

Adsorption of Heavy Metals in Soil

Kumud Tanwar¹, Swati Singh¹, Ashok Kumar Kakodia²

¹Department Of Chemistry, Kanoria PG Mahila Mahavidhyalaya, Jaipur (Rajasthan)

²Department of Chemistry, S. G. G. Government College Banswara, (Rajasthan)

tanwar_kumud@yahoo.co.in, swati_feb2010@rediffmail.com, kakodia30@gmail.com

Abstract : Soil is a major reservoir for contaminants as it possesses ability to bind various chemicals. Diverse amounts of heavy metals may be found everywhere in soils, water, sediments, plants, even the arctic. Heavy metals may physically or chemically interact with the natural compounds. In other words they may react with particular species, change oxidation state and precipitate. Heavy metals may be bound by particular natural substances, which may increase or decrease mobility. Studying the dissipation of heavy metals is called speciation which may be physical or chemically.

Keywords: Dissipation, leaching

Introduction

The transport mechanism of heavy metals through soil has presented great interest to both environmental & soil scientists because of the possibility of ground water contamination through metal leaching¹⁻³. These metals can be Fe, Cr, Mn, Ni, Zn, Cu, Pb, Cd, Hg, etc. Metal transport is not only dependent on the physiochemical properties of the metals but mostly on the physical and chemical properties of soil. The influence of acid rains on soils and sorption properties of soil complex has been extensively studied by scientists from various disciplines.

The long term use this may contaminate the soil with heavy metals which may pose serious human and animal health. If the heavy metals are drawn into the soil plant – animal continuum then their research has shown beneficial effect of sewage irrigation on soil fertility⁴⁻⁶. However, its removal is not easy and since the curative strategies are expensive and very difficult the preventive strategies need to be fixed in our countr. More than 450 cities in India generate more than $17 \times 10^6 \text{m}^3$ of sewage age per day ,it is being increasingly used for irrigation especially the vegetables four decades on the same land.

But it also may contain non- essential heavy metals which when present in large amount could be transferred to animal and human beings through food chain One major limitation in land application of municipal sewage is the resultant heavy metal accumulation in soils in food chain, posing a potential health hazard for human being. These heavy metal contaminants are not biodegradable into non-toxic and products⁷⁻⁹. It contain variable amount of metallic cation and various bacteria and viruses contaminating the soil and plant being grown on them. The nutrient levels of the soil are expected to improve considerable with continuous application of sewage effluent. The agriculturists are much worried about the pollution especially the entry of toxic elements of the heavy metals create serious problem whenever they get accumulate in the environment. Soil micro – organisms are indeed affected by heavy metals as the result of a multiplicity

of interactions that can occur between microbial cells ions and other environmental constituents¹⁰⁻¹³.

Methodology is scientific study of conducting any research in order that a study is reliable and conducted with accuracy. The present study is divided into following section. Location of sample i.e. Jobner area and Kalwar area

Collection of soil sample

On the above basis we collect the soil sample from the field in definite divided areas. Each sample represents an area of approximately 1 hectare. Then we scrap away the surface litter and insert soil auger or sampling tube to a plough depth (about 15cm. Quartering is done by dividing the thoroughly mixed soil into four equal parts and discarding to opposite quarters. Then we are remix the remaining two quarters and again divide it into four parts and reject two of them, repeat this procedure until one half kilogram of soil is left. Put the soil into a clean and numbered cloth bag after air drying in shade.

Material And Method

Principle

DTPA, a chelating agent combines with free metal ions in solution and forms soluble complexes. DTPA offers the most favourable combination of stability constants for the simultaneous complexing of Zn,Cu,Fe and Mn. Since Fe and Zn deficiency is frequently experienced in calcareous soil , the method is designed to avoid excessive dissolution of CaCO_3 with the release of occluded micronutrients which are normally not available to plants.when the extractant is added to soil ,additional Ca^{2+} and some Mg^{2+} enter the solution. This is largely because the protonated TEA exchange with these ions from the exchange sites and this lead to the increased ionic concentration of Ca^{2+} in the solution ,which in turn helps in suppressing the dissolution of CaCO_3 . DTPA extractant has the ability to chelate Zn ,Cu,Fe and Mn in competition with Ca^{2+} and Mg^{2+} .

Instruments

Magnetic Shaker

Atomic absorption spectrophotometer (AAS).



Figure 1:- Atomic Absorption Spectrometer

Determination of zinc

Reagents

- **Dilute HCL** : AR grade HCL diluted 5 times with double distilled water.

