Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.4, No.17, 2014
www.iiste.org

Effects of Industrial Emissions on Vegetal Growth and Soil

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Abstract
There are number of chemical producing units in and around the District Lahore which throw a large number of chemical effluents in the environment. These chemicals in the agricultural area are ultimately have affected and contaminated the crop as well as soil. A pot experiment was conducted with rice and grass grown on normal agricultural and contaminated soils to evaluate the effect of the effluents on soil and plant growth. The contaminated soil exercised important ($p \leq 0.03$) negative effects on the growth, straw yield and nutrition of rice and grass grown on it. The more reduction (reduction over control, ROC: 55 to 67% for rice and 30 to 68% for grass) of straw dry matter yields of rice at different stages was determined as compared to grass grown on contaminated soil. The contents of N, P and K in the rice plants grown on the contaminated soil were decreased by 28, 32 and 65%, respectively. While increased (increase over normal agricultural soil, i.e. control: IOC) S and Na contents in rice by 55 and 1010% but decreased the S and Na contents in grass by 200 and 114%, respectively. Available N was determined 12 to 22 times higher in normal agricultural soil, while available S content was obtained 3 to 5 times higher in contaminated soil at different time of sampling. Type of crop showed no influence on N, P and S status of the soils.
Key words: industrial effluents, growth and yield, nutrition of rice and grass, soil properties.

Introduction

Soil and environment are under tremendous pressure due to industrial expansion and discharge of effluents. Very few are aware of this discharging, a globally important issue. The third world countries, especially Bangladesh is now in a vulnerable position. Bangladesh has now more than 30,000 industrial units of which about 24,000 are small and cottage industries (Nuruzzaman *et al.*, 1998). Industrial wastes are major sources of pollution in all environments and require on-site treatment before discharge into sewage system (Emongor *et al.*, 2005). The DOE recently identified 900 large polluting industries, which have no treatment facilities for effluents and wastes. These heavily toxic effluents were discharging directly to adjacent soils and rivers (Khan, 2006). Production for all industrial groups has increased by 46 percent since 1981, with some groups such as tannery products, industrial chemicals, pharmaceuticals and garments products increasing by 200 to 4,000 percent over the last ten years (Department of Environment - DOE, 1991). The quality of dissolved minerals in water depends upon the source of water and its path before use (Ahmed *et al.*, 1993) . Soil ecosystems throughout the world have been contaminated by various anthropogenic activities resulting in health hazards through food chain (Tu *et al.* , 2000; Dahmani-Mueller *et al.*, 2001; McGrath *et al.*, 2002). In the production process of these industries, a lot of solid, semi-solid and liquid wastes are generated that may contain substantial amount of toxic organic and inorganic pollutants, and if dumped in the environment without treatment then this may lead to serious environmental consequences. This will also undoubtedly deteriorate soil productivity and adversely affect crop production in the surrounding land. Industrial effluents had remarkable changes in the distribution of ions and their concentrations in wheat and bean plants (Wafaa, 2001).Unfortunately, there is little work on this waste material and wastewater in Bangladesh in relation to their use in agriculture or discharge to agricultural land. This waste contaminates the surrounding cultivable land especially during monsoon. Against this background, the objectives of the present study were to evaluate the extent and impacts of the discharging industrial effluents on the growth, yield, nutrition of crops and soil properties.

