INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2006/08–3–391–393
http://www.fspublishers.org

Accumulation of Heavy Metals in Soil and Rice Plant (*Oryza sativa* L.) Irrigated with Industrial Effluents

ALLAH NAWAZ, KASHIF KHURSHID, MUHAMMAD SALEEM ARIF AND A.M. RANJHA
Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad–38040, Pakistan
Corresponding author's e-mail: an_uaf@yahoo.com; kashif4libra@hotmail.com;

ABSTRACT

A field study was carried out to observe the effect of heavy metals polluted water on yield, yield components and heavy metal contents in paddy and straw of rice and soil. For this purpose three fine rice varieties were transplanted at three different sites in district Sheikhupura near the Bank of Nallah Daik irrigated with the Nallah Daik water. The contents of two heavy metals (Cu and Cd) after the harvest of rice crop were further increased but remained within safe limits in soil. These metals were higher in upper layers than the lower horizons. Similarly, minor accumulation of these heavy metals, under study were also observed, but remained within permissible limits.

Key Words: Metals; Rice plants; Irrigated; Industrial effluents

INTRODUCTION

Pakistan falls under arid and semi arid zone of the world. In Pakistan there is only 172 billion cubic meter fresh water available (Ahmad, 1988), which is not sufficient to meet the water requirements of the crops. To sustain irrigated agriculture, one option could be the use of contaminated water for irrigation. Untreated waste water irrigation on urban and sub-urban lands has long been practiced in several parts of the world due to its high contents of plant nutrients and due to lack of infrastructure and facilities for safe disposal. The urban agricultural soils of Pakistan are often irrigated with city effluents for growing vegetables (Ibrahim & Salmon, 1992; Qadir *et al.,* 1998). Farmers use it as a source of irrigation and nutrients (Ghafoor *et al.,* 1994) while the administrators consider it a viable practice for disposal. Even the well-planned capital city of Islamabad lacks proper management of effluents in its two industrial estates and the industrial and slaughterhouse wastes are drained in River Sawan (Mian *et al.,* 1998). These wastes may constitute of dangerous toxic materials, chemical compounds and organic material. Repeated direct discharges of these unwanted toxic materials in excess in the environment from industries bring the failure of self-cleaning mechanism of the universe.

Rice is an important cash crop of Pakistan. Its water requirement is more than any other crop, which is estimated as five-acre feet for one crop. However, due to shortage of irrigation water, the farmers use underground water. The main rice growing area of Pakistan named as Kallar tract consists of districts of Sialkot, Gujranwala, Hafizabad, part of Lahore, Qasur and Sheikhupura. A number of nallahs starting from Kashmir pass through this area. Nallahs Aik, Daik, Palkhu and Basantar being the most famous. Industrial effluents of many factories like Punjab Cables Ltd., Chaudary Cables (Pvt.) Limited, Rainbow Packages Ltd., Dipcon Industries (Pvt.) Limited, Star Silica Industries Ltd., Techpak Extraction (Pvt.) Limited, Ali Paper and Board Industries, Farooq Paper and Board Industries and Sufi Soap, Sufi Group of Industries fall into these nallahs. In rainy seasons these nallahs inundate the surrounding cropped area. Moreover, the farmers uplift this polluted water to irrigate rice fields. This practice is as old as the nallahs are. However, with the increase of population and development of industrial zone in the area, it has turned into menace. Since the use of such effluents may introduce some metal ions, which may accumulate in the plants, the practice has culminated into a hazard. The metal ions can have toxic impact on the living systems if present in excessive concentrations (Tiller, 1989; Nriago, 1990). Present study was conducted to assess the accumulation of Cu and Cd in soil and rice plants grown in this area.

MATERIALS AND METHODS

A study was carried out to assess the effects of industrial effluents contaminated with heavy metals (Cu & Cd) on yield and accumulation in fine rice and soil. For this purpose three suitable sites were selected in the district Sheikhupura (Table I). Baseline data was collected to see heavy metals and their concentration level in the soil. Three fine rice verities i.e. Super Basmati, Basmati-385, Basmati-2000 were transplanted in the month of July. The lay out plan was Randomized Complete Block Design (RCBD). The crop was grown upto maturity. All agronomic and cultural practices were done according to the crop requirement.

Heavy metals in soil and plant samples were determined according to the methods described by AOAC (1990) using atomic absorption spectrophotometer, model

Table I. Physio-chemical characteristics of the soils used in the study

Characteristics	Units	Site-1		Site-2		Site-3	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
pHs	Nil	7.37	7.55	7.8	7.92	7.90	8.20
Ece	dS m^{-1}	0.97	0.91	4.6	3.96	2.06	2.0
TSS	mmolc L^{-1}	9.7	9.1	40.6	39.6	20.6	20.0
SAR	(mmolc kg^{-1}) 1/2	3.86	3.16	7.5	7.66	7.15	7.05
Cu	mg kg^{-1}	0.80	0.65	1.00	0.95	1.33	1.20
Cd	mg kg^{-1}	0.01	0.01	0.005	0.0045	0.10	0.012

varian spectrAA250 plus. All the soil analyses were done by following the methods described in Hand book No. 60(US salinity lab. Staff, 1954). All the data was analyzed statistically using Least Significant Difference (LSD) Test at 5 percent probability level to test the significance among the treatments means (Steel & Torrie, 1980).

