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Original Research Paper

Assessment of Heavy Metals in Wastewater Used for Irrigation in Ajmer - A Semi Arid Region of Rajasthan

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ABSTRACT

The aim of this study was to assess the heavy metal concentration in the wastewater used in irrigation for vegetable production. Seven heavy metals viz., Pb, Cd, Cu, Zn, Ni, Cr and Fe were targeted for the present investigation. Ten sampling sites were selected on the basis of mass vegetable production. The results showed that the average level of Zn, Cu and Ni (3.78, 0.015 and 0.006 mg/L respectively) were within the permissible limit at all the sampling sites. Chromium was below the detectable limit and the concentration of Fe, Cd and Pb (1.004, 0.042 and 0.239 mg/L respectively) were found above the prescribed limit at all the sampling sites.

INTRODUCTION

Cities in developing countries are experiencing unparalleled growth and rapidly increasing water supply and sanitation coverage that will continue to release growing volumes of wastewater. In many developing countries, untreated or partially treated wastewater is used to irrigate the cities own food, fodder and green spaces. Rough estimates show that at least 20 million hectares in 50 countries are irrigated with raw or partially treated wastewater (Mahmood 2006). The question of whether vegetables cultivated by wastewater are safe for human consumption is of great interest to public especially now that the environmental quality of food production is of major concern (Chiroma et al. 2003). The uncontrolled use of wastewater in agriculture has important health implications for consumers, farmers and their families. Negative health impacts from the use of untreated or inadequately treated wastewater have been documented in many studies. Untreated wastewater used for irrigation is the major cause of metal pollution increasing in soil and crop. However, continuous application of untreated sewage may lead to buildup of heavy metals in soil and thereby contamination of food chain (Gupta et al. 1998). Atmospheric deposition, industrial or municipal wastes, improper use of sewage sludge as fertilizers and metal containing phosphoric fertilizer play an important role in high metal content in crop plants and soil. Rajesh & Agrawal (2004) observed that the sewage effluents of municipal origin contain appreciable amount of major essential plant nutrients by which the soil fertility is improved considerably under sewage irrigation of crops fields. Ibrahim et al. (1992) observed that Mn, Cu, Zn, Cd, Pb, Ni and Co increased in the upper soil layer (0-10 cm) with time due to use of sewage water in irrigation. The Ajmer district come under the semi-arid region; drinking water is main problem of this region. Water for irrigation is major problem of farmers in this region. Groundwater of Ajmer city is highly contaminated by heavy metals (Hussain 2001) due to which the water is not suitable for use. Ajmer is fifth largest city of Rajasthan but still there is no policy for wastewater treatment. Thus, farmers directly use wastewater for vegetable production, which may cause severe health problems in human beings. Therefore, present paper is focused on the assessment of various heavy metals in untreated wastewater, which is major source of irrigation water in Ajmer city.

MATERIALS AND METHODS

The area under investigation, Ajmer is centrally situated city of Rajasthan and lies between 26°25' to 26°29' N latitudes and 74°37' to 74°42' E longitudes. Area of the entire Ajmer district is 8481.40 sq. km and area of the Ajmer city is 241.56 sq. km. Population of the city is 4, 85,575 according to 2001 census.

Ten sites were selected for collection of wastewater samples and fortnight collection and monitoring was done in order to have an average overview of concentration of various metals in the wastewater samples. A total 120 wastewater samples were analysed for heavy metals. These samples were taken from major drains of the city. Selections of sampling sites were based on their significance in vegetable production. Standard methods of collection, preservation, digestion of samples and analysis were adopted (APHA 1989). Heavy metals were analysed by using Atomic Absorption Spectrophotometer (ECl-AAS-4141).

RESULTS AND DISCUSSION

The wastewater samples were analysed for assessment of seven different heavy metals during August 2007 to January 2008. The observed average value of Zn, Pb, Ni, Cd, Cu and Cr at the various sites are given in Table 1.

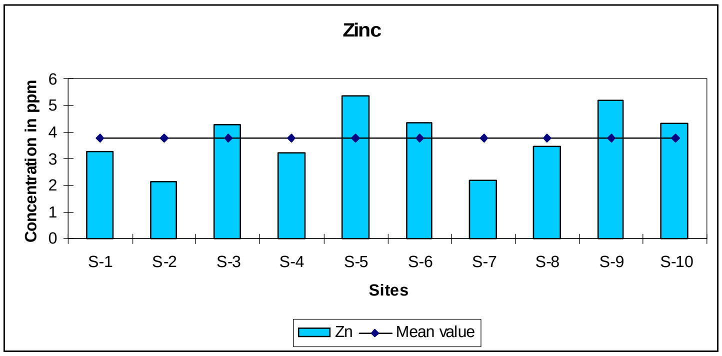
Table 1: Average metal concentration of 120 samples from ten different sites (in ppm).