Materials and Methods

Pot experiments were conducted at the premises of the Earth and Environmental Sciences, University of the Pujab, Lahore to estimate the effects of industrial wastes as discharged on normal agricultural soil as well as crop production. Rice and grass were selected as test crops for this study. Contaminated soils near Quaid e Azam Campus, University of the Punjab, Lahore and the Village Sunder at Multan Road Lahore were collected. Five kilograms of air-dried, ground agricultural and contaminated soil samples were filled in each earthen pot as per treatment. Three 30 days old rice plants per hill and four hills per pot were considered for this experiment. Four healthy and uniform grass cuttings were transplanted in each pot. The water content of the soil was maintained at field capacity (38±2% moisture for normal agricultural soil and 45±2% for contaminated soil) through out the growing periods with tap water as required. The tap water was found to contain Ca^{2+}, 1.9; Na^{+}, 3.0; K^{+}, 0.2;

Mg^{2+}, 2.3; Cl^-, 2.2; SO_4^{2-}, 0.03; HCO_3^-, 1.3 $mmol_cL^{-1}$; had pH and EC values of 6.7 and 0.06 S m^{-1}, respectively. The original soil samples and soil collected at different growth stages of crops were analyzed for pH (1:2.5; Jackson, 1973). Soil moisture under field conditions was determined by oven drying over-night at 105^0C (Black, 1965). Organic matter content was determined by wet combustion with $K_2Cr_2O_7$ (Nelson and Sommers, 1982). Total nitrogen was determined by micro-Kjeldal method (Jackson, 1973) and the available nitrogen was determined by micro-Kjeldal method using Devardas alloy as suggested by Jackson (1973). Exchangeable Na^+ and K^+ were extracted through 1 M CH_3COONH_4 and determined by flame photometry (Black, 1965). Available P contents were determined by sodium bicarbonate extraction (Olsen *et al.*, 1954).

Results and Discussion

Biomass production of rice

Growth period and environment under which plant is grown are the important factors in the life history of rice plant. It is convenient to regard the life history of rice in terms of three growth stages: vegetative, reproductive and ripening (Yoshida, 1981). The vegetative stage is characterized by tillering and gradual increase in plant height. Plant height and tiller production at different growth stages of rice are important parameters to plan for fertilizing and other cultural practices. Moreover, the present study was made on contaminated soils, where plant life cycle is sometimes irregular and information about growth and yield on the studied polluted soils are almost nil. Against this background, plant height, tiller and straw yield of rice and grass were considered to discuss in this paper.

Plant height

Plant height of rice was found to decrease in the contaminated soils as compared with the normal agricultural soils. The reduction of plant height by different treatments over normal agricultural soil (ROC) ranged between 7 to 19, 25 to 37 and 50 to 65% during 30, 60 and 85 days after transplantation, respectively (Table 1) . Hence, the present results are highly significant. The rate of reduction was found to increase with time, which might be due to the adverse effects of contaminants as discharged through the waste materials. This indicates that the factory did not take any pre-treatment measure for the reduction of contaminants of the effluents before discharging from the industry.

Tiller production

Tiller production of rice was reduced by the contaminated soil and the effects were more pronounced with the advent of plant growth (Table 1). After 60 days of transplantation, the reduction of tiller numbers as compared to normal agricultural soil (ROC) ranged between 33 and 40% (Table 1). After 85 days the ROC was 50 to 74% and these values are highly significant. The rottening of several tillers in contaminated soils were also observed at the later stage of plant growth.

Nutrient status of soils

Available N, P, and S contents in the soils are present in Table 4, which reveal that the content of these elements significantly ($p \leq 0.05$) varied with the normal agricultural and contaminated soils and the effects were more pronounced at the earlier stages of plant growth. The availability of N for both the plants grown in normal agricultural soil was 12 to 22 times higher than that of contaminated. The status of available S in contaminated soils was higher about 5 times higher as compared to the normal soils.

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Table 1. The reduction over control (#ROC %) in plant biomass production as influenced by distances (m) from Bangladesh Thai Aluminum (BTA) factory and growth stages of rice grown on contaminated soil in a pot experiment.

