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Accumulation of Heavy Metals in Soil Due to Wastewater Application

Environmental Science

KEYWORDS : Heavy metals; Irrigation; Wastewater

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ABSTRACT

A study was conducted at a wastewater irrigated site, Mansarovar in Jaipur city of Rajasthan, India to estimate the accumulation of heavy metals (Cd,Pb, Zn and Ni) in soil during the pre monsoon and post monsoon period. Simultaneously a control site using bore well water for irrigation was also studied to compare the results. Important soil chemical parameters (pH,EC and Organic carbon %) were also analyzed. The study revealed accumulation of Cd above the safe limits whereas Zn ,Ni and Pb were found under permissible limits. Concentration of metals was found to be higher during pre monsoon period as compared to post monsoon period. An increase in pH, EC and OC % at wastewater irrigated site was also observed during the study. The concentrations of all the metals found in the study are high enough to accumulate in the crops grown on this soil.

Summary

The present study conducted to evaluate the impact of wastewater application on soils revels that continuous application of wastewater is harmful for soil. It is obvious from the results obtained that application of wastewater leads to build up of heavy metal(Cd) in soil which may prove toxic to the soil health as well as human health as these metals have long half life and have a tendency to accumulate in plant and human tissues. As observed from the results obtained, wastewater also supplies nutrients to the soil in the form of organic carbon and other nutrients thus it can a good source of water and nutrients. It is recommended to eliminate toxic metals from wastewater prior to application in soil to utilize its benefits. Thus it is major concern which should be addressed at the earliest to prevent further degradation of the land resource and adverse effect on human health.

Introduction

Wastewater application in agricultural fields is a common practice in water deficit areas. In such areas wastewater is an easy source of water in addition to a source of nutrients for the soil. Wastewater, which includes municipal waste as well as industrial effluents, is a cocktail of several salts, nitrates, phosphates, organic matter as well as toxic metals. When the wastewater is applied to the agricultural fields, it supplies certain nutrients to the soil enhancing its fertility in initial period of application after which the fertility declines due to accumulation of heavy metals. The heavy metals hinder the microbial activity of soil which in turn hinders the process of microbial decomposition, reducing fertility of soil. Heavy metals accumulated in soil have a long half life and are easily taken up by crops grown in such soils which are further transferred to higher trophic levels in toxic concentrations. These metals are known to cause several diseases including cancer. Keeping in view the above facts, the present study was conducted at a water deficit semiarid region Jaipur in Rajasthan, India where wastewater is extensively used for irrigation purpose for growing seasonal vegetables.

Material and method

Study Area: The study was conducted in Jaipur city of Rajasthan, India. Two sites were studied; wastewater irrigated agricultural field at Mansarovar and a control site using bore well water for irrigation. The wastewater irrigated agricultural field is situated near a common drainage *Amahnisha nala* running 35 km across the city, collecting municipal as well as industrial effluents. Farmers pump this wastewater directly from the *nala* in the fields to grow seasonal vegetables which are sold in the local markets all over the city.

Soil samples were collected during pre monsoon period (March-May 2013) and post monsoon (August- October 2013).Samples were collected twice a month from both sites in clean polyethylene bags. They were labeled and bought to the laboratory for analysis. Soil was air dried and sieved through 2mm sieve for further analysis. Soil chemical parameters (ph,EC,OC%) and Heavy Metals (Zn, Fe, Cd and Pb) were analyzed. pH and EC were recorded with microprocessor based meters, OC% was estimated by black and Walkley method whereas metals were estimated by wet digestion method (wet acid digestion) where 0.5 gm each of soil sample was digested with concentrated HNO_3, $H2SO_4$ and $HClO_4$ (5:1:1) at 800°C until the solution become transparent. The digested samples were filtered through the whatman No.42 filter paper and the filtrates were diluted to 50ml with distilled water and readings taken at atomic absorption spectrophotometer (model GCB+).All reagents used were of Merck (analytical Grade).

Results and discussion

Table 1: Chemical characteristics and heavy metals in soil during pre and post monsoon period(n=24)

	Mansarovar	Control	Mansarovar	Control
Parameters	Pre monsoon		Post monsoon	
pH	8.81±0.02	7.3±0.01	7.41±0.04	7.2±0.01
EC	1.02±0.12	0.76±0.03	0.97±0.03	0.75±0.00
OC%	1.12%±0.11	0.96%±0.08	0.98±1.03	0.96±0.01
Zn mg/kg	9.32±0.14	5.26±1.21	7.28±1.02	5.24±1.25
Ni mg/kg	29.15±2.35	0.01±0.00	26.32±5.21	ND
Pb mg/kg	33.42±1.85	ND	29.21±3.11	ND
Cd mg/kg	15.32±1.52	ND	12.54±1.05	ND

