AN AJSS An Asian Journal of Soil Science
Volume **12** | Issue 1 | June, 2017 | 30-36 | e ISSN–0976–7231 ■ Visit us : www.researchjournal.co.in

Research Article

DOI : 10.15740/HAS/AJSS/12.1/30-36

Heavy metal contamination in soils surrounding Mandideep industrial area, Madhya Pradesh

■ GOPAL RATHOR, NEELAM CHOPRA, TAPAN ADHIKARI AND S. B. AHER

Received : 01.02.2017; **Revised :** 05.04.2017; **Accepted :** 19.04.2017

MEMBERS OF RESEARCH FORUM:

Corresponding author :
S.B. AHER, Indian Institute of Soil Science, BHOPAL (M.P.) INDIA
Email: satishbaher@yahoo.com

Co-authors :
GOPAL RATHOR AND NEELAM CHOPRA, Govt. Motilal Vigyan Mahavidyalaya, BHOPAL (M.P.) INDIA

TAPAN ADHIKARI, Indian Institute of Soil Science, BHOPAL (M.P.) INDIA

Summary

Soil contamination in vicinity of industrial establishments due to release and accumulation of heavy metals has been a major concern for last few decades. The main objective of present research was to study the status of heavy metal contamination in the industrial area of Mandideep. The Mandideep being the largest industrial area of Madhya Pradesh in India was selected for present investigation. Mandideep is located between N 23°04' longitude and E 077°31' latitude with an elevation of 1496 m above MSL. The representative soil samples were collected from ten different locations and subjected to laboratory analysis for determination of total and available concentration of seven important heavy metals *viz.*, Pb, Zn, Cr, Cu, Ni, As and Cd. Four acid digestion and DTPA extraction methods were used to digest and extract the total and available form of heavy metal from sample, respectively. The heavy metal concentrations from digest and extractant were estimated by using ICP-OES instrument. In the present study it reveals that the heavy metals concentration is at the nearby maximum level. The results showed that all heavy metal *viz.*, Pb, Zn, Cr, Cu, Ni, As and Cd concentrations in soils surrounding the industrial area of Mandeep found in higher concentrations at all the sampling locations. The concentrations of total lead, copper, chromium, zinc, cadmium, arsenic and nickel varied from 26.6 to 143.9 mg kg^{-1}, 81.0 to 361.0 mg kg^{-1}, 53.0 to 462.0 mg kg^{-1}, 80.1 to 1200.0 mg kg^{-1}, 3.0 to 23.2 mg kg^{-1}, 15.1 to 48.6 mg kg^{-1} and 84.3 to 260.7 mg kg^{-1}, respectively whereas available lead level ranged between 1.2-4.9 mg kg^{-1}, copper varied from 2.7 to 25.5 mg kg^{-1}, chromium occurred in range from 0.018 to 0.052 mg kg^{-1}, whereas zinc found in range from 7.4 to 71.6 mg kg^{-1}, cadmium level ranged from 0.158 to 0.418 mg kg^{-1}, arsenic varied from 0.008 to 0.021 mg kg^{-1} and nickel was found in a range from 0.275 to 5.952 mg kg^{-1}. In conclusion, the soil in the vicinity of Mandideep industrial area is severely contaminated with heavy metals released and accumulated from the industrial operations.

Key words : Heavy metal contamination, Soil pollution

How to cite this article : Rathor, Gopal, Chopra, Neelam, Adhikari, Tapan and Aher, S.B. (2017). Heavy metal contamination in soils surrounding Mandideep industrial area, Madhya Pradesh. *Asian J. Soil Sci.*, **12** (1) : 30-36 : **DOI : 10.15740/HAS/AJSS/12.1/30-36.**

Introduction

In recent years, contamination of large area of land by heavy metals has become a major concern. Heavy metal appears to include all metals of the periodic table with atomic numbers greater than 20, generally excluding the alkali metal and the alkali earths. However, this imprecise term is commonly used in metals classed as environmental pollutants. The heavy metals considered most important as environmental pollutants are Cd, Pb,