S.No.	Name of Sites	ID	Zn	Fe	Cu	Cd	Pb	Ni	Cr
1.	Kotda	S-1	3.281	0.562	0.009	0.011	0.187	0.004	BDL
2.	HBU nagar	S-2	2.145	0.934	0.009	0.026	0.272	0.005	BDL
3.	Gaddi Mali Pad	S-3	4.284	0.520	0.019	0.079	0.257	0.010	BDL
4.	Subash Nagar	S-4	3.246	1.036	0.01	0.030	0.201	0.004	BDL
5.	Paalbichla	S-5	5.376	1.217	0.006	0.012	0.260	0.007	BDL
6.	Makhupura	S-6	4.371	1.034	0.016	0.085	0.303	0.008	BDL
7.	Jonsganj	S-7	2.176	0.992	0.020	0.013	0.226	0.006	BDL
8.	Ramganj	S-8	3.471	0.869	0.015	0.018	0.205	0.005	BDL
9.	Vigyan Nagar	S-9	5.196	0.945	0.024	0.064	0.238	0.004	BDL
10.	Parbatpura	S-10	4.301	1.932	0.022	0.081	0.386	0.007	BDL
	Mean		3.785	1.004	0.015	0.042	0.239	0.006	-
	SD		1.120	0.389	0.006	0.031	0.038	0.002	-
	IARI, 1981		15	0.1	15	0.01	0.1	0.02	0.05

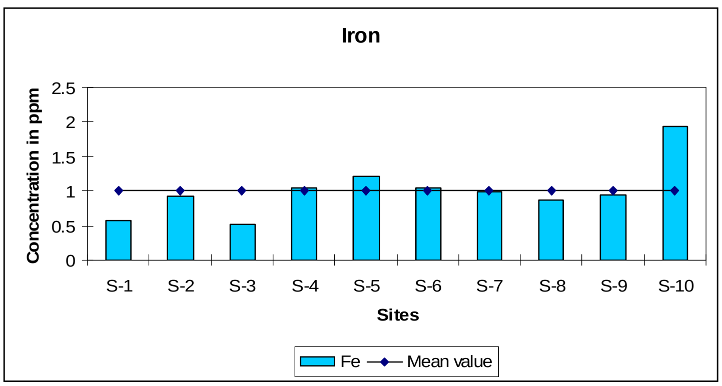
Table 2: Correlation matrix of heavy metals.

~	Zn	Fe	Cu	Cd	Pb	Ni
Zn	1	~	~	~	~	~
Fe	0.228	1	~	~	~	~
Cu	0.192	0.228	1	~	~	~
Cd	0.471	0.271	0.640	1	~	~
Pb	0.302	0.771	0.367	0.678	1	~
Ni	0.320	0.058	0.232	0.574	0.522	1

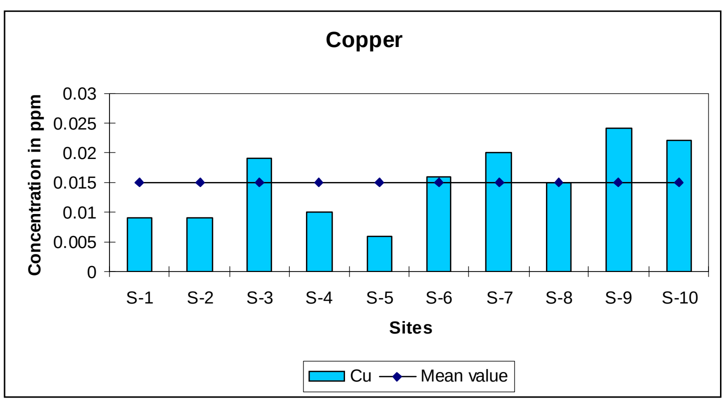
Zinc had highest concentration ranging from 2.14 to 5.37 ppm, with a mean value of 3.78±1.120 ppm. The data showed that highest concentration of Zn was at the site S-5, and minimum at S-7. The level of zinc at all the sites was found safe. There is no significant variance in Zn concentration at different sites. It is observed that enrichment of Zn might be the result of the input of domestic waste (Facetti et al. 1998).



(a)

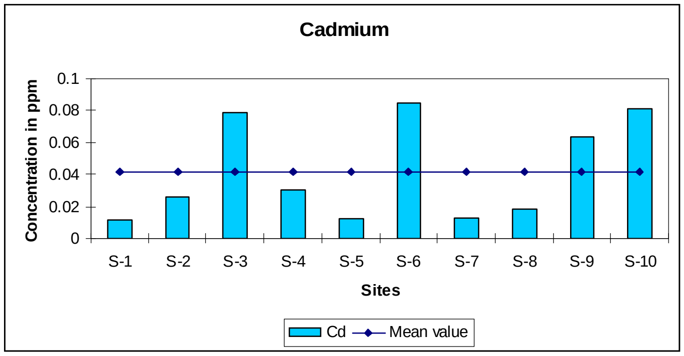


(b)



(c)

Figure cont....



