Asian Journal of Water, Environment and Pollution, Vol. 11, No. 2 (2014), pp. 13–17.

Assessment of Heavy Metals in Top Soil around a Proposed Uranium Tailings Pond in Southern India

K. Brindha and L. Elango*
Department of Geology, Anna University, Chennai – 600 025, India
✉ elango34@hotmail.com

Received July 14, 2013; revised and accepted March 7, 2014

Abstract: The concentration of heavy metals such as copper, iron, manganese, lead and zinc in top soil around a proposed uranium mining and tailings pond area in Nalgonda district, Andhra Pradesh, India was determined. Fourteen soil samples were collected in July 2010 and analysed as per standard procedures. The mean concentration of copper, iron, manganese, lead and zinc in the soil was 0.19, 54.48, 2.0, 0.33 and 0.34 mg/kg respectively. This study provided the spatial variation in concentration of heavy metals as a baseline data for impact assessments of the proposed uranium mining and tailings storage activity in future.

Key words: Soil pollution, agriculture, uranium tailings, heavy metals, agrochemicals.

Introduction

Any undesirable change from natural conditions or introduction of foreign chemicals in the soil environment results in pollution. Soil is an important component of the urban and rural environment, and in both places it is susceptible to pollution. In urban areas, vehicular and industrial emissions are the primary sources of soil pollution (Gowd et al., 2010; Nwachukwu et al., 2010; Mmolawa et al., 2011; Yisa et al., 2011). In rural areas where agricultural activities are prominent, fertilisers and pesticides have long been a known source of soil pollution. This pollution of soil is not a standalone phenomenon, but it has other effects such as pollution of the ground water due to leaching of contaminants from soil during rainfall recharge. Thus, it is essential to maintain the natural soil quality and prevent physical, chemical and biological pollution. Heavy metals occur naturally in soils and have been reported by many researchers (Cheng et al., 2007; Liang et al., 2011; Lianfeng et al., 2011). Landfills and mining activities also alter the true nature of soil (Tripathi and Misra, 2012; Liao et al., 2008). To assess the extent of pollution caused by these activities it is imperative to first quantify the background concentrations of potential pollutants in soil of an area. Currently such background information is commonly unavailable due to non-anticipation of pollution problems. This study was carried out in and around a proposed uranium mining and tailings pond area in Nalgonda district, Andhra Pradesh to determine the baseline concentration of heavy metals such as copper, iron, manganese, lead and zinc in soil.

Earlier studies have been carried out on the groundwater geochemistry of this area based on major ions and minor ions including uranium as the area contains uranium ores (Brindha and Elango, 2013; Brindha and Elango, 2012; Rajesh et al., 2012; Brindha et al., 2011a, b; Brindha et al., 2010; Brindha and Elango, 2010). Radioactive and geochemical modelling were carried out to assess the future impact of storing the uranium tailings on the ground surface in tailings pond (Elango et al., 2012; Brindha, 2012). There are no reported studies on the geochemistry of soils from this area. The present study was carried out with an

*Corresponding Author

aim to assess the composition of heavy metals such as copper, iron, manganese, lead and zinc in soil so as to understand the present status of soil i.e. prior to mining operation. The reported work forms an environmental assessment study which will be useful to compare the quality of soil after the commencement of mining and storage of uranium tailings. The radioactive and geochemical modelling studies can also be fine-tuned taking into consideration the results presented in this paper.

Study Area

This study was carried out in a rural part of Nalgonda district (724 sq km), Andhra Pradesh (Figure 1). It is situated at a distance of 80 km ESE of Hyderabad. The Nagarjuna Sagar reservoir is present at the southeastern side of the study area and the southern boundary is bounded by Pedda Vagu river. The northern boundary of the study area is partly bounded by Gudipalli Vagu river. Uranium ores are present in the southeastern side where the proposed mining will be undertaken (Figure 1). After recovery of uranium from the ore by milling process, the wastes known as tailings will be dumped on the surface of the earth commonly referred as tailings pond. The uranium mining area and the tailings storage area are also shown in Figure 1. This area experiences an arid to semi-arid climate. Summer lasts from April to June with temperature ranging between 30°C and 46.5°C. Winter is from November to January with temperature between 17°C and 38°C. The average rainfall is about 600 mm/year most of which occurs between June and September during the southwest monsoon. The drainage pattern is dendritic to subdendritic, draining to the southeast.

