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Original Research Article

Assessment of Heavy metal Accumulation in Wastewater flooded soil of Allahabad, Uttar Pradesh, India

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ABSTRACT

Assessment of heavy metal accumulation (Cu, Fe, Zn, Pb, and Ni) was conducted in the wastewater irrigated soil in Allahabad district of Uttar Pradesh, India, using contamination factor (CF) and pollution load index (PLI). Samples from each sampling points taken at depth 0-<5, 5-<10, 10-<20, 20-<25cm and were analyzed using Atomic Absorption Spectroscopy (AAS). The maximum contamination of iron was observed in soil irrigated with wastewater of drain. The study area was observed to be contaminated with metals and contamination factor calculated of Cu (maximum0.0796), Fe (maximum 5.2119), Zn (maximum 0.0285), Pb (maximum 0.1163) and Ni (maximum 0.0007) in all different season during 2011-13.The pollution load indices (PLI) were found to be maximum is 0.0045 in winter season and minimum is 0.0034 in monsoon season with increase in depth (0-25 cm) indicating that the study area was polluted by all the observed heavy metals. These results support both the managed utilization of wastewater for irrigating field and regulate the discharge of wastewater into the water from households and runoff that are located upstream.

Keywords: - Heavy metals, Wastewater irrigated soil, Contamination Factor, Pollution Load Index, Allahabad.

INTRODUCTION

Soil contamination with heavy metal is a worldwide environmental concern and leads to bioaccumulation of toxic elements in the food chain, destroys the function and balance of ecosystem, and causes human health problems. Both natural and anthropogenic activities are releasing heavy metals into soil environment. Solid waste disposal, sludge applications, vehicular exhaust, wastewater irrigation, industrial activities, and metal mining are the major sources of soil contamination with heavy metals (Singh *et al.,* 2005; Khan *et al.,* 2008). Heavy metals such as Pb, Cd, Cu, and Zn are considered the most toxic elements in the environment and included in the US Environment Protection Agency (EPA) list of priority pollutants (Cameron 1992).

Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation, may not only result in soil contamination, but also lead to elevated heavy metal uptake by crops, and thus affect food quality and safety (Muchuweti *et al.*, 2006). Heavy metals are ubiquitous in the environment, as a result of both natural and anthropogenic activities, and humans are exposed to them through various pathways (Wilson and Pyatt, 2007). Wastewater irrigation is a widespread practice in the world and recently a number of articles have been published on wastewater-irrigated soils contaminated with heavy metals (Liu *et al.*, 2005; Mapanda *et al.*, 2005; Rattan *et al.*, 2005; Rothenberg *et al.*, 2007).However, an additional insight into metal uptake, accumulation and assessment of human health risks associated with wastewater-irrigated soils is still needed. This study was conducted to investigate the soil pollution load, to understand the appropriateness of wastewater-irrigated soils for vegetable cultivation, and to assess the metal uptake by food crops and the potential health risks associated with human consumption of food crops contaminated with heavy metals. This wastewater is not only a source of irrigation water, but it is also a carrier of significant quantities of macro- and micronutrients and organic matter (Badawy and El-Motaium 1999).

Plants have a natural ability to extract elements from soil and to translocate them between roots, shoot, and fruits based on the biological processes, in which elements are involved (Ximenez-Embun *et al.*, 2002; Page *et al.*, 2006; Fritioff and Greger 2006). Therefore, elements including micro- and Macronutrients as well as heavy metal contaminants can be taken up by plants from soil, and enter the food chain easily. Sewage sludge and wastewater have long been used as fertilizers and as crop irrigation water, especially as supplementary sources of N and other macro and micronutrients, as well as an amendment for the improvement of soil physical properties (Pereira *et al.*, 2011). However, the basic aim is to establish mathematical relations that would lead to the calculation of optimum PLI values that could possibly be used for the effective monitoring of soil pollution problems under the effect of applied sludge.