ND: not detected

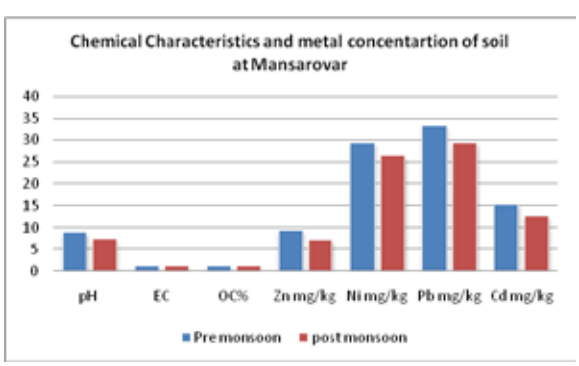

Figure:1 Comparison or chemical parameters and metals concentration in soil during Pre and post monsoon period at Mansarovar

The results obtained during the study are given in the table 1.The results obtained indicate an increase in the pH, EC, OC % as well as metals due to wastewater application as compared to the control site. All the parameters showed a decrease in the mean values during the post monsoon period as compared to the pre monsoon period.

Effect of wastewater on Chemical Characteristics of soil

pH:pH is an important parameter for soil fertility as microbial activity in soil is pH dependent. Bioavailability of metals is also pH dependent where low pH increases the metals in soil solution making them more available for plant uptake. In the present study pH of the wastewater irrigated site was found to be alkaline in nature during the pre monsoon period as compared to the control site and during post monsoon period. This is in accordance with the results reported by Ahmad *et.al* 2012; Singh et al., 2012 where they found an increase in the pH of soil due to continuous application of wastewater. This increase in pH may be attributed to the high content of basic cations viz. Na^{+}, Ca^{2+} and Mg^{2+} in the wastewater, which after accumulation in surface soil layer for a long period of time (Schipper *et al.*,1996) lead to an increase in soil pH.

Electrical conductivity: EC was found to be high in the wastewater irrigated site during the pre monsoon period. The findings of present study are in line with the findings of Murtaza *et al.*, 2008; Mojri 2011. The reason for this increase can be the accumulation of dissolved salts found in the industrial wastewater.

Organic carbon: It is a significant parameter indicating the fertility of soil. OC plays an important role in bioavailability of metals. High levels of organic carbon in soil helps to bind the metals, making them less bioavailable. Results of present study indicate an increase in the OC % due to wastewater application (Table 1)(Fig.1). The reason for this increase can be attributed to the presence of organic matter, organic salts, nitrates, phosphates and salts of calcium and magnesium in wastewater which make the soil rich in OC. Results of the present study are comparable with the findings of Kiziloglu *at al.*, 2008 where they reported 2.8% higher value of OC in wastewater irrigated sites as compared to control site at Turkey as well as Qishlaqi 2008 reported an increase of OC % from 22% to 30 % in wastewater irrigated sites at Iran. OC % was also found to reduce during the post monsoon period.

Heavy metals in soil

The mean concentration of heavy metals in soil (Table 1) was found higher during pre monsoon period as compared to post monsoon period(Fig.1) and the control site. The values of Ni , Zn and Pb were found to be under the permissible limit of 75-100mg/kg ,300-600mg/kg and 250-500 mg/kg respectively according to Indian standards(Awashthi 2000) The mean values of Cd was found to be above the permissible limits 3-6 mg/kg set by the Indian standards(Awashthi 2000).Although the values of Ni, Zn and Pb are under the permissible limits but they are high enough to accumulate at toxic levels in crops grown on such soils. In the present study, wastewater irrigated site showed a higher value of metals as compared to control site which is possibly due to continuous application of waste water. Results of present study can be corroborated with the findings of Kharche *et al.* 2011 where it was found that the total content of Zn, Cd, Cr and Ni in the soils irrigated with sewage water for more than three decades was 3.98, 2.10, 1.62, and 1.24 times higher as compared to their content in the well-irrigated soils. As compared to present study, much higher levels of metals Cd(23.86-48.55 mg/kg),Pb(31.62-66.82 mg/kg),Ni(26.45-37.87 mg/kg) and Zn(74.45-165.73 mg/kg) in wastewater irrigated sites were reported by Jagtap *et al.*, 2010.Similarly, Pathak 2011 reported high levels of metals as compared to the present study where the mean values of metals 2011at wastewater irrigated sites at Dehradun were Zn(211.96 mg/kg),Ni(59.09mg/kg),Pb(86.41 mg/kg) and Cd(6.50 mg/kg).These values were higher than the values obtained at the control site.

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