The geology of the region is dominated by late Archean granitic rocks. These include granite/granitic gneisses, pink biotite granite, grey hornblende biotite gneiss, migmatitic granite and metabasalts. In the

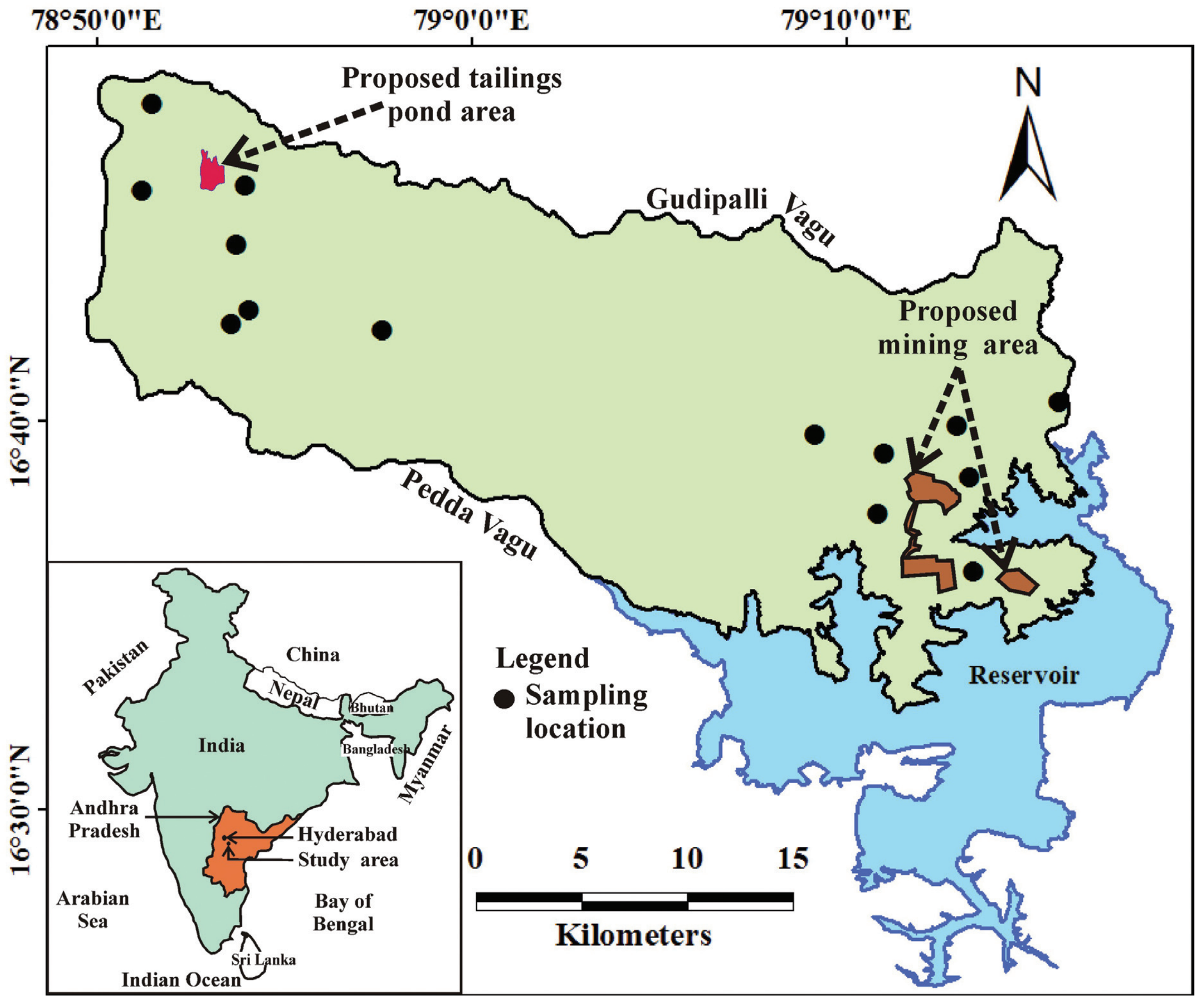

Figure 1: Study area with sampling locations.

early 1990s uranium mineralisation was located in the unconformity of this area (Sinha and Saxena, 2003). Agriculture is the primary use of land in this area. Forest cover is thin to moderate. The cropping pattern depends on climatic conditions and the availability of water resources. This area has numerous tanks, small reservoirs and also few lined canal networks which cater for irrigation activity. Paddy is the principal crop grown in this area. Other common crops include sweet lime, castor, cotton, grams and groundnut.

Materials and Methods

Soil samples were collected at 14 locations in July 2010 which are shown in Figure 1. Care was taken so that the soil samples were collected from different land use pattern such as agricultural and non-agricultural areas. Sample collection was focused near the mining and tailings pond locations. Prior to sample collection 10 cm of the top soil was removed. Then with the help of a non-corrosive stainless steel corer, samples were collected by coring up to 30 cm. The samples were placed in polyethylene bags and appropriately labeled. Care was taken to store the samples in a cool place to avoid any chemical alteration.