- **DTPA extractant** : dissolve 1.967 g of AR grade diethline-triaminepenta acetic acid(DTPA) and 1.470 g of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ (AR grade in about 25 ml of double distilled water (DDW) by adding 13.3 ml of triethanolamine(TEA), followed by 100ml more of DDW. Transfer the solution to one litre volumetric flask giving 4 to 5 washing. Just before making up the volume , adjust pH to 7.3 with dilute HCL. This reagent has 0.005M DTPA, 0.01M $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$.

- **Standard stock solution 'A' (1000 mg Zn L⁻¹):** weigh exactly 1.0 g of pure Zn metal (AR grade) and dissolve it in minimum volume of dil. HCl (1:1) and make the volume to one litre.

- **Standard solution 'B'** Dilute 5 ml of solution A to 100 ml to get solution B containing 50 mg Zn L⁻¹.

- **Standard working solutions:** Dilute 0.5, 1.0, 1.5 , 2.0, 2.5 and 5.0 ml portions of solution B to 50ml to get working standards containing 0.5, 1.0 , 1.5, 2.0, 2.5 and 5.0 mg Zn L⁻¹. The working standards should be prepared in the medium of the extracting solution after every few days as it cannot be preserved for long.

Procedure

Weigh 10 g of soil sample in 100 ml conical flask. Add 20 ml of the DTPA extractant and shake for 2 h on a mechanical shaker. Filter through Whatman No. 42 filter paper, discarding first few drops. For quick filtration, Whatman No. 1 filter paper can also be used if the filtrate is clear. Use the filtrate for Zn measurement using AAS. Feed the standard working solution and prepare a standard curve by plotting AAS readings against Zn concentrations.

Calculation

Available (DTPA-extractable) Zn in soil (mg kg⁻¹) = A × 2

Where, A stands for the Zn concentration in aliquot as read from X- axis of standard curve against the sample reading.

Determination of available copper

Available copper can be determined in the DTPA extract similar to Zn, using AAS. For this, the standard stock solution can be prepared as given below:

Accurately weight 1.0 g AR grade copper metal wire turning and dissolve it in 50 ml ofv diluted HNO_3 (1:1 with DDW) and finally made the volume to one liter. This is solution A containing 1000 mg Cu L⁻¹. Prepare solution B containing 50 mg Cu L⁻¹ by diluting appropriate volume of solution A. Finally prepare working standards containing 0.25, 0.50, 1.0, 1.5, 2.0, and 2.5 mg Cu L⁻¹.

Determination of Iron

Iron in the DTPA extract can also be determined with the help of AAS exactly in the same manner as Zn and Cu described above. However, the working standard solutions of Fe should be prepared for higher concentrations as the DTPA-extractable Fe content of soils is generally more than both Zn and Cu. Thus, the Fe standards may be prepared as given below:

Prepare standard stock solution (solution A) by dissolving exact 1.0 g of AR grade Fe metal in about 50 ml of 1:1 diluted HNO_3 and dilute the contents to one liter with DDW. Prepare solution B by diluting 50 ml of solution A to 500 ml to get 100 mg Fe L⁻¹. Finally prepare working standard solutions containing 1.0, 2.0, 3.0, 5.0 and 10.0 mg Fe L⁻¹ by diluting appropriate volumes of solution B with the medium of extraction (DTPA).

Determination of available manganese

DTPA extractable Mn is also determined following the same technique as adopted for Zn, Cu and Fe. For this prepare the standard solutions as follows:

Weigh 1.583 g of AR grade MnO_2 or 1.0 g of pure Mn metal and dissolve it in 50 ml of dilute HNO_3 (AR grade). Make the volume to 1 liter with DDW to get solution A having a Mn concentration of 1000 mg L⁻¹ from solution A, dilute 25 ml to 250 ml with DDW to get solution B having 100 mg Mn L⁻¹. Finally prepare working solution of 0.5, 1.0, 2.0, 2.5 and 5.0 mg Mn L⁻¹ concentration by diluting 0.5, 1.0, 2.0, 2.5 and 5.0 ml portions of solution B to 100 ml.

