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Heavy Metals Contamination Through Industrial Effluent to Irrigation Water and Soil in Korangi Area of Karachi (Pakistan)

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ABSTRACT

Wastewater mixed with industrial effluent used for irrigation in the vegetable growing area of Korangi was tested for its heavy metal contents. For this purpose, 24 samples from different drains and four tube well water samples were collected and analyzed in the year 2000. Similarly, soil and plant samples were taken from the same area and analyzed to assess their heavy metal contamination. It was found that Zn was 0.005-5.5, Cu 0.005-1.19, Fe 0.04-5.58, Mn 0.01-1.79, Cd 0.004-2.4, Cr 0.004-5.62, Ni 0.02-5.35 and Pb 0.05 to 2.25 mg L^{-1} in various waste water samples. It was noted that 4% samples contained Zn, Cu, Fe and Cr above the critical values; while 7, 21, 14 and 36% samples were higher than the required values in Mn, Cd, Ni and Pb respectively. Similarly, soil analysis (0-20 cm) showed higher values of Zn, Fe, Mn, Cd, Ni and Pb at some places. Like wise plant samples (spinach) had greater concentrations of many heavy metals than the recommended values. However, area irrigated with tube well water was safe and heavy metal quantities were within the limits in soil and plants.

Key Words: Heavy metals; Contamination; Effluent irrigation

INTRODUCTION

Wastewater of the urban area is being used profitably to irrigate vegetable crops in the vicinity of cities from the time unknown. Waste and sewerage water is still considered most rich in plant nutrients and organic matter. In many cities and towns the sewerage water is sold and it is a good source of income to municipalities. However, the situation is changed now.

With the establishment of industries in suburban area, the wastewater is mixed with industrial effluents and big culverts are coming out from the cities. These culverts and drains not only contain heavily polluted water but also give noxious and off smell gases. The polluted water even then is still used for growing vegetables in the nearby area of the cities with out knowing their adverse impact on the life of consumers. A study conducted in Faisalabad showed that soil and plants contained many toxic metals, that received irrigation water mixed with industrial effluent (Khan *et al*., 1994; Qadir, 1999). Similarly, Jaffer *et al.* (1995) found many fish containing higher concentrations of heavy metals in the area of Southeast Arabian Sea where polluted industrial water is thrown though Malir River. The industrial effluent produced in several industries in Korangi area is dumped in Malir River and finally it leads to Arabian Sea.

It was therefore felt necessary that effluent mixed wastewater, which is also used in the Korangi area for irrigation purposes, might contain toxic metals. Hence, present study was taken in hand to estimate the concentration of Cu, Zn, Fe, Cd, Ni, Pb and Cr in the irrigation water, in soil and plants.

MATERIALS AND METHODS

Sampling

Irrigation water. Twenty four industrial effluent mixed irrigation water samples (1/2 liter) were taken in nicely washed plastic bottles from the different places of the Korangi area. Similarly, four tube well irrigation water samples were also collected for comparison.

Soil. Separate soil samples (about ½ Kg) were taken from both the areas that received effluent mixed water and tube well water, in new plastic bags. Total twenty-eight samples were there. Twenty four with effluent and four with tube well irrigated water up to 0-20 cm depth.

Plants. Spinach plant leaves were sampled in plastic bags. Twenty four samples from Effluent Mixed Waste Water (EMWW) and four from Tube Well Water (TWW) land.

Following determinations were made

Water analysis. Electrical Conductivity (dS/m), pH, heavy metals i.e. Cu, Zn, Mn, Fe, Cr, Pb, Ni and Cd contents.

Soil analysis. Electrical Conductivity (1:5) (dS/m), pH (1:5), lime content (%), organic matter content (%), texture, heavy metals

Plant analysis. Heavy metal contents

Methods employed. Electrical conductivity, pH, organic matter, lime content and texture using standard methods for water and soil analysis (Page *et al.,* 1985). Heavy metals content (AOAC, 1990).

Water. Direct or by dilution feeding to atomic absorption spectrophotometer (AASP).

Soil. AB-DTPA method extracts feeding to AASP

Plant. Wet digestion method $HClO_4$ + HNO_3 (1:5 mixture) digest feeding to AASP.