Copper, iron, lead, manganese and zinc were extracted from the soil samples using a complete dissolution method with perchloric acid-hydrofluoric acid in an open vessel. The soil solution was analysed using a flame atomic absorption spectrophotometer (GBC 932 Plus) which was calibrated with a single element standard solution. All analytical reagents used in the experiments are of Merck brand. For the preparation of base maps and spatial variation maps, Arc GIS 9.3 was used and Statistica was used for the preparation of dendrogram and correlation matrix.

Results and Discussion

There is a possibility that heavy metals in soil might leach into infiltrating rainwater and reach the groundwater table. Thus, it is necessary to study their concentration in soil. A statistical summary of the various heavy metals concentration measured in the soil samples is presented in Table 1. The average concentration of copper, iron, manganese, lead and zinc in the soil was 0.19, 54.48, 2.0, 0.33 and 0.34 mg/kg respectively. These heavy metals may usually be present in soil in minute quantities.

Table 1: Minimum, maximum and mean concentration of heavy metals in soil (mg/kg)

	Copper	*Iron*	*Manganese*	*Lead*	*Zinc*
Minimum	0.11	50.53	0.84	0.18	0.18
Maximum	0.32	59.00	4.76	0.45	0.88
Mean	0.19	54.48	2.00	0.33	0.34

There are no standards in India for the maximum permissible concentrations of various ions in soil. Hence, the results are compared with the Canadian environmental quality guidelines (Canadian Council of Ministers of the Environment, 2007). The soil quality guidelines for copper, lead and zinc in agricultural soil are 63 mg/kg, 70 mg/kg and 200 mg/kg respectively (Canadian Council of Ministers of the Environment, 2007). Thus, the concentration of copper, lead and zinc in soil from the study area can be considered very low. No standard guideline values are available for the concentration of iron and manganese in soils and thus a comparison cannot be made.