Cu, Cr, Zn, Ni and As. The term heavy metal is least satisfactory for those metals involved in biochemical and toxicological processes (Tiller, 1989). These heavy metals are persistence, accumulate and not metabolized in other intermediate compounds and do not easily breakdown in environment. These metals are accumulating in food chain through uptake at primary producer level and than through consumption at consumer level. Metals generally enter the human body either through inhalation or injection. Due the solution nature of metal complex, they are found to be more harmful for environment as compared to their free ionic form. Industrial and urban activities have led to the elevated levels of concentration of a wide range of contaminants in soil, affecting the health of millions of people worldwide. Heavy metal contamination originate mainly from industrial waste, municipal waste incinerators, car exhausts, residues from metal liferous mining and the smelting industry and the use of urban compost, pesticides, fertilizers or sludge and sewage. Pollution of agricultural soils by heavy metals may lead to reduced yields and elevated levels of these elements in agricultural products and thus provide their entrance into food chain. Soil constituents may immobilize heavy metals, so prevent the detrimental effects on soil organisms, crops and ground water quality (Blume and Brummer, 1991 and Ahmad *et al.*, 2007). The soil contaminants of heavy metals were studied in different parts of India (Parkpian *et al.*, 2003 and Singh *et al.*, 2003). Govil (2001) studied that the very high concentrations of Cu (400 ppm), Zn (1000 ppm), Pb (1600 ppm) and Ni (700 ppm) of Jeedimetla industrial area of Andhra Pradesh, India. Sujatha *et al.* (2001) found higher concentrations of heavy metal in soil sample from a lake in Mysore, Karnataka, and indicating metal toxicity. Gowda *et al.* (2003) studied the status of pollutants in soil in industrial area in Bangalore. Bansal (2004) found that the soils under sewer water irrigation had higher concentrations of Zn, Cu, Pb and Cd when compared to fields irrigated by underground water. Anuratha (2006) investigated the heavy metal concentration in soil in the vicinity of industries around Coimbatore city in Tamil Nadu, India. In this study it was aimed to investigate the heavy metal concentrations of soils surround industrial area of Mandideep.

Resource and Research Methods

Study area :

Mandideep is the largest industrial area in Madhya Pradesh (India), situated about 27 km away from Bhopal. Mandideep is located between N 23°04' longitude and E 077°31' latitude, elevation 1496. The average rainfall of Mandideep is 950mm. It has both large and small scale industries. Large number reputed companies are functioning in Mandideep (Fig. A1 and A2).

Collection of soil samples :

Total 10 soil samples were collected from the

Table A1 : GPS Locations of soil sample collection point of polluted area

Sr. No.	Location	GPS location
1.	Tristar pvt.ltd. Mandideep (S_1)	±18 N 23°04'54.0" E 077°31'45.7" ELEVATION 1496 ft
2.	Around of Lupin, Shri Vijay, Inder plastics and R.K. Engineering Pvt.Ltd. Mandideep (S_2)	±17 N 23°04'39.9"E 077°32'9.7" ELEVATION 1446 ft
3.	Around of Yanars CCP, Cunital, Vardhaman textile Mandideep (S_3)	±23 N 23°04'40.0" E 077°33'14.1" ELEVATION 1476 ft
4.	Nala all industrial area of Mandideep (S_4)	±13 N 23°04'13.5" E 077°32'15.4" ELEVATION 1433 ft
5.	Agriculture field soil sample (irrigation by Nala) industrial area of Mandideep (S_5)	±12 N 23°04'13.4" E 077°32'10.1" ELEVATION 1420 ft
6.	Back side of Nahar textile Mandideep (S_6)	±13 N 23°2'59.4" E 077°32'45.9" ELEVATION 1450 ft
7.	R.V.R. Technologies Ltd. Hershey Ltd. new industrial area of Mandideep (S_7)	±18 N 23°4'23.4" E 077°31'46.8" ELEVATION 1423 ft
8.	Bansal Iron Pvt.Ltd. industrial area Mandideep (S_8)	±15 N 23°4'36.3" E 077°31'41.0" ELEVATION 1433 ft
9.	Saurabh metal Pvt.Ltd. And Cromption power greaves ltd. industrial area (S_9)	±16 N 23°4'44.4" E 077°31'20.1" ELEVATION 1440 ft
10.	Saurabh metal Pvt.Ltd. and Cromption power greaves Ltd. industrial area (S_{10})	±14 N 23°4'44.0" E 077°31'19.7" ELEVATION 1436 ft