RESULTS AND DISCUSSION

Heavy Metal Contents in Paddy and Straw

Copper. Paddy and straw samples were analyzed for Cu contents from all three sites which indicated that in paddy Cu concentration was in variable range (Table II). Its concentration ranged from 0.960 to 1.620 mg kg^{-1} while Cu concentration in straw ranged from 17.80 to 27.60 mg kg^{-1}. These analyses showed that most of the Cu absorbed by rice plant was retained in straw and minute quantity was translocated to grains. Data regarding Cu concentration in paddy showed significant differences at sites 1 and 3 while non-significant differences at site 2. At site 1 maximum Cu concentration (1.620 mg kg^{-1}) was observed in paddy of Bas-2000 while minimum (1.460 mg kg^{-1}) was observed in paddy of basmati-385. At site 2 maximum Cu concentration (1.210 mg kg^{-1}) was found in paddy of Super basmati while minimum (1.140 mg kg^{-1}) was observed in Bas-385. At site 3 maximum Cu concentration (1.120 mg kg^{-1}) was observed in paddy of basmati-385 while minimum (0.960 mg kg^{-1}) was observed in paddy of Super basmati.

Data regarding Cu concentration in straw showed significant differences at site 1 and 2 while non significant differences at sites 3. At site 1 maximum Cu concentration (26.75 mg kg^{-1}) was observed in straw of Super basmati while minimum (22.50 mg kg^{-1}) was observed in straw of basmati-385. At site 2 maximum Cu concentration (27.60 mg kg^{-1}) was found in straw of Super basmati while minimum (24.50 mg kg^{-1}) was observed in Bas-2000. At site 3 maximum Cu concentration (18.70 mg kg^{-1}) was observed in straw of Super basmati while minimum (17.80 mg kg^{-1}) was observed in straw of basmati-385.

Cadmium. Paddy and straw samples were analyzed for Cd contents from all three sites. The data (Table III) obtained after analysis indicated that its concentration in paddy ranged from 0.116 to 0.370 mg kg^{-1} while in straw its concentration ranged from 0.135 to 0.370 mg kg^{-1}. Both in paddy and straw the concentration of Cd was within safe limits (Lindsay & Norvell, 1978). Data regarding Cd concentration in paddy showed non significant differences at site 2 and 3 while significant differences at site 1. At site 1 maximum Cd concentration (0.370 mg kg^{-1}) was observed in paddy of Bas-2000 while minimum (0.229 mg kg^{-1}) was observed in paddy of Super basmati. At site 2 maximum Cd concentration (0.145 mg kg^{-1}) was found in paddy of Super basmati while minimum (0.116 mg kg^{-1}) was observed in Bas-385 which was at par with Bas-385. At site 3 maximum Cd concentration (0.195 mg kg^{-1}) was observed in paddy of Super basmati while minimum (0.175 mg kg^{-1}) was observed in paddy of Bas-385.

Data regarding Cd concentration in straw showed significant differences at all three sites. Maximum Cd concentration (0.370 mg kg^{-1}) was observed in straw of Bas-2000 at site 3 while minimum (0.135 mg kg^{-1}) was observed in straw of Super basmati at site 2.

Heavy Metals Contents in Soil

Copper. The Cu concentration in the soil under investigation ranged from 0.600 to 1.490 mg kg^{-1} but this concentration was within permissible limit. Its concentration after harvest of rice crop was further increased. Its concentration was higher in upper soil layer, which decreased with an increase in soil depth. Similar results were observed by Khan *et al.* (1994) in the soils irrigated with city effluents near Faisalabad city.

Cadmium. Cd concentration in soil under study ranged from 0.008 to 0.069mg Kg^{-1} but this concentration was within permissible limit (Rowell, 1994). The increase in Cd concentration was less than 0.1 mg kg^{-1} after the harvest of

Table II. Accumulation of Cu in paddy and straw (mg kg^{-1})

Varieties	Site 1		Site 2		Site 3	
	Paddy	Straw	Paddy	Straw	Paddy	Straw
Super Basmati	1.510b	26.75a	1.210a	27.6a	0.9600b	18.70a
Bas –2000	1.620a	24.25b	1.160a	24.5ab	1.150a	18.10a
Bas- 385	1.460b	22.50c	1.140a	25.8b	1.120ab	17.80b

TableIII. Accumulation of Cd in paddy and straw (mg kg^{-1})

