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EFFECT OF TEXTILE FACTORY EFFLUENT IRRIGATION ON PRODUCTIVITY OF WHEAT CROP

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Abstract: The effect of treated textile (synthetic fiber) factory effluent irrigation on different productivity parameters of wheat crop (var. L. cv. HD-1553) were studied in field conditions at Naini industrial area in comparison to control. Length of ear m^{-2}, No. of grain ear^{-1} and yield (Q/ ha) were found higher in effluent irrigated crop in comparison to control. The control showed higher values in No. of plants m^{-2}, No. of ears m^{-2}, plant height (cm), test weight (wt. of 1000 grains in gm.) and protein content (11.37 %) in comparison to effluent irrigated crop.
Keywords: Textile factory, Effluent, Irrigation, Crop productivity.

1. INTRODUCTION

Wastewater is being used for agriculture throughout the entire tropical and semitropical areas of the world. Recycling of wastewater for irrigation purposes may not only solve the disposal problem but also serve as an additional source of liquid fertilizer providing all the macro and micro nutrients and elements needed for the growing crops (Joshi et al., 1996; Kannabiram and Harilal, 1992). But indiscriminate discharge of huge amount of wastewater into natural water bodies or nearby area by the industries, which is a the common practice in India, posing serious problems to cultivated fields specially of the area where due to water scarcity, farmers are compelled to use the industrial wastewater for irrigation without knowing the direct and long term impacts of wastewater irrigation (Christou et al., 2014). Previous studies revealed that textile mill effluents particularly at higher concentration inhibit germination and growth of crop plants seedlings (Dutta and Boissya, 1997; Singh et al., 2006) as well as adversity effects the soil fertility (Nema et al., 1990; Castro et al., 2015) and crop productivity (Ajmal and Khan, 1985; Carr et al., 2011). Keeping these facts in view, an attempt has been made to assess the extent to which textile factory effluents affect the yield component of wheat

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(*Triticum aestivum*) viz., collected from the farmer's fields which are using the factory wastewater for their cropland irrigation. The aim of this study is to test whether textile factory wastewater can be used for irrigation of wheat crop plants. The study also helps in understanding of the physico-chemical characteristics and heavy metal content in industrial wastewater and their role on yield and quality aspects on irrigated crop.

2. MATERIAL AND METHOD

2.1 Study Area, collection of samples and quality analysis for wastewater samples: Wastewater samples were collected from Naini, an industrial area of Allahabad district, Uttar Pradesh, India (Figure 1). At Naini industrial site, Racron, a synthetic fibres (polyester yarn) manufacturing textile industry and their treated wastewater is disposed off and drain out by common drainage channel in the adjoining areas of farmers' field and is being used for irrigating the crops. Wastewater samples were collected from the identified sites during the different seasons of an year i.e., pre-monsoon, monsoon and post monsoon, while tube well water samples (control) were also collected for comparative studies. Samples were processed and analyzed for the various physico-chemical parameters viz., pH, EC, DO, BOD, COD, TS, TSS, TDS, TH, Ca, Mg, Cl as per the standard methods of APHA (1998). For heavy metals analysis samples were processed by acid digestion with 1:4 mixtures of $HClO_4$ and HNO_3 and measured by atomic absorption spectrophotometer.

2.2 Crop Productivity Analysis: The experiments with industrial wastewater effect on wheat crop (*Triticum aestivum*, var. L. cv. HD-1553) productivity were conducted at nearby farm's of Naini, where Racron industry wastewater is used for cropland irrigation. The experimental field for crop productivity analysis was performed by dividing the experimental plots into two subplots i.e. control and industrial wastewater irrigated field. At control subplot, the source of irrigation was tube well water (groundwater) and at experimental subplots, the source of irrigation was industrial wastewater. The crop productivity/yield parameters of the wheat crop i.e., no. of plants/ m^2, no. of Ears/ m^2, length of ear (cm), no. of grains/ ear, plant height (cm), test weight (gm) (wt. of 1000 seeds), yield (q ha^{-1}), straw yield (q ha^{-1}) were measured at the time of harvesting. Moisture content was analysed by heating sampled wheat grain's flour at 130-133 ^oC for 2 hours. The protein content of sampled wheat crop's grains (wheat flour) was done by the method as described by Lowry et al. (1951). For heavy metals analysis samples (wheat grain flour) were processed by acid digestion with 1:4 mixtures of $HClO_4$ and HNO_3 and measured by by using ICP- 8440 Plasmalab Latam Atomic Absorption Spectrophotometer (AAS).

2.3 Statistical Analysis: The data obtained after analysis was statistically analyzed by using analysis of variant (ANOVA), to test the statistical significance of the difference between the means of treatments.

