Physico-chemical analysis of treated distillery effluent irrigation responses on crop plants pea (*Pisum sativum*) and wheat (*Triticum aestivum*)

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Abstract

Physico-chemical properties of distillery effluent and their responses of different concentrations like 0%, 25%, 50%, 75% and 100% on crop plants, i.e. pea and wheat were studied under field condition. Where waste water is acidic in nature with high dissolved salts and organic load, on subsequent dilution it is serving as liquid fertilizer up to 50% effluent concentration, > 50% effluent concentration it is posing inhibitory effect on the tested crops, further work on marginal dilution are needed to substantiate the present study. [Life Science Journal. 2009; 6(1): 84 – 89] (ISSN: 1097 – 8135).

Keywords: distillery effluent; physico-chemical parameters; crop response parameters; *Pisum sativum*; *Triticum aestivum*

1 Introduction

Water pollution is prime cause of unavailability of the suitable water for irrigation purpose. Where agro-based industries are the most culprit. The total waste water produced per liter of alcohol production is around 40 to 50 liters (Vasanthy *et al*, 2006). About 40.72 million/ m^3 spent wash is generated annually from distilleries in India, considerable amount of plant nutrients are available in distillery effluent like: N = 1,660 to 4,200 mg/L, P = 225 to 3,038 mg/L, K = 9,600 mg/L, Cl = 7,238 to 42,096 mg/L, Ca = 2,050 to 7,000 mg/L, Mg = 1,715 to 2,100 mg/L, SO_4 = 240 to 425 mg/L. It also contains plant growth promoters like gibberellic acid (GA) and indol acetic acid (IAA) nearly 3246 mg/L with good fertilizers value, it contains high biological oxygen demand (BOD) and chemical oxygen demand (COD) and organic compounds like phenol, lignin, oil and grease which deteriorate the surroundings. Some compounds like endol, sketol and other sulphur compounds which not under goes effective degradation by yeast and methanogenic bacteria, are the cause of objectionable smell of distillery effluent (Murugaragavan, 2002). In water scarce situation effluent is single permanent water source for irrigation, consequently causes positive effect at lower concentrations in this relation studied has been carried out (Rani and Srivastava, 1990; Subramani, 1995; Pandey *et al*, 2007). Adverse effect on the plant and soil has been find on higher concentrations of the effluent (EC). The present study is an effort to analyze the effluent's physico-chemical parameters and their relative response on pea and wheat to speculate its suitability for irrigation purpose at their marginal dilutions.

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2 Materials and Methods

2.1 Study area

Ghazipur a suburban area of district headquarters, located in the eastern Gangetic plain of the Indian sub continent at 25º 19' and 25º 54' N latitude, 83º 4' and 83º

58' E longitude and 67.50 m above the sea level. The experiment was carried out between October 2000 to January 2001. This period of the year is characterized by mean monthly maximum temperatures between 18.6 ºC and 34.1 ºC and mean monthly minimum temperatures between 5.4 ºC and 16.7 ºC. Maximum relative humidity varied from 95% to 100% and minimum from 69% to 71%.

2.2 Selection of seeds

Seeds of wheat (*Triticum aestivum*) Var. K68 and field pea (*Pisum sativum*) Var. Swati (KFPD-24) were chosen for the experimental work both adoptive to the site of the study (Eastern U.P.) India, and recently developed and exceedingly espouse high yield varieties.

2.3 Experimental design and set up

Experiment was carried out on farmhouse near P.G. College, Ghazipur. Plot area about 24 × 15 feet, and individual replicates size was 3 × 3 feet. There were five treatments and each treatment having 3 replicates in each, means whole area has been divided in to 40 plots, each plots have separated by 20 cm deep bricks around the each plot boundary. About 100 seeds of wheat and 50 seeds of pea with uniform size for each variety were selected for each plot, the seeds were surface sterilized in 5% sodium hypochlorite solution to remove the microbial contamination, then seed were thoroughly washed with de-ionized water. The plots were prepared by proper tillage, then seeds were sown in the plots and were irrigated with 5 litter of different concentrations of the distillery effluents like 0%, 25%, 50%, 75% & 100% (here the distillery effluents are over diluted by the factory before discharge) at the interval of 5 days or as per its requirements, after 65 days plants were take-up and roots were very carefully wash to remove the soil particles along with constant safety of secondary roots.