A correlation matrix (Table 2) indicates good correlation between Mn-Fe, Zn-Fe and Zn-Mn. The relationship between the various heavy metals is represented as a dendrogram (Figure 2). This shows that copper, lead and zinc have a common source distinct from iron and manganese. The spatial variation in the concentration of each heavy metal in soil is given in Figure 3. It can be seen that the concentrations of heavy metals are comparatively low in the southeastern part of the study area where mining is to be undertaken. Iron and manganese in the soil are contributed likely from the granitic rocks (Blatt and Tracy, 1997) which are present in most of this area (Brindha and Elango, 2013; Elango et al., 2012). Though the exact source of copper, lead and zinc cannot be known at present, these heavy metals may be attributed to vehicular exhausts and agrochemicals. This analysis of spatial variation in heavy metal concentration in the soil could be used as a reference for assessing possible future changes.

Table 2: Correlation between various heavy metals in soil

	Cu	*Fe*	*Mn*	*Pb*	*Zn*
Cu	1				
Fe	0.46	1			
Mn	0.10	0.84	1		
Pb	0.12	0.16	0.06	1	
Zn	0.38	0.81	0.87	0.27	1

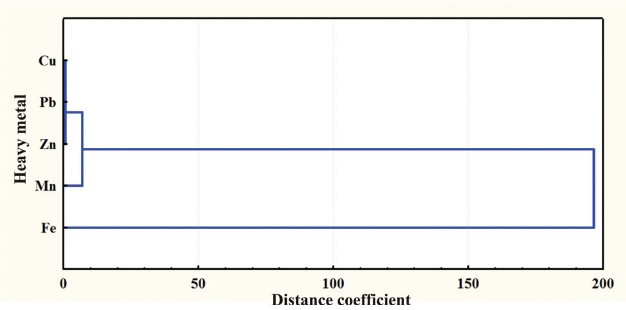

Figure 2: Dendrogram showing relation between the heavy metals in soil.

Conclusion

The concentration of the heavy metals such as copper, iron, lead, manganese and zinc were analysed in 14 soil samples from a part of Nalgonda district, Andhra Pradesh. The concentration of copper, iron, manganese, lead and zinc varied 0.11-0.32 mg/kg; 50.53-59 mg/kg; 0.84-4.76 mg/kg; 0.18-0.45 mg/kg and 0.18-0.88 mg/kg respectively. In the absence of any industrial activities in this area, geology, vehicular emission and agrochemicals may be the primary source for the presence of these heavy metals in soil of this area.