Assessment and comparison of heavy metal was done with the concentration of National Environmental Quality Standards (NEQS) and US Environmental Protection Agency (USEPA)

RESULTS AND DISCUSSION

Water analysis. Data presented in Table I reveal the analysis of two kinds of irrigation waters used in Korangi area of Karachi. Samples of industrial effluent mixed water varied greatly in heavy metal concentrations as well as in electric conductance. However, tube well water samples were almost similar in nature. The evaluation study for both kinds of irrigation water indicates that many samples of waste water were quite higher than the NEQS values. Thus, Zn, Cu, Fe, Mn, Cd, Cr, Ni and Pb concentrations were 4, 4, 4, 7, 21, 4, 14 and 36% greater respectively than the safe limits. The tube well water was found excellent both for drinking and irrigation purposes.

Soil analysis

Physico-chemical properties. The findings given in Table

Table I. Trace Element Concentration in irrigation water samples collected from Korangi Industrial Area-Karachi.

Trace Elements	Tubewell Water	Effluent Mixed Water	NEQS Values	Percent Samples of 3 more than 4
1	2	3	4	5
		Mg/L		
Zn	0.048	0.005-5.50	<5.0	4
Cu	0.032	0.005-1.19	<1.0	4
Fe	2.39	0.040-5.88	<8.0	4
Mn	0.124	0.010-1.79	<1.5	7
Cd	0.041	0.004-2.4	<0.1	21
Cr	0.030	0.004-5.62	<1.0	4
Ni	0.656	0.020-5.35	<1.0	14
Pb	0.24	0.050-2.25	<0.5	36
EC dS/m*	1.80	2.02-45.00	>2.0	11
pH*	7.41	6.00-8.88	6.5-8.5	-

*Drinking water values of WHO (1984).

Table II. Physico-Chemical properties of Soil (0-20cm) in Korangi Area Karachi

Parameters	TWW irrigated Soil	EMW irrigated Soil
Texture	Loamy Sand	Loamy Sand to Sandy Loam
EC (dS/m)	0.31	0.20-0.41
pH	8.39	8.01-8.09
Lime (%)	22.37	20.95-23.09
Organic Matter (%)	0.64	0.84-1.14
Total nitrogen (mg/kg)	22.08	75.04-82.11
Nitrate-N (mg/kg)	11.69	62.43-65.82
P-AB-DTPA Ext. (mg/kg)	12.23	37.98-39.37
K-AB-DTPA Ext. (mg/kg)	102.54	87.94-103.12

plants with heavy metals when irrigated with EMWW. Similar results were also reported by Khan *et al.* (1994) and Qadir (1999) for the analyzed plants irrigated with industrial effluents.

CONCLUSIONS

Water, soil and plant samples analysis show that waste water mixed with industrial effluent contains many heavy metals quite in excess. Similarly, plants receiving effluent mixed water for irrigation are found fully contaminated with heavy metals. However, soil condition is not so deteriorated rather it is improved in plant nutrients, especially in N, NO3-N, P and organic matter content. Increase in organic matter improves water holding capacity of the excessively drained light soil. It is therefore suggested that wastewater mixed with industrial effluent can be used for growing vegetables provided it is pre-treated to reduce the level of heavy metals.

Table III. Trace elements content in soil at various places in Korangi Area Karachi

Trace elements (AB-DTPA Ext.)	TWW irrigated Soil	EMW irrigated Soil	Index value *
		mg/kg	
Zn	1.80	3.71-4.99	1.5
Cu	3.10	3.92-5.87	0.5
Fe	5.39	13.60-22.06	4.0
Mn	5.29	8.98-17.07	1.8
Cd	0.07	0.11-0.21	0.07
Cr	0.14	0.17-0.58	0.14
Ni	0.12	0.92-1.57	0.98
Pb	1.53	2.65-3.03	1.53

Havlin and Sultanpour (1981)

Table IV. Heavy metal concentration in spinach leaf samples collected from Korangi Industrial Area

Heavy metals	Excessive values*	TWW irrigated	EMWW irrigated	Samples greater than toxic vlues
		mg/kg%		
Zn	>100	32.0	32.50-78.80	-
Cu	>20	19.50	21.80-103.25	100
Fe	>130	172.5	98-638.8	78
Mn	>300	111.8	52.8-973.3	13
Cd	>5	1.80	0.85-74.0	18
Cr	>5	4.20	1.5-22.50	50
Ni	>10	14.8	26.95-88.0	93
Pb	>30	12.4	0.5-64.0	50

* Kabata Pendias and Pendias (1984)

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