

Heavy metal contamination in soils surrounding Gurh region of Rewa (M.P.)

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Abstract : 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 Gurh. The Gurh being the largest industrial area of Madhya Pradesh in India was selected for present investigation. Gurh 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 Gurh 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 Gurh industrial area is severely contaminated with heavy metals

released and accumulated from the industrial operations.

(Keywords: Heavy metal contamination, Soil pollution)

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 processes¹. 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 metaliferous 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^{2,3}. The soil contaminants of heavy metals were studied in different parts of India^{4,5}. Govil *et al.* 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, India⁶. Sujatha *et al.*, found higher concentrations of heavy metal in soil sample from a lake in Mysore, Karnataka and indicating metal toxicity⁷. Gowda *et al.*, studied the status of pollutants in soil in industrial area in Bangalore⁸. Bansal *et al.*, found that the soils under sewer water irrigation had higher concentrations of Zn, Cu, Pb and Cd when compared to fields irrigated by underground water⁹. Anuratha *et al.*, investigated the heavy metal concentration in soil in the vicinity of industries around Coimbatore city in Tamil Nadu, India¹⁰. In this study it was aimed to investigate the heavy metal concentrations of soils surround industrial area of Gurh.

Experimental

Materials

All the chemicals used were of reagent grade. Distilled water was used in all kinetic runs. The ionic strength and the acidity of the reaction solution were adjusted with *p*-toluenesulphonic acid and its sodium salt. Chloropentaammineruthenium (III) Chloride was prepared by the method of Allen *et al.*,^{3,4} from ruthenium trichloride and hydrazine hydrate. Found: H, 5.08; N, 23.75%. Calcd for $[\text{RuCl}(\text{NH}_3)_5]\text{Cl}_2$: H, 5.19; N, 23.98%. Aquopentaammineruthenium(III) *parchlorate* was prepared by the method of Endicott and Taube⁵.

Found: H, 3.20; N, 13.74%.
Calcd for $[\text{Ru}(\text{H}_2\text{O})(\text{NH}_3)_5](\text{ClO}_4)_3$:
H, 3.42; N, 13.94%.

Halogenoacetatopentaammineruthenium(III) perchlorates were prepared by the method of Stritar and Taube⁶ from chloropentaammineruthenium chloride, a halogenoacetate buffer solution and a zinc amalgam.

Resource and Research Methods

Study area

Gurh is the industrial area in Madhya Pradesh (India), situated about 30 km away from Rewa. Gurh is located between E 81°30' longitude and N 24°30' latitude, elevation 325.57 meters. The average rainfall of Gurh is 15.69 mm. It has large scale industry are functioning in Gurh.

Collection of soil samples

Total 10 soil samples were collected from the industrial area Gurh. These soil samples were collected in polyethene bags by proper marking.

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 of¹¹.

Total heavy metal analysis

The methods were used for determination of total heavy metal of soil¹² 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 HNO₃ 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 Elmer Optima DV 2100).

Available heavy metal analysis

The method were used for determination of available heavy metal of soil¹³. The content of heavy metal was determined with the help of an ICP- OES (Perkin Elmer Optima DV 2100).

Results and Discussion

In soil samples taken from 10 different stations of Gurh, pH, EC, total organic carbon, Pb, Zn, Cr, Cu, Ni, As and Cd were estimated. 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 percent (Table -1).

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

S.No.	pH	EC (mS cm ⁻¹)	Organic carbon (%)
1	7.42	1.261	21.0
2	6.62	1.661	36.9
3	7.88	0.872	8.4
4	7.95	0.462	22.8
5	7.85	0.210	14.7
6	8.00	2.640	18.3
7	8.05	0.560	4.5
8	7.74	1.026	52.5
9	7.47	0.670	31.8
10	7.56	1.832	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 plant industry but available in sample 1 (Solar plant) (Fig.1).

