5.30	22.37 ± 0.10	14.43 ±2.10
Total Carbohydrates	79.31±45.85	80.75±46.68	73.29±1.20	81.09±0.10
Ether extract	1.20± 0.69	1.11±0.64	1.73 ± 0.80	1.24 ± 0.30

Total Nitrogen

Total Nitrogen exhibited significant decrease in treated plants over the respective control. The decrease was in the following sequence 35.47%, 18.68%, 7.28%, 6.24% in seeds, leaf, stem, and root, respectively. Though the concentration of nitrates and nitrites was higher in effluent the reduction in the total nitrogen in the seeds suggests impairment of nitrification caused by inactivation of microbes at low pH (6.5-4) of the effluent (Tables 2-3). Effect of nitrogen starvation was manifested as yellowing of leaves brought about by reduction Chlorophyll biosynthesis and depressive effect on nitrogenous bases like, purines and pyrimidines [14].

Total Carbohydrates

Data revealed overall increase in the concentration of total carbohydrates in the root, stem, leaf and the seeds of the cultivars studied. Maximum increase (10.64%) was obtained in the case of seed followed by leaf (1.81%), Root (1.24%) and stem (0.27%). Greater concentration of carbohydrates was found to be associated with decrease in fat content. Regeneration of organic matter in the form of carbohydrates takes place in a cyclic in which CO_2, H_2O and O_2 which are liberated by the decomposing organic matter become readly available for their synthesis [15].

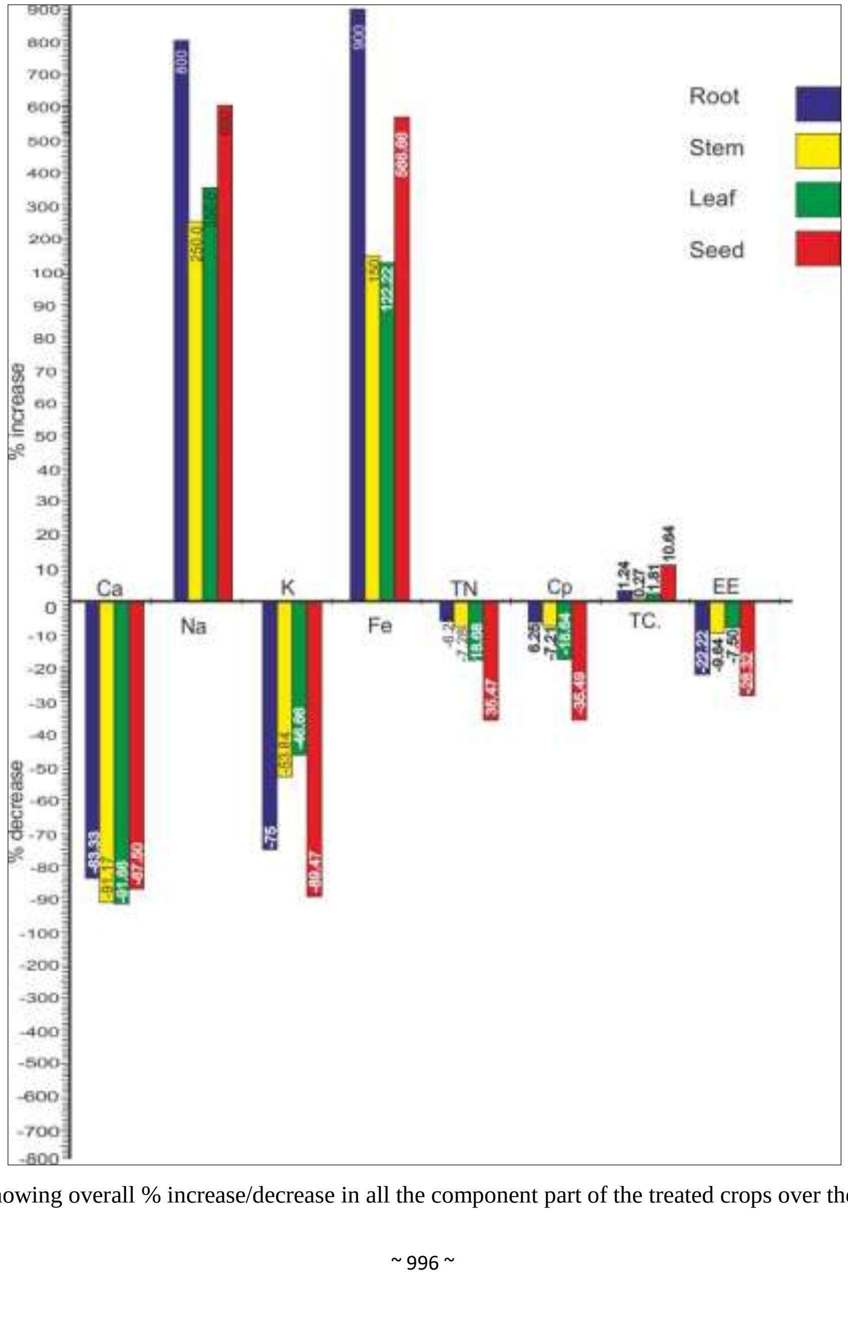

Fig 1: Bar diagram showing overall % increase/decrease in all the component part of the treated crops over their respective control.

Crude Protein

Crude protein contents exhibited overall decrease in seed, leaf, stem and root, being 35.47%, 18.68%, 7.21% and 6.25% respectively. Protein content has been found to be positively correlated to total-N. Inorganic nitrogen is taken up as NO_3^- ions is converted into NH_2 groups before being elaborated into amino acids. Synthesis of proteins as also of fats is intimately linked with carbohydrate metabolism. Protein breakdown into amino acids is also adversely affected due to effluent toxicity [12]. Hence poor availability of nitrogen may be a causative factor for reduction in crude protein content in different parts. Decrease in protein content has been found to be associated with increase in total carbohydrates which is nutritionally unsound since with decline in protein the subtle balance of amino acids is disturbed (Table 2).

Ether Extract

Ether extract showed overall decrease in all the component parts of the treated crop (Table 2-3). Maximum decrease was observed in the case of seeds followed by root, stem and leaf over their respective controls. This is attributed to decline in carbohydrate reserve leading to break down of fats that are first hydrolyzed in the presence of lipases to yield fatty acids and glycerol. Suppression of fat metabolism is accounted by inhibitory action of heavy metals, sodium and chlorides on fatty acid synthesizing enzymes [16].

Acknowledgements

The authors are thankful to the Principal, Hindu College, Moradabad for providing necessary laboratory facilities and providing financial assistance.

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