Result & Discussion

Standard Graph of Zn- absorbance v/s concentration

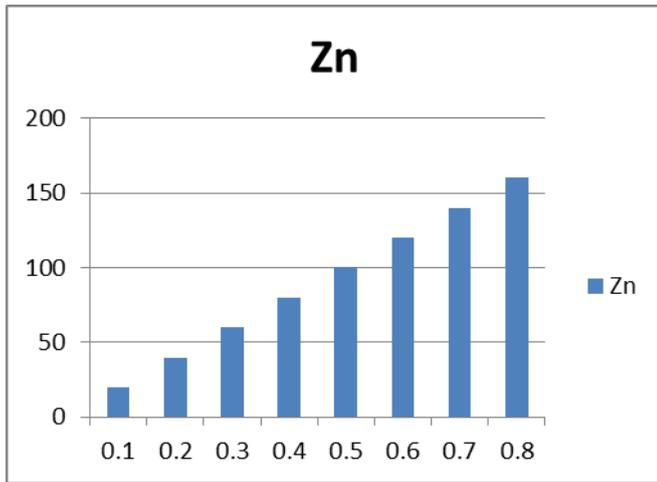
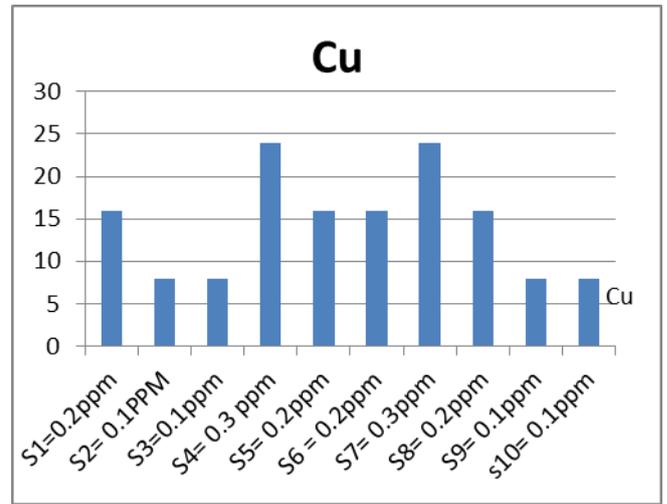


Figure 2:- Standard chart

X- Axis= Zn concentration ,Y- Axis= Absorbance



Here, S1-S10 = Sample Number

Figure 4: Standard graph - Fe absorbance v/s Concentration

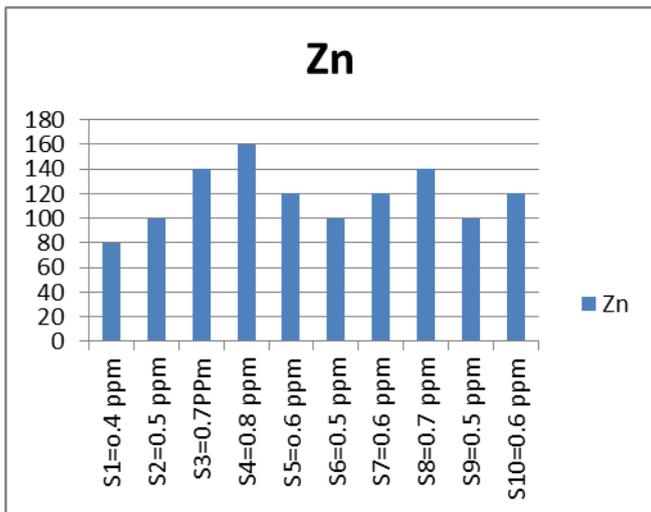
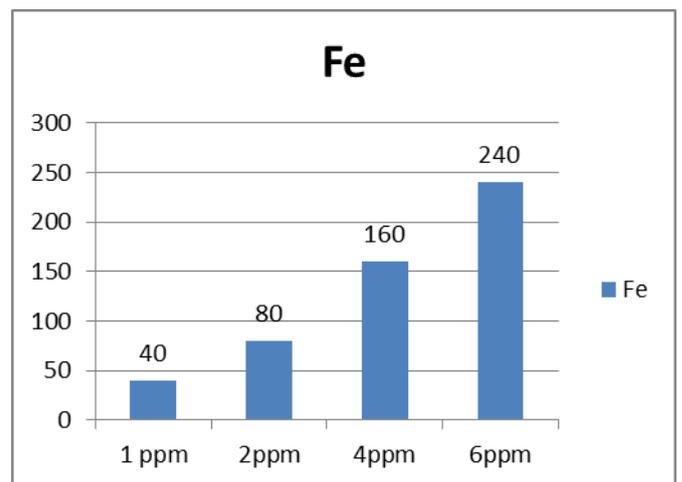
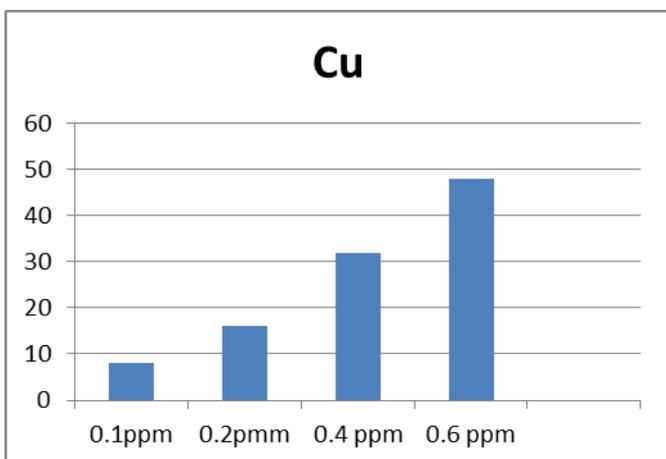