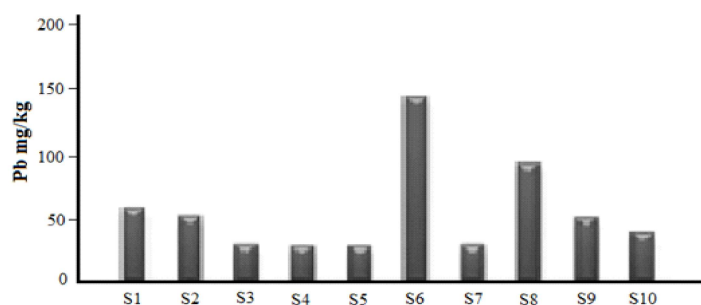


Fig. 1 Total and available concentration of lead in soil

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 (plant industry). There are so many sources of Zn like fossil fuels, metal manufacturing and fertilization¹⁴.

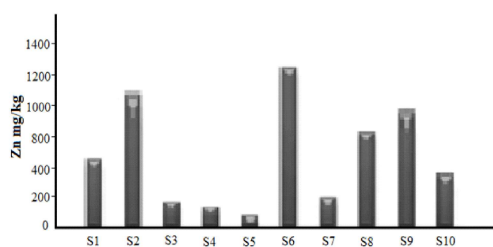


Fig. -2 Total and available concentration of zinc in soil

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 toxic¹⁵.

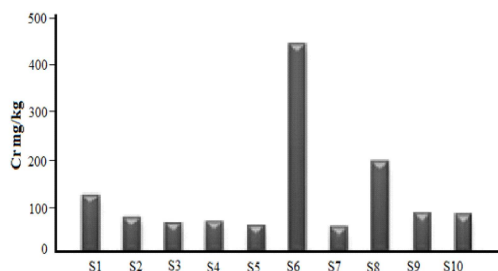


Fig. - 3 Total and available concentration of chromium in soil

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 (Rajeev agro Industrial area). Cu enters into the ecosystem *via* so many sources like house device industry, wood and pesticide usage, animal manures and septic tanks.

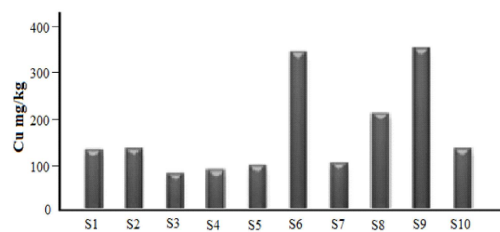


Fig. 4 Total and available concentration of copper in soil

Cadmium

The perusal of the data presented that in Fig.5 the maximum value of total and available Cd concentration 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 uptake¹⁶.

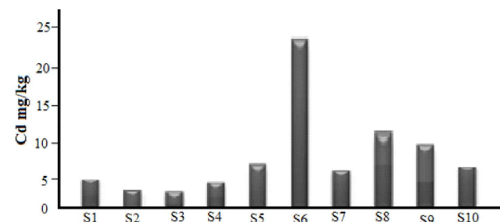


Fig. - 5 Total and available concentration of cadmium in soil

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 RDPL plant, non-ferrous alloys and super alloys.

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 (Rajeev agro Industrial area). Cu enters into the ecosystem *via* so many sources like house device industry, wood and pesticide usage, animal manures and septic tanks.

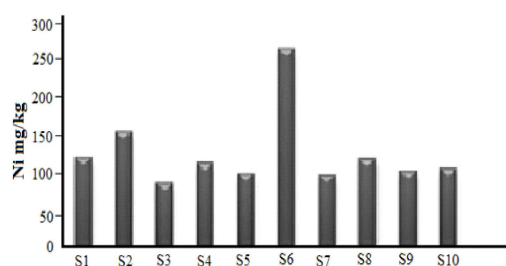


Fig. - 6 Total and available concentration of nickel in soil

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 were 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 manufacturing¹⁷.

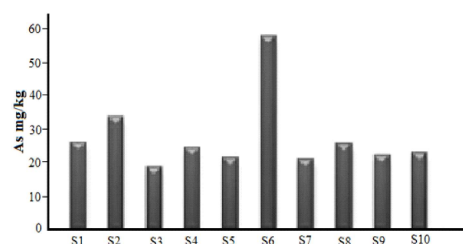


Fig. 7 Total and available concentration of arsenic in soil

Conclusions

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

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