MATERIALS AND METHODS

Study Area

Mori gate drain run from Allahabad city and carry mainly domestic wastewater from the eastern part of city. Mori gate drain collects the domestic through underground sewerage drain network of the city which opens at 25°26'10.64''N 81°51'37.61''E outside the city and join river Ganga at 25°26'23.15''N 81°53'4.26''E. this wastewater is utilize by people for irrigating vegetable in summers under Shastri bridge of national highway (NH 2).

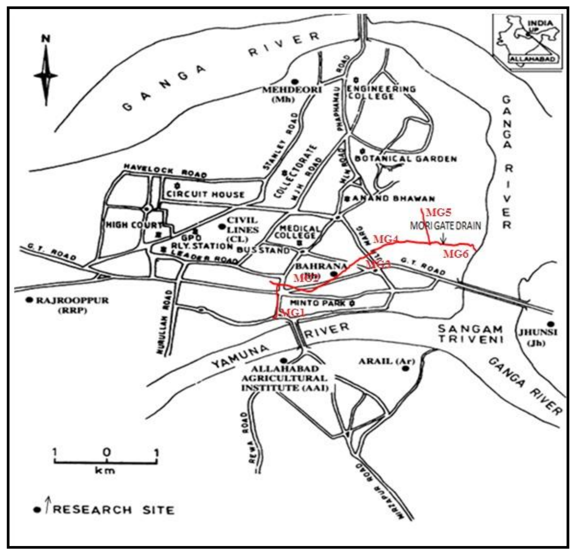

Figure 1.Map of Allahabad city showing Mori gate drain.

Method of sample collection

The water quality survey was conducted at Mori gate Drain, during different seasons of the year from December 2011 to December 2013. The samples were collected in 5L plastic container between 8 to 10 AM. The containers were thoroughly washed and rinsed with concentrate HNO_3 fallowed by distilled water. For heavy metal analysis fifty milliliters of contaminated water sample was digested with 10 ml of concentrated HNO3 at 80^oC until the solution became transparent (APHA 1985). The solution was filtered through Whatman no. 42 filter paper and the filtrate was diluted to 50 ml with distilled and dehumanized water. Soil samples from the surface soil to a depth of 12cm around each plant root zone were collected simultaneously from the field. The soil samples were air dried at room temperature finally powdered, and sieved through a 2-mm nylon mesh to remove large debris, stones and pebbles. Then the samples (500 gm of soil) were dried at 105^oC for 2 hour to remove all the moisture content and homogenized for analysis. The dried samples were wet digested according to standard protocols. Trace elements concentrations in wastewater and soil samples were estimated by an atomic absorption spectrophotometer (Perkin Elmer AAnalyst 300). Blank samples were analyzed after three samples. Concentrations were calculated on a dry weight basis. All analyzed replicated sample were three times. The precision and analytical accuracy were checked by analysis of standard reference material, NIST-SRM 1570 for water. The results were found to be within 2% of certified values for every heavy metal. Statistical summary and analysis was performed using Microsoft Excel (version 2007).

Heavy metal pollution assessment for soils

The Pollution Load Index (PLI) evaluate the degree to which the sediment associated chemical status might adversely affect aquatic organisms and are designed to assist sediment assessors and manager responsible for the interpretation of sediment quality. It is also to rank and prioritize the contaminated areas or the chemicals for further investigation.

Calculation method of PLI:

CF = C metal / C background value

PLI= n√ (CF1 x CF2 x CF3 x…x CFn)

Where,

CF = contamination factor, n = number of metals

C metal = metal concentration in polluted sediments

C Background value = background value of that metal.

RESULTS AND DISCUSSIONS

Heavy metals in wastewater of Mori gate drain are mentioned in table 1 which is source for heavy metal contamination for soil irrigated with its wastewater. The accumulation of heavy metals in soil irrigated with drain is mentioned in table 2. With the help of background value of the heavy metals the contamination factor and pollution load index (PLI) was calculated (table 3) which reflects the pollution of metals in soil. In winter season of year 2011-12 contamination factors of different metals in soil irrigated with Mori Gate drain was Cu (0.0773), Fe (4.8178), Zn (0.0263), Pb (0.1163) and Ni (0.0005). The Pollution Load Index (PLI) for the season was (0.0038). In summer season contamination factor, Cu (0.0760), Fe (4.7246), Zn (0.0261), Pb (0.1109) and Ni (0.0006) respectively and PLI was (0.0038). In Monsoon season contamination factor of Cu (0.0747), Fe (4.7881), Zn (0.0242), Pb (0.1139) and Ni (0.0005) respectively and PLI was (0.0034).