Fig. A1 : Study area (Industrial area of Mandideep)

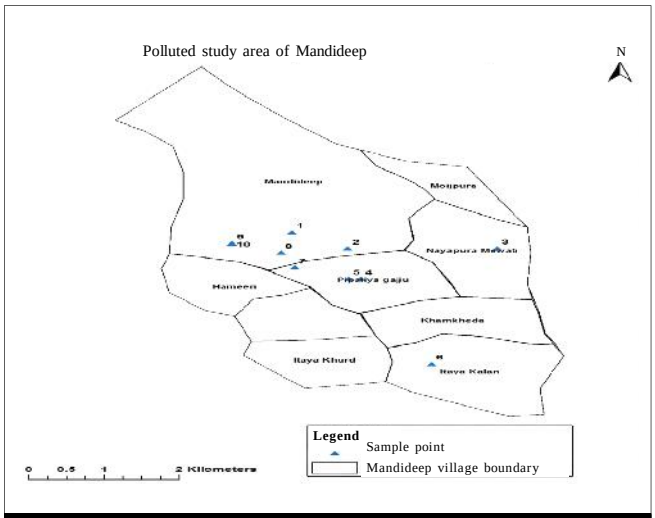

Fig. A2 : Sample collection point (Industrial area of Mandideep)

industrial area Mandideep. These soil samples were collected in polyethene bags by proper marking. GPS (GERMIN GPS MAP 76CS$_X$) was used for Geo information of particular area for sample collection.

Preparation soil samples :

Soil samples were dried in shade, ground with wooden pestle and mortar and passed through 2 mm sieve. The fine samples were stored in separate polyethylene bags and used for heavy metal analysis. Necessary precautions were taken to avoid all possible contaminations. Soil pH was determined in 1:2, soil: water suspension by potentiometric method. The electrical conductivity was determined by in 1:2. soil-water extract by using conductivity bridge. Soil organic carbon was determined by the method of Walkley and Black (1934).

Total heavy metal analysis :

Edgell (1988) method were used for determination of total heavy metal of soil. The soil samples were oven dried (50°C) and finely ground (<2 mm). Soil was burnt to ashes in a crucible. Ashes of 0.5 g of soil sample were taken in a conical flask and were moistened with 1ml of double distilled water; concentrated HCl and HNO_3 were successively added in a 3: 1 ratio. The flask was heated gently on a heating plate until the sample was digested and indicated by the formation of a clear solution above the soil residue. The mixture was reduced to a volume of 1ml. Double-distilled water was added to reach a final filtrate volume of 50ml and filtered through Whatman filter paper number 42. Digested soil samples were analyzed for heavy metal using ICP-OES (Perkin Elmear Optima DV 2100).

Available heavy metal analysis :

Lindsay and Norvell (1978) method were used for determination of available heavy metal of soil. The content of heavy metal was determined with the help of an ICP- OES (Perkin Elmear Optima DV 2100).

Research Findings and Discussion

In soil samples taken from 10 different stations of industrial area, Mandideep, pH, EC, total organic carbon, Pb, Zn, Cr, Cu, Ni, As and Cd were estimated. Map 1a and Map 1b showed the details of sample collection site. The pH of polluted soil varied from 6.62 to 8.05, EC of polluted soil sample were recorded 0.210 to 2.640 mS cm^{-1} and organic carbon varied from 4.5 to 52.5 per cent (Table 1).