3. RESULT AND DISCUSSION

3.1 Industrial wastewater quality: Results of the physico-chemical parameters and heavy metals analysis of Racron wastewater are presented in table-1 and 2. The results of physico-chemical parameters analysis indicated the high ($p<0.001$) level of EC, BOD, COD, Phosphate, TS, TDS, TSS, Ca, Cl, SO_4, K, Na, Na (%) and SAR followed by low ($p< 0.001$) level of DO, TA, TH and Mg indicating high nutrient and pollution load. Whereas, results of heavy metals analysis showed the high ($p<0.001$) concentration of Zn, Ni, Mn and Fe in comparison to control but where below than recommended limits (EPA, 2004).

3.2 (a) Crop productivity of wastewater irrigated wheat crop: Results of the analysis of Racron wastewater irrigated wheat crop (*Triticum aestivum*) variety HD-1553 at Naini site for crop productivity parameters are presented in table-3. Results of the analysis showed that number of grain/ ear (28 grain/ ear) was found significantly high ($p<0.01$) in wastewater irrigated crop than control. Length of ear (7.8 cm), yield (20.29 q ha^{-1}) and straw yield (29.42 q ha^{-1}) were also found high in wastewater irrigated crop than control. The high values of yield parameters of wastewater irrigated wheat crop productivity indicate the positive impact of wastewater irrigation on wheat crop productivity. This was due to use of treated wastewater for wheat crop irrigation, as the wastewater has manurial potential due to presence of essential nutrients (P, K, S) required for higher wheat productivity (Devi, 1991; Srikanth and Rao, 1993).

Results of wheat crop quality irrigated with wastewater at Naini industrial area are presented in the table-4. The results revealed that moisture content (0.85 %) was low in wastewater irrigated crop samples than control. It indicates the negative impact of wastewater irrigation on wheat crop quality. The value of moisture content indicates that wastewater irrigated wheat grains are inferior to control and the standards recommended for the moisture content in wheat flour are given in table-5. However, value of moisture content in wastewater irrigated wheat flour sample has no harmful impact on bakery industry, as the values are in safe limits (table-5). The protein content (9.29 %) was found significantly low in industrial wastewater irrigated wheat crop than control, which showed negative impact of industrial wastewater on the quality of wheat crop. The reason for low values of moisture content and protein in wastewater irrigated wheat grains was mainly due to presence of high concentrations of heavy metals in wastewater used for crop irrigation, which accumulates in the crop and affect the enzymatic activity of crop plants (Shaikh et al., 2001; Keser, 2013).

3.2(b) Results of heavy metals analysis in wastewater irrigated wheat crop (*Triticum aestivum*) of Naini industrial area:

The results of heavy metals analysis in wastewater irrigated crop samples (wheat grains) collected from Naini industrial area are presented in table-6. It is quite obvious from result that Cu, Zn and Mn contents were found significantly high ($p<0.01$) in wastewater irrigated crop samples than control. The high concentration of heavy metals in analysed wastewater irrigated crop samples indicate the accumulation of heavy metals in wheat crop due to the presence of higher heavy metal contents in wastewater used for crop irrigation (Ghafoor et al., 2004) but were below the standards prescribed for maximum permissible limit of heavy metal in food articles (PFA, 1954) and hence safe for consumption. In spite of high concentration of metals in wastewater irrigated crop plants, the plant did not show any phenotypic symptoms due to competition among metals at binding site in plant tissues, which may reduce the effectiveness of individual metals (Tripathi et al., 1998 and Barman et al., 2001). The concentration of heavy metals in wastewater was also found below the standard limits for the heavy metals in irrigation water (Pescod, 1992). Therefore, wastewater irrigation has no significant harmful impact on crop yield. The use of wastewater having higher concentration of heavy metals can be harmful to crop and to consumers in a long run. The analysis of wastewater irrigated wheat crop samples proves the above facts as the concentrations of some heavy metals in wastewater irrigated crop samples were found many fold higher than the control (Javid et al., 2003).

4. CONCLUSION

The overall results of different wastewater irrigated wheat crops on yield/ productivity and quality parameters indicate the positive impact of wastewater on the irrigated crop. This may be attributed that the wastewater using for the irrigation of the wheat crop was treated. Therefore, the wastewater used for wheat crop irrigation was found safe on the basis of analysed crop yield parameters and standards prescribed for the crop yield quality as well as for irrigation water. Another reason for positive impact of wastewater irrigation on crop was due to presence of nutrients i.e. P, K and S which nourish the experimental crop better than control crop.

Reduction in some yield parameters such as number of grains/ear and test weight and quality parameters such as moisture and protein content followed by high level of heavy metal contents in wastewater irrigated crop is of special concern. Therefore, in long run, regular monitoring of heavy metal concentrations in wastewater irrigated soil and crops are essential to avoid the harmful impact on irrigated crops and consumers. Use of some soil improvement methods like addition of phosphate amendments in affected soil can also be adopted by the farmers for reducing heavy metal accumulation in soil by the long term use of wastewater in cropland irrigation (Mishra and Kumar, 1993).