In winter season of year 2012-13 contamination factors of different metals in soil irrigated with Mori Gate drain was Cu (0.0796), Fe (5.0297), Zn (0.0285), Pb (0.1103) and Ni (0.0006). PLI for the season was (0.0045). In summer season contamination factor, Cu (0.0782), Fe (4.9364), Zn (0.0258), Pb (0.1115) and Ni (0.0007) respectively with PLI value (0.0044). In Monsoon season Cu (0.0791), Fe (5.2119), Zn (0.0247), Pb (0.1157) and Ni (0.0006) respectively and PLI was (0.0042).

Table 1: Heavy metal concentration in wastewater of Mori gate drain.

S. No	Parameters	Unit	Wastewater Quality from December 2011-2012						Wastewater Quality from December 2012-2013					
			Winter season	Summer season	Monsoon season	Mean	±	SD	Winter season	Summer season	Monsoon season	Mean	±	SD
1	Copper	mg/l	0.0074	0.0078	0.0075	0.0076	±	0.0002	0.0076	0.0082	0.0079	0.0079	±	0.0003
2	Iron	mg/l	0.26	0.32	0.29	0.29	±	0.03	0.35	0.38	0.37	0.367	±	0.015
3	Manganese	mg/l	0.80	0.80	0.79	0.797	±	0.006	0.80	0.80	0.81	0.803	±	0.006
4	Zinc	mg/l	0.08	0.09	0.08	0.083	±	0.006	0.092	0.098	0.086	0.092	±	0.006
5	Lead	mg/l	0.005	0.008	0.005	0.006	±	0.002	0.006	0.008	0.003	0.006	±	0.003
6	Nickel	mg/l	0.06	0.07	0.03	0.053	±	0.021	0.06	0.08	0.04	0.060	±	0.020

Table 2: Heavy metal accumulation in soil irrigated with Mori gate drain.

S. No	Parameters	Unit	Soil sample collection from December 2011-2012						Soil sample collection from December 2012-2013					
			Winter season	Summer season	Monsoon season	Mean	±	SD	Winter season	Summer season	Monsoon season	Mean	±	SD
1	Copper	mg/Kg	3.48	3.42	3.36	3.42	±	0.035	3.58	3.52	3.56	3.55	±	0.021
2	Iron	mg/Kg	22.74	22.3	22.6	22.55	±	0.160	23.74	23.3	24.6	23.88	±	0.651
3	Manganese	mg/Kg	4.52	4.82	4.25	4.53	±	0.285	4.72	4.84	4.28	4.61	±	0.282
4	Zinc	mg/Kg	2.5	2.48	2.3	2.43	±	0.092	2.71	2.45	2.35	2.50	±	0.078
5	Lead	mg/Kg	1.96	1.87	1.92	1.92	±	0.028	1.86	1.88	1.95	1.90	±	0.037
6	Nickel	mg/Kg	0.034	0.038	0.031	0.03	±	0.920	0.044	0.048	0.041	0.04	±	0.004

Table 3: Pollution Load Index of soil irrigated with wastewater of Mori Gate Drain.