2.4 Waste water analysis

The experiment was conducted at Department of Evironmental Science, P.G. College, Ghazipur where pH was measured with the help of pH meter (Model No. 101 E) of Electronic India, standardized with pH buffer 4, 7 and 9.2. Total dissolved solids (TDS) was estimated by evaporation method at 180 ºC, alkalinity, BOD, COD, hardness, dissolved oxygen (DO), chloride, CO_2 and all parameters were analyzed by standard procedure mentioned in APHA (1995).

2.5 Estimation of germination %, root length, shoot length and No. of secondary roots, girth of plants, leaf area and vigor index

Germination percentage was calculated by dividing the seed germinated on each day by total No. of seed taken × 100. And finally adding the total percentage. Root, and shoot length measured by normal scale of 150 mm size. Girth was measured by screw gauge; vigor index measured by Jain and Saha (1971), leaf area was measured using portable leaf area meter (Model LT 3100, LICOR).

2.6 Estimation of chlorophylls

The chlorophyll contents of primary leaves were estimated with 80% acetone with help of spectrophotometer (Hitachi, Ltd. Tokyo) (Jain and Saha, 1971).

Chlorophyll a = (0.0127) (OD_{663}) – (0.00269) (OD_{645}) gm/lit.

Chlorophyll b = (0.0229) (OD_{645}) – (0.00488) (OD_{638}) gm/lit.

Total chlorophyll = (0.0202) (OD_{645}) + (0.00802) (OD_{663}) gm/lit.

2.7 Statistical analysis

The data were subjected to mean and one way ANOVA (analysis of variance) using SPSS ver. 10 software Ducan's multiple range test performed to test the significance difference among the treatments.

3 Results

The waste water analysis results (Table 1) revealed that all the values of the different tested parameters were not compatible to the Bureau of Indian Standard (BIS). Total solid (TS), TDS, total suspended solids (TSS) values were nearly two times higher. The value of total alkalinity and total hardness were nearly one and half times higher compared to bureau of Indian standard. Value of the calcium was 182 about (7.69%) higher than BIS (169). Chloride's value was 875 about (45.83%) more than BIS (600). BOD value was 808 and COD value was 2,020 extremely higher about 2593 % and 708% than BIS values respectively. DO level was very lower < 2 than BIS value (4 – 6).

In plant responses tests, the treatments on wheat (Table 2), the entire maximum values of the plant response parameters achieved at 50% EC, except germination, chlorophyll b and root length. Maximum value of root length and chlorophyll b achieved at 25% concentration and maximum germination achieved at control condition. In case of treatments on pea (Table 3), the entire maximum values achieved at 50% EC except germination percentage, No. of functional leaves and girth of plant. No. of functional leaf, girth of plant and germination achieved maxima at control condition.

In both plant response cases (pea and wheat), vigor achieved maxima at 50% concentration effluent and gradually decreases on further elevation on concentration (Table 4). The leaf area of wheat achieved maxima at 50% concentration and in pea (*Pisum sativum*) maxima was at control condition (Table 4). Effect of growth retardation is significant (at 0.05 level of significance) and vigorous on elevated concentrations more than 50% concentration of the effluent as evident by the aforementioned tables, while in number of functional leaves, root length and number of secondary roots (where the retardation is non significant at 0.05 level of significance).

Co-relation study revealed there is a positive correlation with increasing level of the effluent concentration up to 50% concentration of treated dis-

Table 1. Waste water analysis of treated distillery effluent

Parameters	Value	BIS
Temperatures (ºC)	38 ± 0.27	40
Color	Reddish	None
TS (mg/L)	4080 ± 0.07	2100
TDS (mg/L)	3800 ± 0.08	2100
TSS (mg/L)	280 ± 0.09	100
pH	6.5 ± 0.08	5.5 – 9
Total alkalinity (mg/L)	1437.5 ± 0.39	–
Total hardness (mg/L)	565 ± 0.05	300
Ca hardness (mg/L)	455 ± 0.05	–
Calcium (mg/L)	182 ± 0.22	169
Chloride (mg/L)	875 ± 0.56	600
DO (mg/L)	< 2	4 – 6
BOD (mg/L)	808 ± 0.76	30
COD (mg/L)	2020 ± 0.20	250
Na (mg/L)	1312 ± 0.50	–
EC	18 ± 0.9	–