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Table 1: Physico- chemical characteristics of wastewater samples collected from selected sites of Naini industrial area.

Wastewater characteristics	Control			Industrial Wastewater		
	Premonsoon	**Monsoon**	**Postmonsoon**	**Premonsoon**	**Monsoon**	**Postmonsoon**
pH	7.32 ± .03	7.61 ± .02	7.21 ± .05	8.0 ± .1**	8.1 ± .02**	7.82 ± .04**
EC (dSm^{-1})	0.98 ± .05	1.45 ± .01	0.89 ± .00	2.86 ± .02**	1.85 ± .00**	2.14 ± .03**
DO (mg/L)	4.2 ± .17	3.45 ± .08	3.9 ± .02	3.8 ± .02**	3.2 ± .02**	4.2 ± .06**
BOD (mg/L)	2.1 ± .00	4.2 ± .02	1.26 ± .04	26.21 ± .28	37.2 ± .08**	13.2 ± .05**
COD (mg/L)	8.4 ± .00	12.4 ± .06	6.7 ± .04	68.4 ± 2.2**	94.1 ± 1.6**	28.7 ± 2.1**
Temp (^oC)	26 ± .00	27 ± .00	26 ± .00	26 ± .00	28 ± .00	26 ± .00
TA (mg/L)	432.3 ± 5.8	320 ± 3.4	174.4 ± 4.1	262.8 ± 5.8**	193.3 ± 2.1**	87.2 ± 3.7**
Phosphate (mg/L)	1.89 ± .35	1.3 ± .12	2.62 ± .01	19.1 ± 1.2**	1.97 ± .06**	24.2 ± .08**
TS (mg/L)	840 ± 5	950 ± 10	1020 ± 8	1500 ± 7**	1600 ± 10**	1320 ± 11**
TDS (mg/L)	785 ± 2	800 ± 3	780 ± 6	1475 ± 3**	1500 ± 3**	1310 ± .00**
TSS (mg/L)	55 ± 2	150 ± 3	240 ± 6	25 ± 3**	100 ± 3**	10 ± .00**
TH (mg/L)	641.2 ± 5.77	525.4 ± 3.2	420 ± 2.5	671.2 ± 6.3**	592.3 ± 1.3**	461.4 ± .27**
Ca (mg/L)	8.94 ± 0.46	12.24 ± .42	10.2 ± 1.2	65.7 ± 2.3**	125.3 ± 3.1**	120.8 ± .51**
Mg (mg/L)	112.2 ± 1.56	119.6 ± .86	122.4 ± .42	63.47 ± 2.6**	67.52 ± 1.4**	1.4 ± .02**
Cl (mg/L)	12 ± 1.2	105.2 ± 8.6	610.2 ± 12.6	820.9 ± 1.7**	404.8 ± 10.1**	1210.7 ± 12.8**
SO_4 (mg/L)	9.2 ± .35	1.8 ± 0.2	12.1 ± .00	87.2 ± 2.4**	2.65 ± .00	62.4 ± 3.25 **
K (mg/L)	2.67 ± .00	4.8 ± .00	3.24 ± .02	1.0 ± .00**	7.4 ± .2**	1.3 ± .00**
Na (mg/L)	29.4 ± 2.5	70.8 ± 4.5	65.52 ± 3.54	74.32 ± 2.2**	72.78 ± 3.3	44.51 ± 2.52**
Na (%)	19.18 ± 1.8	34.11 ± 2.2	32.53 ± 1.8	36.39 ± 1.5**	26.66 ± 1.8**	36.77 ± 1.1**
SAR	0.471 ± .12	1.090 ± .18	1.005 ± .13	1.156 ± .12**	0.926 ± .01**	0.712 ± .05**

* Above values are average ± SD of three determinations.
** Indicates p < 0.01 at significant level (1%).

Table 2: Results of the analysis of heavy metals (mg/L) in wastewater samples collected from Naini industrial area

*Metals	Naini Industrial Area		***Recommended Maximum Concentration (mg/l) (EPA, 2004)
	Control	Industrial Wastewater	
Cd	<0.001 ± .00	<0.010 ± .00	0.01
Zn	0.081 ± .002	0.195 ± .002**	2.0
Ni	0.065 ± .004	0.08 ± .005**	0.20
Pb	0.28 ± .0002	0.69 ± .003**	5.0
Cu	<0.003 ± .00	<0.005 ± .00	0.20
Mn	<0.0131 ± .00	0.0514 ± .00**	0.20
Co	ND ± .00	0.003 ± .00	0.05
Fe	0.123 ± .003	0.361 ± .004**	5.0

*Above values are average ± SD of three determinations, ND = Not detected
** Indicates $p < 0.01$ at significant level (1%).
**** Recommended limits for short-term use of wastewater reuse in crop irrigation; Source: Guidelines for Water Reuse: EPA/ 625/ R-04/ 108 (EPA, 2004).