Table 1 : Physico-chemical properties of the soil collected from industrial area of Mandideep

Sr. No.	1	2	3	4	5	6	7	8	9	10
pH	7.42	6.62	7.88	7.95	7.85	8.00	8.05	7.74	7.47	7.56
EC (mS cm^{-1})	1.261	1..661	0.872	0.462	0.210	2.640	0.560	1.026	0.670	1.832
Organic carbon(%)	24.0	36.9	8.4	22.8	14.7	18.3	4.5	52.5	31.8	19.8

Lead :

In this study, it was found that the total Pb concentration was varied from 26.6 to 143.9 ppm and available was from 1.2 to 4.9 ppm. Total Pb concentration was highest at sample 6 which is located back side of Nahar textile industry but available in sample 1 (Tristar Pvt. Ltd.) (Fig.1).

Zinc :

According to the Fig. 2, total and available Zn concentration was lowest (80 ppm) and highest (1200 ppm) and from 2.4 to 96.3, respectively. The highest Zn concentration was found at sample 6 (Nahar textile industry, Table A1). There are so many sources of Zn like fossil fuels, metal manufacturing and fertilization (Markert, 1993).

Chromium

The main sources of Cr pollution are the plastic wastes, septic wastes and sewages. The highest total and available Cr concentration level was measured at sample 6 (462.1 ppm) and (0.052 ppm) at site 1, respectively (Fig.3). The natural and essential one is the chromium (III), whereas chromium (VI) is generally by-product of industrial activities and considered to be more mobile and toxic (Paiva *et al.*, 2009).

Copper :

The total and available Cu concentration was varied from 81.0 to 361.1 and 2.7-25.5, respectively (Fig. 4). The highest Cu concentration was found at site 9 (Saurabh Metal Pvt. Ltd. and Cromption Power Greaves Ltd. Industrial area). Cu enters into the ecosystem *via* so many sources like house device industry, wood and metal manufacturing, pesticide usage, animal manures and septic tanks.

Cadmium :

The perusal of the data presented that in Fig.5 the maximum value of total and available Cd concentration