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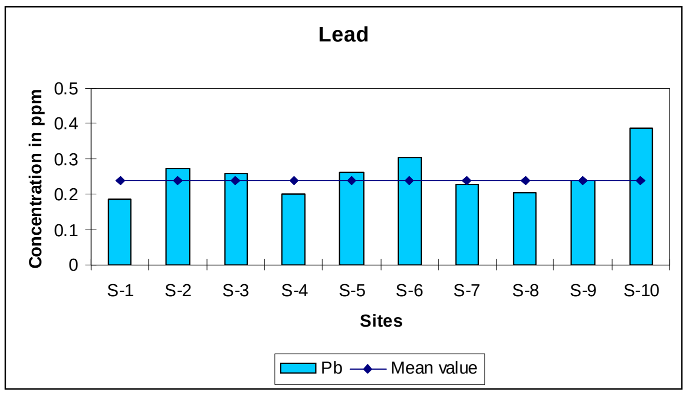

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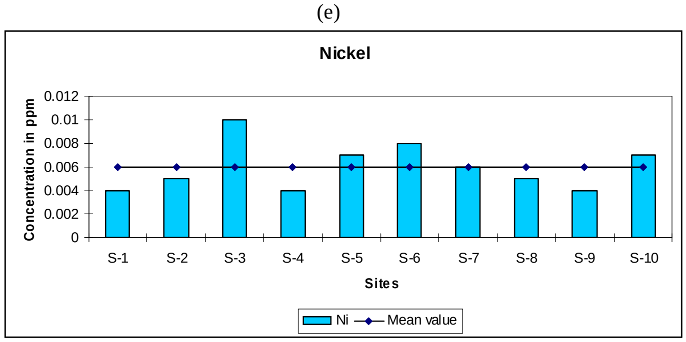

(f)

Fig. 1: (a-f): Heavy metals concentration at different sites.

The average concentration of Fe at different sites during study period was ranging from 0.520 ppm (S-3) to 1.932 ppm (S-10) and average concentration of Fe at all the sites was 1.004±0.38 ppm. The observed concentrations of Fe at all the sites were above prescribed irrigation water limit (IARI 1981). The higher concentration of Fe may be due to industrial effluent, discharged from Parbatpura industrial area, North Western Railway Carriage Work shop and urban runoff provided by municipal wastewater (Reemtsma et al. 2000).

The level of Cu in wastewater used for irrigation at different sites varied from 0.006 ppm (S-5) to

0.024 ppm (S-9). The average value of Cu was 0.015±0.006 ppm, which is well under the permissible limit.

The study showed that wastewater used for irrigation in Ajmer city was highly contaminated with cadmium. Observed concentrations of Cd ranged between 0.011 ppm (S-1) and 0.085 ppm (S-6). The average value of Cu was 0.042±0.031 ppm. Although the concentration of Cd was higher than standard limit, but the Cd level at various sites did not show significant differences. It was reported that samples collected from S-6 and S-10 had high level of Cd in comparison to samples taken from other sites. Sources of Cd include wastes from Cd-based batteries and runoff from agricultural soil where phosphatic fertilizers are used. Cd is a common impurity in phosphatic fertilizers (Stoeppler 1991).

The concentration of lead at various sampling sites was in the range of 0.187 ppm (S-1) to 0.386 ppm (S-10). The average level of Pb at various sampling sites was 0.239±0.038 ppm. Results showed that the concentration of lead at all the sites had higher than the safe limit prescribed for irrigation water. The higher concentration of lead at S-10 sampling sites might be due to heavy traffic on nearby highway (NH-8). It is also reported that Pb along with traces of Fe and Zn arrives from urban runoff (Reemtsma et al. 2000).

The level of Ni in wastewater, at various sampling sites was in the range of 0.004 ppm (S-1, S-4, S-9) to 0.010 ppm (S-3). The average concentration of nickel at different sites was 0.006±0.002 ppm, which was within the recommended maximum level, thus, the wastewater for irrigation is quite safe from Ni contamination point of view. The concentration of Cr at various sampling sites was below detectable limit of 0.02 mg/L.

Correlation test was carried out on the data of wastewater samples between the heavy metals (Table 2). The values of correlation coefficients (r) were calculated among all the possible sets of parameters of heavy metals. The correlation matrix showed a positive correlation between all the variables. Pb, Ni or Cu correlated positively with Cd, and Fe strongly correlated with Pb. Also Pb correlated with Ni. The positive relationship existing between the heavy metals shows their origin from the same source.

CONCLUSION

The data showed that the wastewater used for irrigation is contaminated with heavy metals by industrial effluents, domestic waste and agricultural runoff. All these activities are gradually increasing the concentration of heavy metals in wastewater. Among the samples collected from the sites, S-10 and S-6 showed high contamination of different heavy metals due to industrial effluents. S-1, S-2 and S-4 sites were quite safe than other sampling sites. There is no significant difference in heavy metal contamination level at different sites which clearly demonstrated that the sources of these heavy metals are not much diverse.

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