Table 2. Effect of different dilution of treated distillery effluent on the growth parameters and chlorophyll content of wheat (*Triticum aestivum*)

Treatment	% germination	Shoot length (cm)	No. of functional leaf	Girth of plant (mm)	Length of root (cm)	No. of second roots	Total chlorophyll (mg/L)	Chlorophyll a (mg/L)	Chlorophyll b (mg/L)
Control	98 ± 0.11^{a}	12.3 ± 0.11^{c}	4 ± 0.57^{a}	1.23 ± 0.0096^{c}	8.85 ± 0.20^{b}	5 ± 0.57^{b}	0.006377 ± 0.037E-3^{c}	0.00230 ± 0.012E-3^{c}	0.00388 ± 0.041^{a}
25%	89 ± 0.33^{b}	14.85 ± 0.16^{b}	4 ± 1.1^{a}	1.56 ± 0.0097^{b}	12.90 ± 0.0076^{a}	6 ± 1.1^{ab}	0.00833 ± 0.02E-3^{b}	0.00241 ± 0.014E-2^{c}	0.00519 ± 0.06^{a}
50%	67 ± 0.57^{c}	19.57 ± 0.57^{a}	4 ± 0.57^{a}	2.45 ± 0.10^{a}	9.19 ± 0.0086^{b}	10 ± 2^{a}	0.00986 ± 0.067E-3^{a}	0.0271 ± 0.049E-2^{a}	0.00724 ± 0.011^{b}
75%	61 ± 0.66^{d}	15.15 ± 0.45^{b}	4 ± 0.57^{a}	2.45 ± 0.005^{a}	8.77 ± 0.0088^{b}	9 ± 1^{ab}	0.00608 ± 0.068E-3^{c}	0.0266 ± 0.062E-2^{a}	0.00388 ± 0.012^{a}
100%	30 ± 0.00^{e}	5.02 ± 0.56^{d}	3 ± 0.57^{a}	1.08 ± 0.006^{c}	8.85 ± 0.125^{b}	9 ± 0.57^{ab}	0.00550 ± 0.00^{d}	0.00835 ± 0.021E-2^{b}	0.00363 ± 0.012^{a}

Different letters in each group showed significant difference at $P < 0.05$ levels (Mean ± Stand. error).

Table 3. Effect of different dilution of treated distillery effluent on the growth parameters and chlorophyll content of pea (*Pisum sativum*)

Treatment	% germination	Shoot length (cm)	No. of functional leaf	Girth of plant (mm)	Length of root (cm)	No. of second roots	Total chlorophyll (mg/L)	Chlorophyll a (mg/L)	Chlorophyll b (mg/L)
Control	100 ± 0.0^{a}	31. 34 ± 1.1^{b}	27.42 ± 0.57^{a}	1.547 ± 0.007^{a}	7.0 ± 0.76^{a}	13 ± 0.57^{bc}	0.00694 ± 0.03E-4^{c}	0.00134 ± 0.20E-5^{b}	0.00388 ± 0.47E-5^{b}
25%	98 ± 1^{a}	30.69 ± 0.26^{b}	21.24 ± 2.6^{b}	1.40 ± 0.005^{ab}	7.5 ± 0.76^{a}	15 ± 0.66^{b}	0.00852 ± 0.02E-4^{b}	0.00281 ± 0.66E-5^{b}	0.0035 ± 0.45E-4^{b}
50%	89 ± 0.33^{b}	36.32 ± 1.7^{a}	20.00 ± 0.00^{b}	1.26 ± 0.006^{b}	7.53 ± 0.00^{a}	19 ± 0.00^{a}	0.0635 ± 0.07E-4^{a}	0.0945 ± 0.1E-3^{a}	0.0053 ± 0.15E-4^{a}
75%	70 ± 1.1^{c}	31.60 ± 0.20^{b}	19.28 ± 0.57^{b}	1.47 ± 0.0056^{a}	7.08 ± 0.39^{a}	11 ± 1^{cd}	0.00424 ± 0.08E-5^{d}	0.000138 ± 0.4E-5^{b}	0.0027 ± 0.20E-4^{c}
100%	65 ± 1.5^{d}	16.98 ± 0.13^{c}	18.4 ± 0.3^{b}	1.22 ± 0.0056^{b}	6.9 ± 0.37^{a}	10 ±1.1^{d}	0.00400 ± 0.00^{d}	0.000127 ± 0.8E-5^{b}	0.0022 ± 0.00^{c}

Different letters in each group showed significant difference at $P < 0.05$ levels (Mean ± Stand. error).