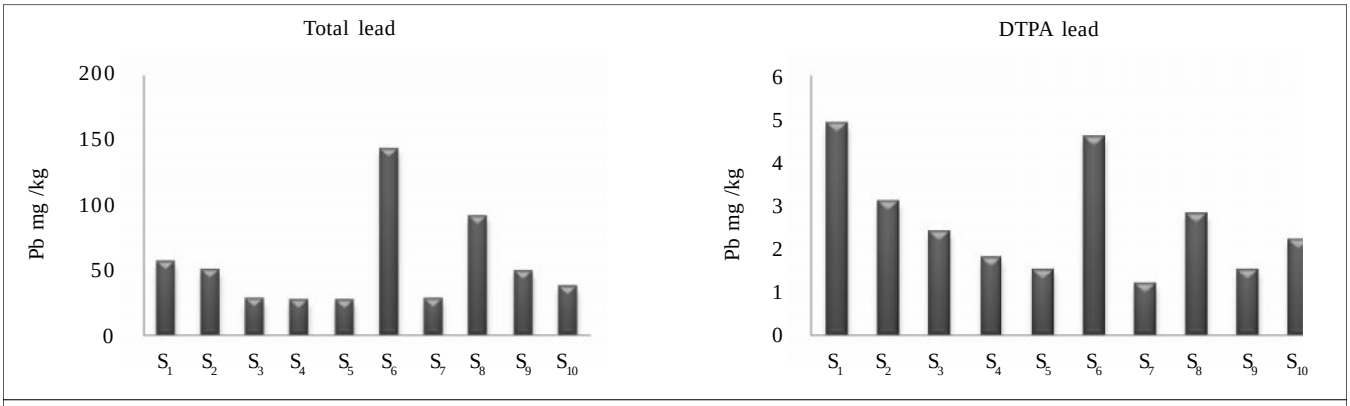

Fig. 1 : Total and available concentration of lead in soil

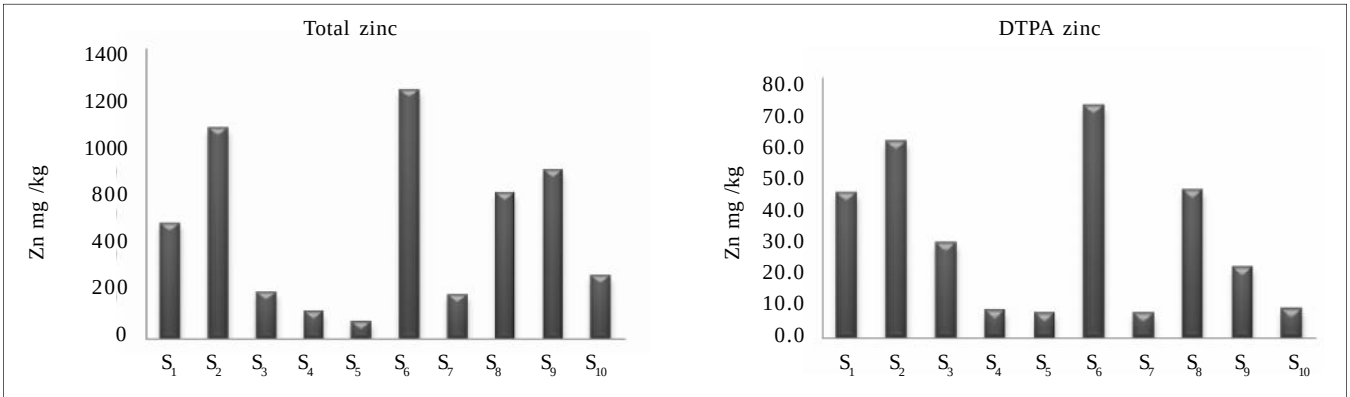

Fig. 2 : Total and available concentration of zinc in soil

was 23.2 ppm at site 6 and 0.42 ppm at site 1, respectively. The minimum value of total and available Cd concentration was 3.0 ppm at site 3 and 0.158 ppm at site 7, respectively.

It is very toxic to animals and plants and plants' exposure to Cd causes reductions in photosynthesis, water and nutrient uptake (Sanita *et al.,* 1999).

Nickel :

The highest total Ni concentration was measured at site 6 (260.7 ppm) and available 5.95 ppm at site 2 (Fig. 6). Nickel is used mainly in the production of