Figure 3: Standard Graph- Cu Absorbance v/s concentration



X- axis = concentration, Y- axis = absorbance

Observation graph:-



X- axis = concentration,

Y-axis = absorbance

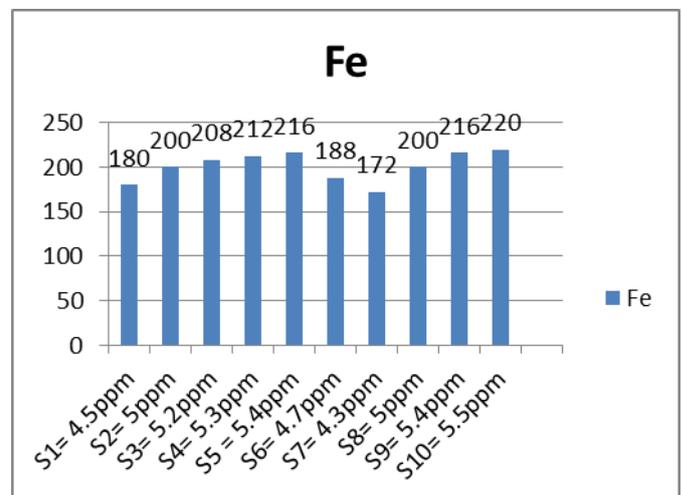
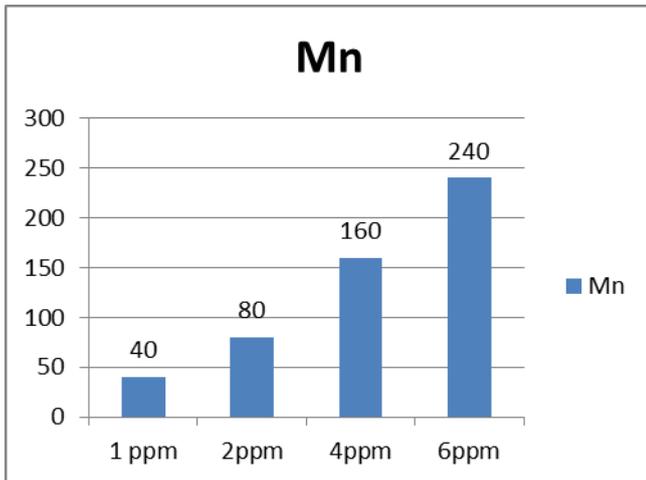