Varieties	Site 1		Site 2		Site 3	
	Paddy	Straw	Paddy	Straw	Paddy	Straw
Super Basmati	0.229b	0.135ab	0.145a	0.295a	0.195a	0.2200b
Bas-2000	0.370a	0.160a	0.125b	0.275b	0.1900a	0.3700a
Bas-385	0.270b	0.140a	0.116b	0.225c	0.1750a	0.3500a

Table IV. Soil Analysis after harvest of Rice

Characteristics	Depth (cm)	Site 1			Site 2			Site 3		
		Super Bas	Bas-2000	Bas-385	Super Bas	Bas-2000	Bas-385	Super Bas	Bas-2000	Bas-385
pHs	0.15	7.26	7.28	7.31	7.51	7.55	7.53	7.73	7.55	7.54
	15-30	7.28	7.31	7.34	7.64	7.69	7.65	7.71	7.51	7.50
Ece	0-15	0.78	0.69	0.70	3.74	3.77	3.67	2.08	1.6	2.19
(dSm^{-1})	15-30	0.86	0.76	0.72	2.81	2.85	2.76	1.56	1.48	1.93
SAR	0-15	2.76	2.98	2.96	6.76	6.75	6.98	6.15	6.08	7.2
($mmol\ L^{-1})^{1/2}$	15-30	2.72	2.86	2.81	6.06	6.08	5.92	6.1	6.0	7.15
Cu ($mg\ kg^{-1}$)	0-15	0.7400	0.6933	0.6400	0.9400	1.127	0.9600	1.280	1.240	1.490
	15-30	0.7000	0.6300	0.6000	0.9800	1.260	1.107	1.220	1.200	1.360
Cd($mg\ kg^{-1}$)	0-15	0.0090	0.0160	0.0140	0.0001	0.0001	0.0001	0.01900	0.01700	0.01500
	15-30	0.0080	0.0390	0.01100	0.0001	0.0001	0.0001	0.01700	0.01600	0.01200

the rice crop but this increased concentration was also within safe limit. Its concentration was higher in surface layer than lower horizons indicating its less mobility into deeper soil layers. Similar results were observed by Khan *et al.* (1994) in the soils irrigated with city effluents at different villages near the Faisalabad town.

REFERENCES

Ahmed, K., 1988. Removal of toxic substances by anaerobic waste stabilized pond. *Sci. Technol. Develop.*, 7: 45–51

Ghafoor, A., A. Rauf and M. Arif, 1996. Soil and plant health irrigated with Paharang drain sewage effluents at Faisalabad. *Pakistan J Agri. Sci.*, 33: 73–6

Ghafoor, A., A. Rauf and W. Muzaffar, 1995. Irrigation with Madhuana drains water: Impact on soils and vegetables (spinach and cauliflower) at Faisalabad. *J. Drainage and Recl.*, 7: 7–12

Ghafoor, A., A. Rauf, M. Arif, and V. Muzaffar, 1994. Chemical composition of effluents from different industries of the Faisalabad city. *Pakistan J. Agri. Sci.*, 31: 367–9

Ibrahim, M. and S. Salmon, 1992. Chemical composition of Faisalabad city sewage effluent. Nigrogen, Phosphorus and Potassium contents. *J. Agri. Res.*, 30: 381–90

Khan, A., M. Ibrahim, N. Ahmad and S. Ahmad, 1994. Studies on accumulation and distribution of heavy meals in agricultural soils receiving sewage effluents irrigation. *Soil Science of Pakistan proceedings of the 4th Annual Conference,* Islamabad.

Lindsay, W.L. and W.A. Norvell, 1978. Development of a DTPA soil test for Zn Fe Mn and Cu. *Soil Sci. Soc. Am. J.,* 42: 421–8

Mian, Z., T. Ahmad and A. Rashid, 1998. Accumulation of fheavy metals in water of river Sawan due to effluents of industrial area. *Pro. of Inter Sym. on Agro-Environmental issues and future Faisalabad,* Pakistan.

Nariago, J.O., 1990. Global metal pollution. Poisoning the biosp-here. *Environment,* 32: 7–33

Qadir, M., A. Ghafoor, S.I. Hussain, G. Murtaza and T. Mahmood, 1998. *Metal ion Contamination in Vegetables and Soils Irrigated with city Effluent.* pp. 89–92. In Proc. Environmental Polution: third Natl. Symp. Modern Trends in Contemporary Chemistry. 24-26 February, 1997, Islamabad

Rowell, D.L., 1994. Pesticides and Metals. *In: Soil Sciences; Method and applications.* pp. 303–27. Longman Singapore Publisher Ltd. Singapore

Steel, R.G.D. and J.H. Torrie. 1980. *Principles and Procedures of Statistics. A Biometrical Approach.* McGraw Hill Book Co. NY, USA

Tiller, K.G., 1989. Heavy metals in soils and their environmental significance. *Adv. Soil Sci.,* 9: 113–42

U.S. Salinty Lab. Staff, 1954. *Diagnosis and Improvement of Saline and Alkali Soils.* USA Hand Book No. 60. Washington, D.C., USA

(Received 10 September 2005; Accepted 25 April 2006)