Duration		CF_{Cu}	CF_{Fe}	CF_{Zn}	CF_{Pb}	CF_{Ni}	PLI
2011-2012	Winter season	0.0773	4.8178	0.0263	0.1163	0.0005	0.0038
	Summer season	0.0760	4.7246	0.0261	0.1109	0.0006	0.0038
	Monsoon season	0.0747	4.7881	0.0242	0.1139	0.0005	0.0034
2012-2013	Winter season	0.0796	5.0297	0.0285	0.1103	0.0006	0.0045
	Summer season	0.0782	4.9364	0.0258	0.1115	0.0007	0.0044
	Monsoon season	0.0791	5.2119	0.0247	0.1157	0.0006	0.0042

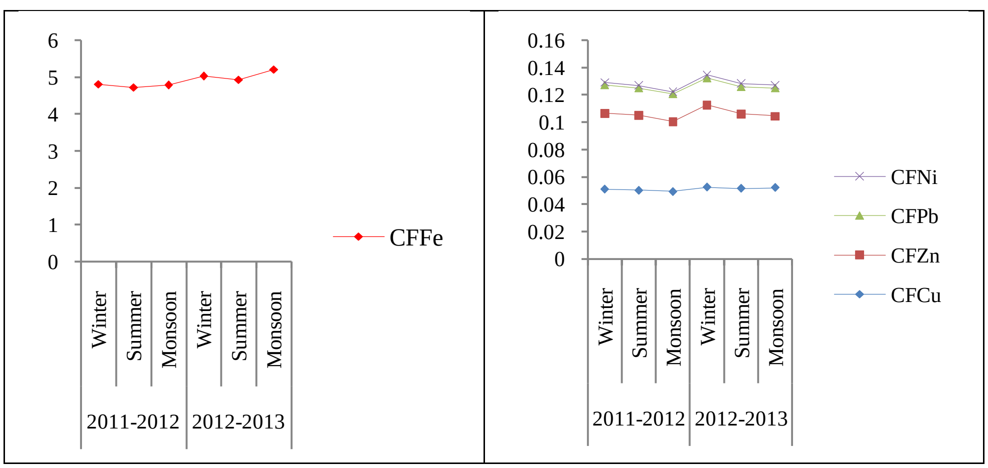

Figure 2: Contamination factors of heavy metals in study area.

Seasonal variation of PLI was not as significant as lower PLI was reported in monsoon only and PLIs of monsoon season were slight lower to the summer and winter season PLI respectively (fig.3).

Accumulation of iron in soil increase with time whereas other metals found to be constant in their respective presence in soil irrigated with Mori gate drain during the study period. The negative effect of heavy metals depends on the percentage weight of their concentration as well as on a series of physical and chemical soil specific characteristics, such as: texture, organic matter content, pH, redox potential, etc. A large proportion of trace metals in soil fraction are in a crystalline solid state (usually in low concentration) and are environmentally immobile. On the other hand, fine particles, such as clay and colloidal materials, are generally surface-active and contain organic matter and Fe/Mn oxide surface coatings, and they can play an important role in controlling deposition of trace metals to sediments from an estuary to a coastal area. Human activities have greatly altered the geochemical cycle of trace metals, resulting in widespread environmental contamination (Nriagu and Pacyna, 1988). The concentration in sediments depends not only on anthropogenic and lithogenic sources but also upon the textural characteristics, organic matter contents, mineralogical composition and depositional environment of the sediments (Trefry and Parsley, 1976).

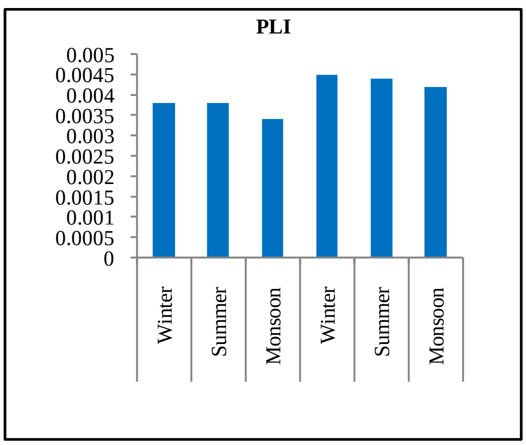

Figure 3: Pollution load index of soil irrigated with Mori gate drain from 2011-2013

CONCLUSION

Pollution Load index of soil irrigated with wastewater useful to assess the pollution in soil and it was found that Mori gate drain irrigated soil is contaminated with heavy metal but the contamination is not sever. As with the increase in population the quantity of wastewater would increase adding more heavy metals to the soil where it is used for irrigation may cross the safe limit and will affect the health of the people consuming the food raised with the wastewater irrigation.