Table 4. Reading of the vigor index and the leaf area

Treatment	Vigor index		Leaf area (cm^2)	
	Pea	Wheat	Pea	Wheat
Control	3014.40 ± 3.3^{a}	1306.50 ± 2.3^{a}	4.86 ± 0.009^{a}	27.5 ± 0.25^{d}
25%	2359.60 ± 1^{b}	1317.20 ± 3.8^{a}	4.48 ± 0.003^{b}	38.48 ± 0.002^{b}
50%	1861.69 ± 3.5^{bc}	1805.40 ± 6.0^{a}	3.96 ± 0.09^{c}	47.30 ± 0.008^{a}
75%	1738.00 ± 3.2^{ab}	921.10 ± 3.2^{ab}	4.42 ± 0.007^{b}	32.20 ± 0.41^{c}
100%	439.00 ± 2.6^{d}	150.60 ± 1.77^{b}	2.02 ± 0.004^{d}	24.7 ± 0.15^{e}

tillery effluent in case of pea *(Pisum sativum*) and wheat (*Triticum aestivum*) as shown in and Figures 1 – 6 and 7 – 12, respectively.

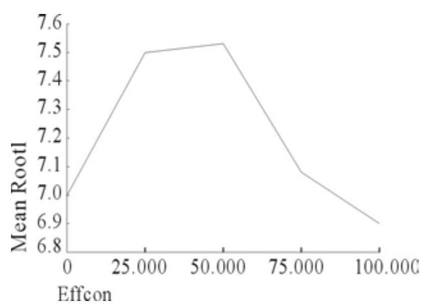

Figure 1. Co-relationship between varying levels of effluent concentrations and their responses on root length of pea.

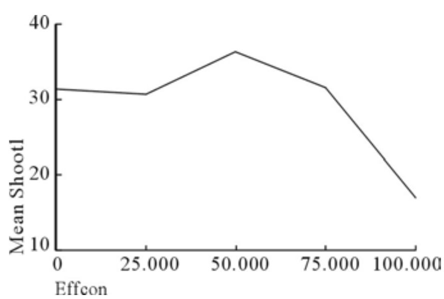

Figure 2. Co-relationship between varying levels of effluent concentrations and their responses on shoot length of pea.

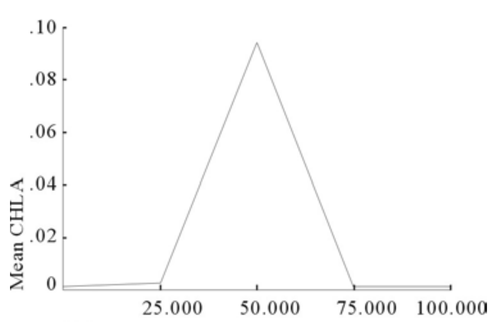

Figure 3. Co-relationship between varying levels of effluent concentrations and their responses on chlorophyll a of pea.

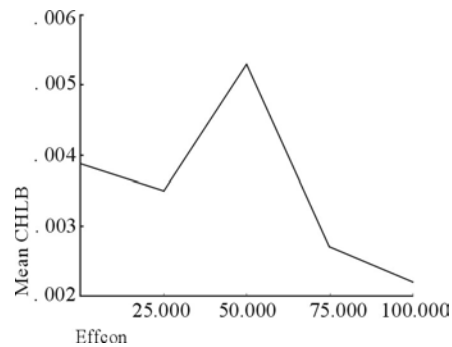

Figure 4. Co-relationship between varying levels of effluent concentrations and their responses on chlorophyll b of pea.