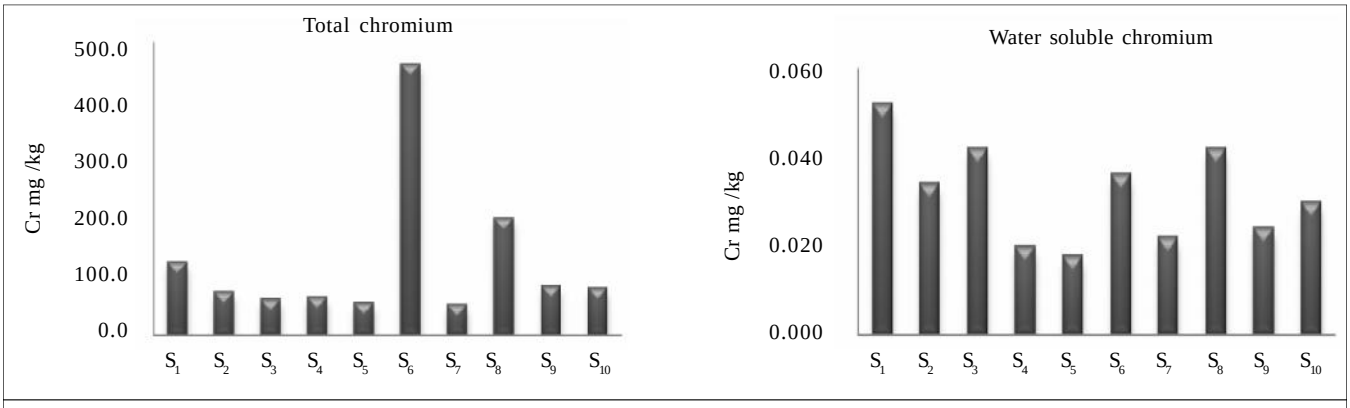

Fig. 3 : Total and available concentration of chromium in soil

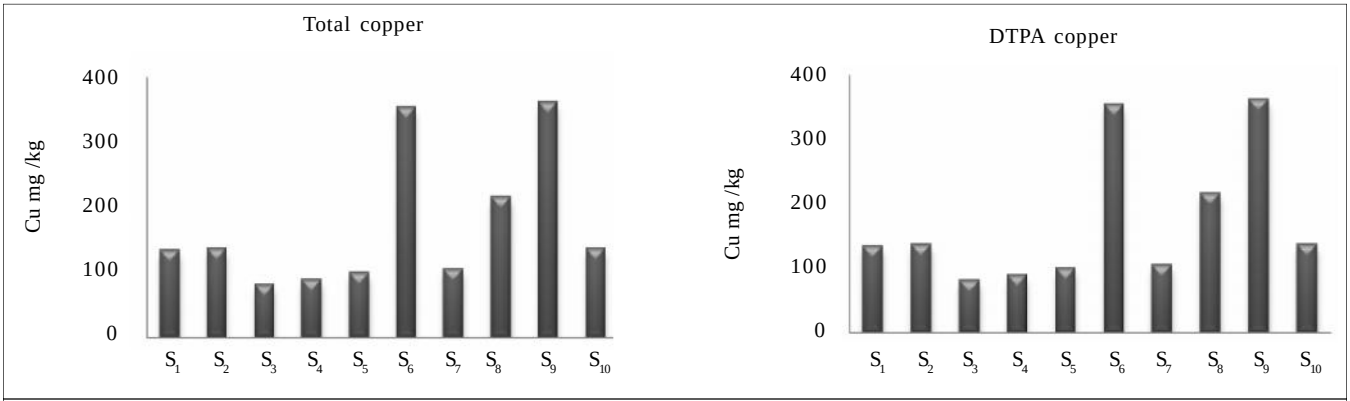

Fig. 4 : Total and available concentration of copper in soil

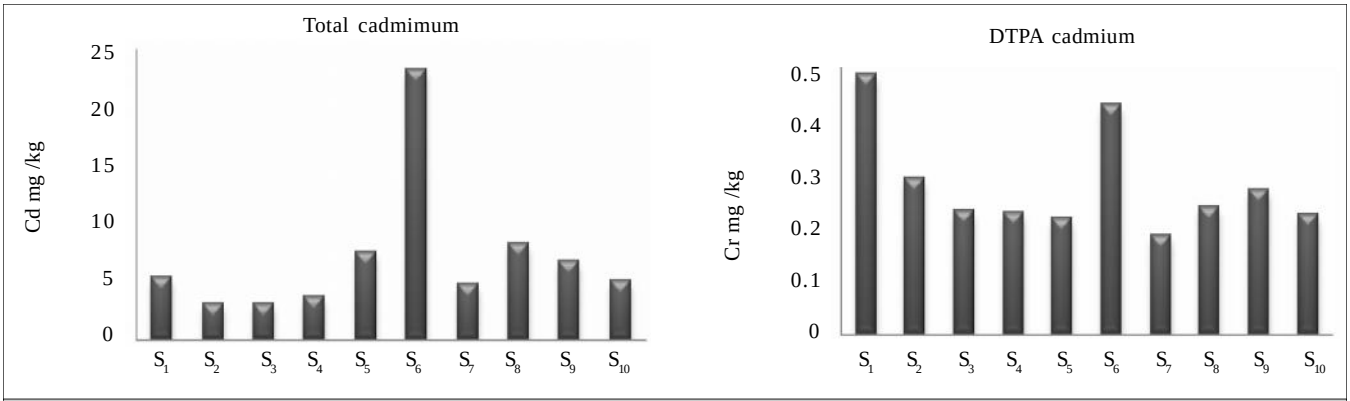

Fig. 5 : Total and available concentration of cadmium in soil

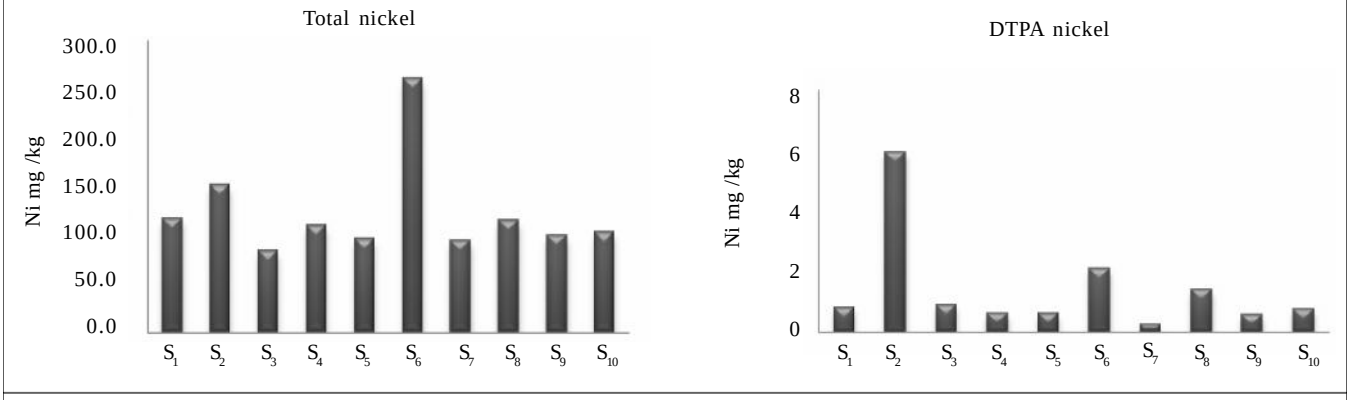

Fig. 6 : Total and available concentration of nickel in soil

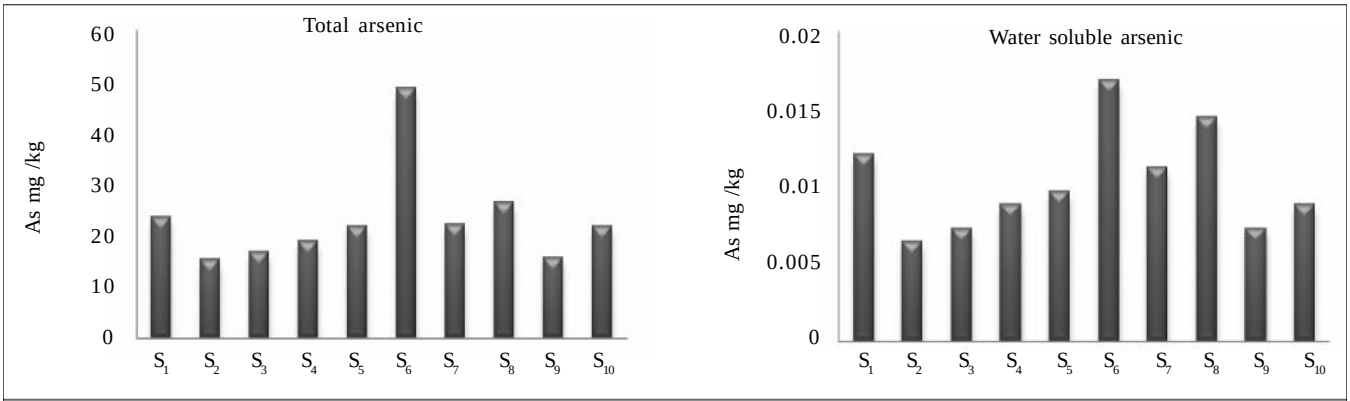

Fig. 7 : Total and available concentration of arsenic in soil

stainless steels, non-ferrous alloys and super alloys.

Arsenic :

Arsenic is in many industrial raw materials, products, and wastes and is a contaminant of concern in soil. According to Fig.7, total as concentration varied from 15.1-48.6 ppm and available from 0.008 to 0.021 ppm. In this study As concentration ware high at site 6. Industrial products containing arsenic include wood preservatives, paints, dyes, pharmaceuticals, herbicides and semiconductors. The man-made sources of arsenic in the environment include mining, agricultural applications, burning of fossil fuels, pulp and paper production, cement manufacturing (U.S.EPA. 2000).