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REFERENCES

- Badawy, S. H. and El-Motaium, R. A. 1999. Effect of Irradiated and Non-irradiated sewage sludge application on some nutrients and heavy metals content of soils and tomato plants. Proceeding of 1st Congress on Recent Technology in Agriculture. Bull. Fac. Agric., Cairo University, Special Edition, 4, 728–744.
- Cameron, R. E. 1992. Guide to site and soil description for hazardous waste site characterization. Volume 1: Metal. Environmental Protection Agency EPA/600/4- 91/029. Washington, DC: US EPA. http://nepis.epa. Gov/EPA/html/Pubs/pubtitleORD. htm.
- Fritioff, A. and Greger, M. 2006. Uptake and distribution of Zn, Cu, Cd, and Pb in an aquatic plant Potamogeton natans. Chemosphere, 63, 220–227.
- Khan, S., Cao, Q., Zheng, Y. M., Huang, Y. Z., and Zhu, Y. G. 2008. Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environmental Pollution, 152, 686–692.
- Liu, W.H., Zhao, J.Z., Ouyang, Z.Y., Soderlund, L. and Liu, G.H. 2005. Impacts of sewage irrigation on heavy metals distribution and contamination in Beijing, China. Environment International 31, 805e812.
- Mapanda, F., Mangwayana, E.N., Nyamangara, J. and Giller, K.E. 2005. The effect of long-term irrigation using wastewater on heavy metal contents of

soils under vegetables in Harare, Zimbabwe. Agriculture. Ecosystem and Environment 107, 151e165.

- Muchuweti, M., Birkett, J.W., Chinyanga, E., Zvauya, R., Scrimshaw, M.D. and Lester, J.N. 2006. Heavy metal content of vegetables irrigated with mixture of wastewater and sewage sludge in Zimbabwe: implications for human health. Agriculture. Ecosystem and Environment 112, 41e48.
- Nriagu, J. O. and Pacyna, J. M. 1988. Quantitative assessment of worldwide contamination of air, water and soils by trace metals. Nature. 333:134– 9.
- Page, V., Weisskopf, L. and Feller, U. 2006. Heavy metals in white lupin: uptake, root-to-shoot transfer and redistribution within the plant. New Phytologist, 171, 329–341.
- Pereira, B. F. F., He, Z. L., Stoffela, P. J. and Melfi, A. J. 2011. Reclaimed wastewater effects on citrus nutrition. Agricultural Water Management, 98, 1828–1833.
- Rattan, R.K., Datta, S.P., Chhonkar, P.K., Suribabu, K. and Singh, A.K. 2005. Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater-a case study. Agriculture. Ecosystem and Environment 109, 310e322.
- Rothenberg, S.E., Du, X., Zhu, Y.G. and Jay, J.A., 2007. The impact of sewage irrigation on the uptake of mercury in corn plants (Zea mays) from suburban Beijing. Environmental Pollution 149, 246e251.
- Singh, A. N., Zeng, D. H. and Chen, F. S. 2005. Heavy metal concentrations in redeveloping soil of mine spoil under plantations of certain native woody species in dry tropical environment, India. Journal of Environmental Science, 1, 168–174.
- Trefry, L. H. and Parsley, B. J. 1976. Heavy metal transport from the Mississippi river to the Gulf of Mexico. In: HL Windhom and R. A Duce (Eds.). Marine Pollution Transfer. Lexington: Lexington Books, pp. 39-76.
- Wilson, B. and Pyatt, F.B. 2007. Heavy metal dispersion, persistence, and bioaccumulation around an ancient copper mine situated in Anglesey. UK. Ecotoxicology and Environmental Safety 66, 224e231.
- Ximenez-Embun, P., Rodriguez-Sanz, B., Madrid-Albarran, Y. and Camara, C. 2002. Uptake of heavy metals by lupin plants in artificially contaminated sand: preliminary results. International Journal of Environmental Analytical Chemistry, 82, 805–813.

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