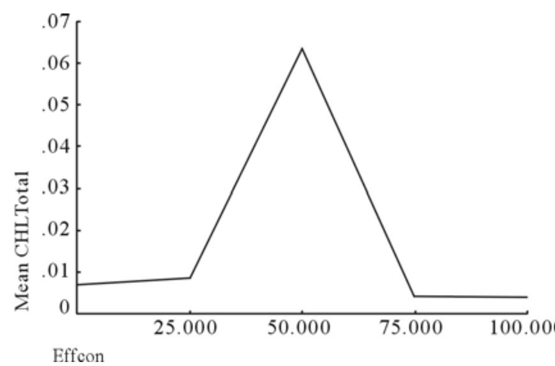

Figure 5. Co-relationship between varying levels of effluent concentrations and their responses on Total chlorophyll of pea.

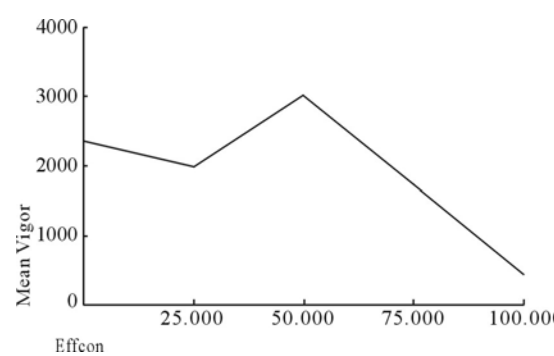

Figure 6. Co-relationship between varying levels of effluent concentrations and their responses on Vigor of pea.

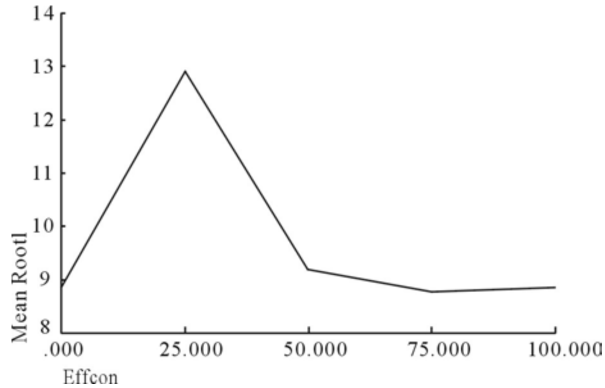

Figure 7. Co-relationship between varying levels of effluent concentrations and their responses on root length of wheat.

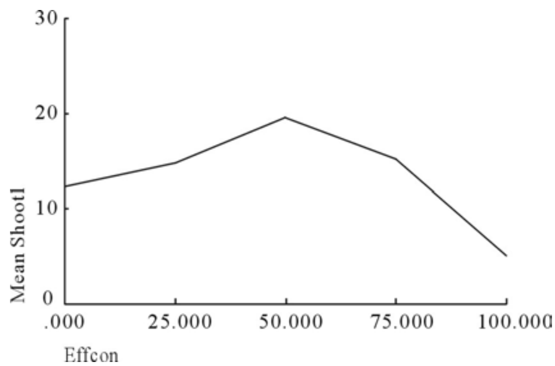

Figure 8. Co-relationship between varying levels of effluent concentrations and their responses on shoot length of wheat.

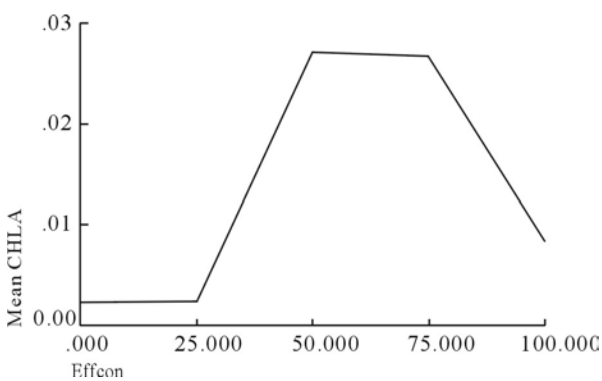

Figure 9. Co-relationship between varying levels of effluent concentrations and their responses on chlorophyll a of wheat.