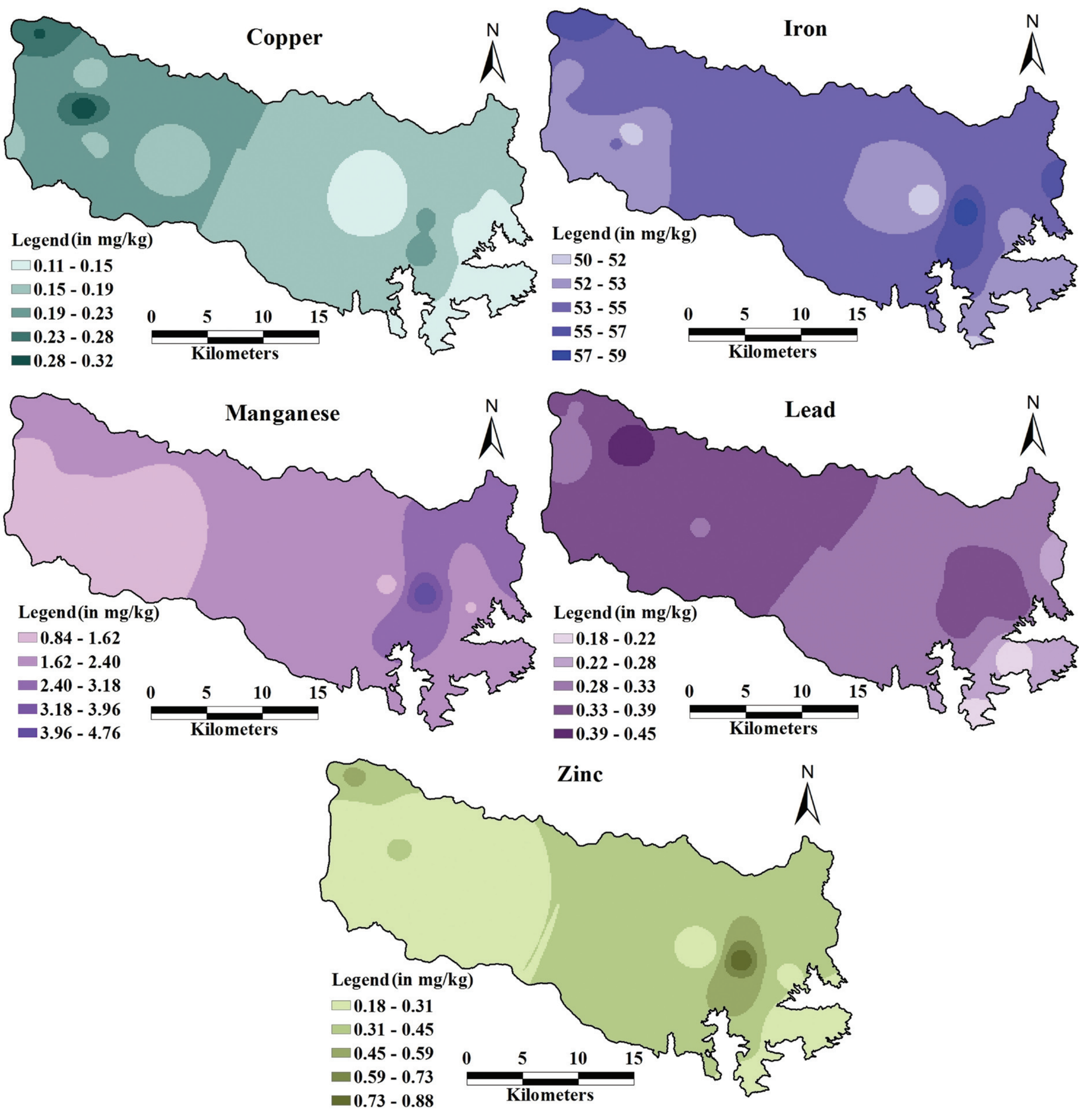

Figure 3: Spatial variation in the concentration of various heavy metals in soil.

Acknowledgements

The authors acknowledge the Board of Research in Nuclear Sciences, Department of Atomic Energy, Government of India, for funding this work (Grant no. 2007/36/35). Authors also thank the Department of Science and Technology's Funds for Improvement in Science and Technology scheme (Grant No. SR/FST/ESI-106/2010) and University Grants Commission's Special Assistance Programme (Grant No. UGC DRS II F.550/10/DRS/2007(SAP-1)) for their support in creating laboratory facilities, which helped in carrying out part of this work. Thanks are due to Mr. Md. T. Zuhail, Research Fellow, Department of Geology, Anna University for carrying out analysis of soil samples.

References

Blatt, H. and R.J. Tracy (1997). Petrology (2nd ed.). Freeman, New York.

Brindha, K. (2012). Assessment of fluoride and uranium in groundwater and hydrogeochemical modelling in a proposed uranium tailings pond area, southern India. Unpublished Ph.D. thesis, Department of Geology, Anna University, India.

Brindha, K. and L. Elango (2010). Study on bromide in groundwater in parts of Nalgonda district, Andhra Pradesh. *Earth Science India*, **3(1):** 73-80.

Brindha, K. and L. Elango (2012). Groundwater quality zonation in a shallow weathered rock aquifer using GIS. *Geo-spatial Information Science*, **15(2):** 95-104.

Brindha, K. and L. Elango (2013). Occurrence of uranium in groundwater of a shallow granitic aquifer and its suitability for domestic use in southern India. *Journal of Radioanalytical and Nuclear Chemistry*, **295:** 357-367.

Brindha, K., Elango, L. and R.N. Nair (2011a). Spatial and temporal variation of uranium in a shallow weathered rock aquifer in southern India. *Journal of Earth Systems Science*, **120(5):** 911-920.