Conclusion :

Present study concludes that heavy metal pollution in and around the industrial area of Mandideep was found significant. Discharge of untreated industrial waste to the soil was found responsible for soil contamination and decreasing soil quality.

Acknowledgment :

The authors are thankful to Dr. Abha Gargav, Principal, M.V.M. College, Bhopal and Dr. A. Subba Rao, Director, Indian Institute of Soil Science (IISS), Bhopal for continuous encouragement and providing necessary facilities required for analytical part of present research. We also extend our thanks to Mr. Poonam Singh Rajput, Mr. Balram Singh Yadav and all those who helped in the present work.

Literature Cited

Ahmad, M.S.A., Hussain, M., Saddiq, R. and Alvi, A.K. (2007). Mungbean: A nickel indicator, accumulator or excluder? *Bull. Environ. Contamin. & Toxicol.,* **78** : 319-324.

Anuratha, A. (2006). Assesment of heavy metal pollution in the industrial site of Coimbatore. *J. Eco Toxicol.& Environ. Monitor.,* **16** : 13-17.

Bansal, O.P. (2004). Uptake of heavy metals by crop plants. *Pollu. Res.,* **23** : 501-506.

Blume, H.P. and Brummer, G. (1991). Prediction of heavy metal behavior in soil by means of simple field tests. *Ecotoxicol. & Environ. Safety,* **22** : 164-174.

Edgell, K. (1988). *USEPA method study 37 - SW-846 method 3050 acid digestion of sediments, sludges and soils*. EPA Contract No. 68-03-3254, November 1988.

Govil, K.P. (2001). Distribution and characterization of heavy metals in Jeedimetla industrial area Andra Pradesh, India. *Pollu. Res.,* **20** : 245-255.

Gowda, N.K.S, Malathi, V.S., Jash, S. and Roy, K.S. (2003). Status of pollutants and trace elements in water, soil, vegetation and dairy animals in industrial area of Bangalore. *Indian J. Dairy Sci.,* **56**: 86-90.

Lindsay, W.L. and Norvell, W.A. (1978). Development of DTPA test for Fe, Zn, Mn and Cu. *Soil Sci. Soci. America J.,* **42** : 421-428.

Markert, B. (1993). *Plants as biomonitors, indicators for heavy metals in the terrestrial environments.* VCH Publishers.

Paiva, L.B., Oliveira, J.G., de Azevedo, Ribeiro, R.A., Silva, D.R., Da, M.G. and Vitoria, A.P. (2009). Ecophysiological responses of water hyacinth exposed to Cr^{3+} and Cr^{6+}. *Environ. Exp. Bot.,* **65** : 403-409.

Parkpian, P.S., Hing, T.L., Laortanakul, P. and Thunthaisong, N. (2003). Regional monitoring of lead and cadmium contamination in a tropical grazing land site, Thailand. *Environ. Monitor. & Assess.,* **85** : 157-173.

Sanita, di Toppi L. and Gabbrielli, R. (1999). Response to cadmium in higher plants. *Environ.l Exp. Bot.,* **41**: 105-130.

Singh, R., Randhawa, S.S. and Randhawa, C.S. (2003). Trace element status of crossbred cattle from sub-mountainous belt of Punjab in relation to soil and fodder. *Indian J. Anim. Sci.,* **73** : 1072-1076.

Sujatha, S.D., Sathyanarayanan, S., Satish, P.N. and Nagaraju, D. (2001). A sewage and sludge treated lake and its impact on the environment Mysore. *Indian J. Environ. Geol.,* **40** : 1209-1213.

Tiller, K.G. (1989). Heavy metals in soil and their environmental significance. *Adv. Soil Sci.,* **9** : 113-142.

U.S.EPA (2000). National primary drinking water regulations, arsenic and clarifications to compliance and new source contaminants monitoring, proposed rule. *Federal Register,* **65**(121):38888. *http://www.epa.gov/safewater/ars/arsenic.pdf.*

Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.,* **37**: 29-38.