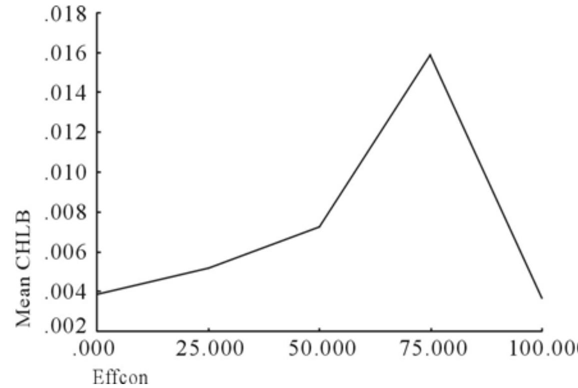

Figure 10. Co-relationship between varying levels of effluent concentrations and their responses on chlorophyll b of wheat.

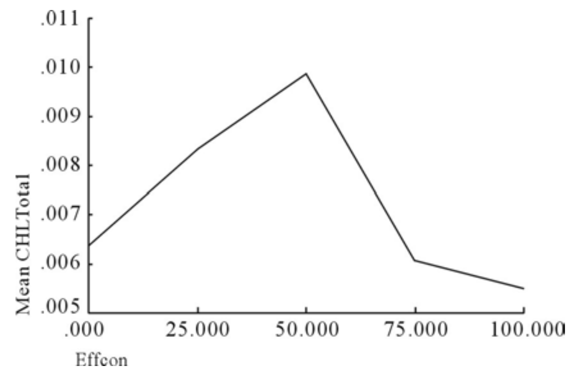

Figure 11. Co-relationship between varying levels of effluent concentrations and their responses on total chlorophyll of wheat.

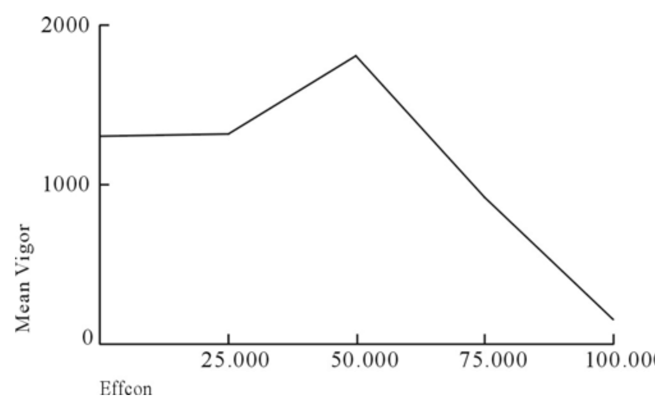

Figure 12. Co-relationship between varying levels of effluent concentrations and their responses on vigor of wheat.

4 Discussion

The extremely higher TS indicates that the effluent is very saline at the same time higher BOD and COD indicates higher organic loads, the cause of the adverse effect on the germination is the higher salinity evident by the higher EC value. The root growth at all levels (Non significant difference at 0.05 level of significance) indicates that it is not the heavy metals which has been retarding the growth parameters but the higher salinity and higher organic load, causing a cumulative retardation effect on the growth and biochemical parameters of the pea and wheat. The salinity in rhizosphere causes a higher osmotic pressure evident by higher electrical conductivity, it causes low wall pressure and deficit of suction pressure, causes narrowing of the water balance required. The lowering water balance lowering the respiration of the plants. While increase in the organic matter content in soil increase the biodegradation and elevates the CO_2 level in rhizosphere, affecting the respiration. Three factors which governs the respiration of plants are CO_2 level in soil, water supply and temperature here CO_2 level in soil is higher, water is physiologically scarce and low temperature. These all coincide causing encumbrance in respiration, resultant is the adverse effect on physiological and biochemical parameters. The positive response on the growth parameters are at 25% to 50% concentration of the effluent is probably due to effect of effluent as liquid fertilizer (Subramani *et al*, 1995). And as gradually the concentration raises growth retardation is vigorous. It is possibly due to excess of nitrogen, phosphate, potassium, sulphate, calcium, and chloride by affecting the water absorption and other metabolic process in plants (Rani and Srivastava, 1990; Chandra *et al*, 2002). Correlations study suggested that the $\leq$ 50% concentration of distillery effluent having positive correlations with root length, shoot length, chlorophyll a, chlorophyll b, total cholorophyll, vigor, but the intra pigment dependencies are not certain for both pea and wheat plants. Still further work on marginal dilution is needed to substantiate the present study.

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