Brindha, K., Rajesh, R., Murugan, R. and L. Elango (2010). Natural and anthropogenic influence on the fluoride and nitrate concentration of groundwater in parts of Nalgonda district, Andhra Pradesh. *Journal of Applied Geochemistry*, **12(2):** 231-241.

Brindha, K., Rajesh, R., Murugan, R. and L. Elango (2011b). Fluoride contamination in groundwater in parts of Nalgonda district, Andhra Pradesh, India. *Environmental Monitoring and Assessment*, **172:** 481-492.

Canadian Council of Ministers of the Environment (2007). Canadian soil quality guidelines for the protection of environmental and human health: Summary tables. Updated September, 2007. *In:* Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Cheng, J., Shi, Z. and Y. Zhu (2007). Assessment and mapping of environmental quality in agricultural soils of Zhejiang Province, China. *Journal of Environmental Sciences*, **19:** 50-54.

Elango, L., Brindha, K., Kalpana, L., Sunny, Faby, Nair, R.N. and R. Murugan (2012). Groundwater flow and radionuclide decay—Chain transport modelling around a proposed uranium tailings pond in India. *Hydrogeology Journal*, **20(4):** 797-812.

Gowd, S.S., Reddy, M.R. and P.K. Govil (2010). Assessment of heavy metal contamination in soils at Jajmau (Kanpur) and Unnao industrial areas of the Ganga Plain, Uttar Pradesh, India. *Journal of Hazardous Materials*, **174:** 113-121.

Lianfeng, W., Yingxia, B. and G. Shinan (2011). Single-factor and Nemerow multi-factor index to assess heavy metals contamination in soils on railway side of Harbin-Suifenhe railway in Northeastern China. *Applied Mechanics and Materials*, **71-78:** 3033-3036.

Liang, J., Chen, C., Song, X., Han, Y. and Z. Liang (2011). Assessment of heavy metal pollution in soil and plants from Dunhua sewage irrigation area. *International Journal of Electrochemical Science*, **6:** 5314-5324.

Liao, G., Liao, D. and Q. Li (2008). Heavy metals contamination characteristics in soil of different mining activity zones. *Transactions of Nonferrous Metals Society of China*, **18:** 207-211.

Mmolawa, K.B., Likuku, A.S. and G.K. Gaboutloeloe (2011). Assessment of heavy metal pollution in soils along major roadside areas in Botswana. *African Journal of Environmental Science and Technology*, **5(3):** 186-196.

Nwachukwu, M.A., Feng, H. and J. Alinnor (2010). Assessment of heavy metal pollution in soil and their implications within and around mechanic villages. *International Journal of Environmental Science and Technology*, **7(2):** 347-358.

Rajesh, R., Brindha, K., Murugan, R. and L. Elango (2012). Influence of hydrogeochemical processes on temporal changes in groundwater quality in a part of Nalgonda district, Andhra Pradesh, India. *Environmental Earth Sciences*, **65:** 1203-1213.

Sinha, R.M. and V.P. Saxena (2003). Cuddapah basin: A storehouse for uranium deposits. Nuclear India. Available from http://www.dae.gov.in/ni/nijul03/cudapah.pdf Accessed on 23rd June 2012.

Tripathi, A. and D.R. Misra (2012). A study of physico-chemical properties and heavy metals in contaminated soils of municipal waste dumpsites at Allahabad, India. *International Journal of Environmental Sciences*, **2(4):** 2024-2033.

Yisa, J., Jacob, J.O. and C.C. Onoyima (2011). Identification of Sources of Heavy Metals Pollution in Road Deposited Sediments Using Multivariate Statistical Analysis. *Journal of Emerging Trends in Engineering and Applied Sciences*, **2(4):** 658-663.

Asian Journal of Water, Environment and Pollution

Volume 10 Number 4 **October – December, 2013**

Contents