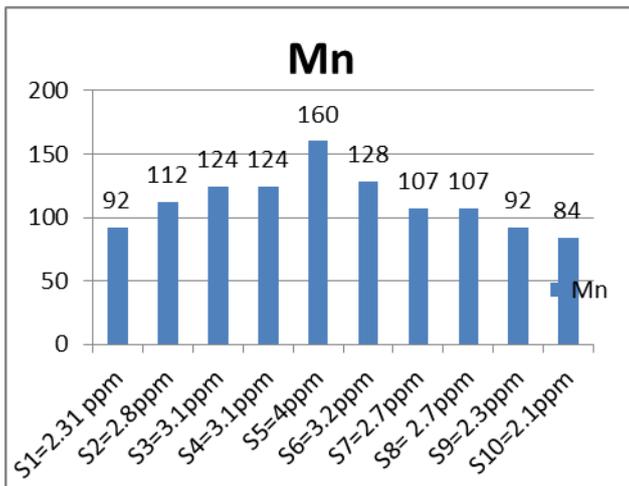
Figure 5: Here S1- S10 = Sample Number

Standard graph- Mn Absorbance V/S Concentration



X-axis = concentration, Y- axis = absorbance

Observation Graph- Mn absorbance V/S concentration



Here, S1-S10 = Sample number

Soil Sample observation table of heavy metal

Table -1

Sample	pH	EC	Heavy metals concentration in			
			Zn	Cu	Fe	Mn
1	8.8	0.33	0.44	0.22	4.56	2.32
2	8.2	1.00	0.56	0.18	5.00	2.86
3	8.1	0.34	0.70	0.18	5.22	3.12
4	8.4	0.35	0.82	0.30	5.38	3.14
5	8.4	0.40	0.66	0.24	5.44	4.00
6	8.4	0.57	0.54	0.22	4.78	3.22
7	8.3	0.38	0.68	0.34	4.32	2.76
8	8.0	0.76	0.72	0.20	5.00	2.76
9	8.7	0.64	0.54	0.18	5.48	2.30
10	8.5	0.51	0.64	0.14	5.56	2.18

Result for Zinc:-

Zn heavy metal critical limit in soil is 0.6 ppm. If the concentration Zn metal in soil more than critical limit, the value of Zn in soil is sufficient and low value show the deficient.

The sufficient value of Zn show in sample number 3, 4, 6, 7, 8, 10 and deficient value of Zn show the sample no. 1, 2, 6, 9.

Result for Copper:-

Cu heavy metal critical limit in soil is 0.2 ppm. If the concentration Cu metal in soil more than critical limit, the value of Cu in soil is sufficient and low value show the deficient.

The sufficient value of Cu show in sample number 1, 4, 5, 6, 7, 8 and deficient value of Cu show the sample no. 2, 3, 9, 10.

Result for Iron:-

Fe heavy metal critical limit in soil is 4.5 ppm. If the concentration Fe metal in soil more than critical limit, the value of Fe in soil is sufficient and low value show the deficient.

The sufficient value of Fe show in sample number 1, 2, 3, 4, 5, 6, 8, 9, 10 and deficient value of Fe show the sample no. 7.

Result for manganese:-

Mn heavy metal critical limit in soil is 0.2 ppm. If the concentration Mn metal in soil more than critical limit, the value of Mn in soil is sufficient and low value show the deficient.

The value of Mn show in all taken sample is sufficient.

Bibilography

- i. P. Szefer, *Environment International*, 1995, 24, 359.
- ii. P. Szefer, *Chemical Geology*, 1995, 120, 11.
- iii. J. M. Pacyna, *Perspective on Lead Mercury & Cadmium Cycling in the Environment*, Edition by T.C.Hutchingson Wiley Eastern Ltd. 1994, 315-328.
- iv. F.M. Abdou and M. Nennah, *Effect of irrigating loamy sand soil by liquid sludge on its content of some micronutrient pH soil. Plant and soil*, 1980, 56 : 53-57.
- v. Antil, R.S. Gupta, A.P. and Narwal, R.P. 2001. *Nitrogen transformation and microbial biomass content in soil contained with nickel and cadmium from industrial wastewater irrigation. Urban Water*, 3: 299-302.
- vi. ATSDR, (Agency for toxic substances and disease Registry) 1993. *Toxicological profile*
- vii. P.C. Brookes and S.P. McGrath, *Effect of metal toxicity on the size of the soil microbial biomass. Journal of the Indian Society of Soil Science*, 1984, 35 : 341-346.
- viii. P.C. Brookes, S. P. Mcgrath, D.A.Klein, and E.T. Elliot, *Effect of heavy metals on microbial activity and biomass in field soil trested with sewage sludge. Environmental contamination (International Conference) CEP Ltd. Edinburgh. 1984*, 574.
- ix. K Chander and P.C. Brooker, *Effect of heavy metals from past application of sewage sludge on microbial biomass and organic matter accumulation in a sandy loam and a silty loam U.K. Soil. Soil biology and Biochemistry*, 1991, 23 : 927-932.

x. (10) X. Zhang, Makoto Nakatsugawa, Kuniyoshi Takeuchi, Hiroshi Ishidaira, Naoki Yamamoto and Saori Hayama, *Monthly report of civil engineering research institute*, **2002**, 592, 13-33.

xi. (11) Nasrullah, Naz Rafic, Bibi Hamida, Iqbal Mudassar and Durrani M.ilyas, *Journal of agricultural and Biological science*, **2006**, (3), 18-22.

xii. (12) J. R. Prajapati and B.V. Raol, *Nature Environmental and Pollution Technology*, **2008**, 7(1), 27-32.

xiii. (13) S. Perumal, Bhagavathi and P. Thamarai, *International Journal of a pplied Environmental Science*, **2008**, 3(2), 211-216.