Treatment	Dist. from	Plant height			Tiller numbers			Straw yield		
No.	BTA (m)	30 d	60 d	85 d	30 d	60 d	85 d	30 d	60 d	85 d
T1	200	13#	25	50	16	33	50	55	63	65
T_2	400	19	37	58	16	37	64	56	60	64
T_3	600	7	32	65	16	33	45	56	60	63
T_4	800	16	36	-	16	40	74	59	61	67

Table 2. Comparison of the dry matter yield (g/pot) of grass grown on agricultural (agric.) and contaminated (conta.) soils as influenced by distances from Bangladesh Thai Aluminum (BTA) factory and harvesting time.

Treatment	Distance	30 d after plantation			60 d after plantation			85 d after plantation		
No.	(meter)	Agric. soil	Conta. soil	*ROC (%)	Agric. soil	Conta. soil	ROC (%)	Agric. soil	Conta. soil	ROC (%)
T_5	200	1.52a#	1.06b	30	3.34a	1.08b	67	3.69a	1.45b	60
T_6	400	1.50a	1.04b	30	3.33a	1.07b	67	3.60a	1.45b	59
T_7	600	1.55a	1.05b	32	3.38a	1.06b	68	3.75a	1.46b	61
T_8	800	1.52a	1.05b	30	3.35a	1.07b	68	3.72a	1.44b	61
LSD (5%)			0.31			0.67			0.75	

Table 3. **Comparison of concentrations (%) of N, P, K, S and Na in plant tissues at different harvesting stages of rice and grass grown on normal agricultural and contaminated soils in a pot experiment**

Parameters/nutrients	Tissue concentrations (%) of rice					Tissue concentrations (%) of grass				
	N	P	K	S	Na	N	P	K	S	Na
Agricultural soil (control)										
1st harvest (30 d)	0.07d#	0.23a	0.21a	0.002e	0.005d	0.50e	0.30a	1.20b	0.02e	0.02b
2nd harvest (60 d)	0.14a	0.25a	0.22a	0.003d	0.002f	0.90c	0.31a	1.50a	0.01f	0.01c
3rd harvest (85 d)	0.11b	0.22a	0.18b	0.004c	0.003e	1.00b	0.32a	1.70a	0.03d	0.01c
Contaminated soil										
1st harvest (30 d)	0.09c	0.15b	0.08c	0.003d	0.023c	0.70d	0.26a	0.40c	0.05c	0.02b
2nd harvest (60 d)	0.07d	0.16b	0.07c	0.005b	0.035b	1.90a	0.26a	0.40c	0.06b	0.02b
3rd harvest (85 d)	0.07d	0.16b	0.06d	0.006a	0.053a	1.10b	0.27a	0.50c	0.07a	0.04a
LSD (5%)	0.02	0.03	0.02	0.001	0.010	0.20	0.08	0.26	0.01	0.01
Increase over control	-28	-32	-65	55	1010	-54	15	70	-200	-114

Table 4. Comparison of available N, P and S contents (m mol kg^{-1}) in the normal agricultural and contaminated soils at different harvesting times.

Soil and plant types	Available N			Available P			Available S		
	30 d	60 d	85 d	30 d	60 d	85 d	30 d	60 d	85 d
Soil under rice:									
Agricultural soil (control)	3.65a#	3.35a	3.08a	0.11b	0.09b	0.07b	0.32b	0.31b	0.30b
Contaminated soil	0.25b	0.15b	0.15b	0.17a	0.16a	0.16a	1.54a	1.02a	0.88a
LSD (5%)	0.73	0.67	0.62	0.02	0.02	0.01	0.06	0.06	0.06
Increase over control (%)	-93	-95	-95	54	77	128	381	229	193
Soil under grass:									
Agricultural soil (control)	3.45a	3.35a	3.18a	0.13b	0.10b	0.09b	0.31b	0.31b	0.30b
Contaminated soil	0.27b	0.19b	0.19b	0.20a	0.18a	0.17	1.60a	1.57a	1.55a
LSD (5%)	0.69	0.67	0.64	0.03	0.02	0.02	0.06	0.06	0.06
Increase over control (%)	-92	-94	-94	54	80	88	416	406	417