Table 3: Productivity/ yield parameters of wheat crop (*Triticum aestivum*) variety HD-1553 at Naini site.

S.No.	Yield/ Productivity Parameters	Naini Industrial Area	
		Control	Industrial w.w. irrigated
1.	No. of plants/ m^2	62 ± 1.5	53 ± 1.15**
2.	No. of Ears/ m^2	244 ± 5.29	185 ± 5.0**
3.	Length of Ear (cm)	7.1 ± 0.7	7.8 ± 0.11
4.	No. of grains/ Ear	20 ± 2.1	28 ± 1.5**
5.	Plant height (cm)	78.9 ± 3.0	74.8 ± 2.6
6.	Test weight (gm) (wt. of 1000 seeds)	39.34 ± 1.9	39.17 ± 1.7
7.	Yield (q ha^{-1})	19.2 ± 2.31	20.29 ± 2.1
8.	Straw Yield (q ha^{-1})	27.07 ± 4.1	29.42 ± 3.83

*Above values are average ± SD of three determinations.
** Indicates $p < 0.01$ at significant level (1%).

Table 4: Results of the analysis of wastewater irrigated wheat crop (*Triticum aestivum*) variety HD-1553 collected from Naini industrial area

S.No.	Quality parameters	Naini Industrial Area	
		Control	Industrial wastewater irrigated
1.	Moisture content (%)	0.93 ± 0.072	0.85 ± 0.078
2.	Protein content (%)	11.37 ± 1.64	9.29 ± 0.813**

*Above values are average ± SD of three determinations.
** Indicates p < 0.01 at significant level (1%).

Table 5: Standards of Moisture content in wheat flour.

S.No.	Quality of wheat flour	Moisture content (%)*
1.	Good	0.9 - 1.01
2.	Low	0.9>
3.	Harmful (for the bread preparation)	1.01/ 1.04<

*Source: Chopra and Kanwar (1999)

Table 6: Results of heavy metals (mg/g) analysis in wastewater irrigated wheat crop (*Triticum aestivum*) variety HD-1553 collected from Naini industrial area

S.No.	Metals*	Naini Industrial Area		*** Permissible Limits
		Control	Industrial wastewater irrigated	(PFA, 1954)
1.	Fe	ND	ND	-
2.	Cu	0.268 ± .007	0.44 ± .002**	30.0
3.	Mn	0.276 ± .002	0.636 ± .012**	-
4.	Zn	1.04 ± .010	1.256 ± .004**	50.0
5.	Pb	ND	ND	2.5
6.	Cd	ND	ND	1.5

* Above values are average ± SD of three determinations, ND = Not detected
** Indicates p < 0.01 at significant level (1%).
***Source: Standards of Wheat prescribed in Indian Prevention of Food Adulteration Act (PFA, 1954).

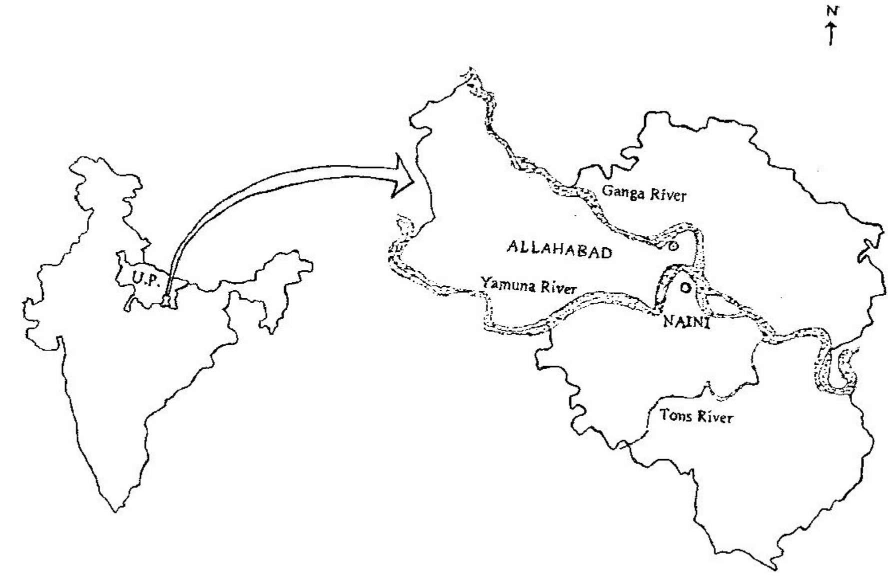

Figure 1: Location of sampling site at Naini, Allahabad district, Uttar Pradesh.