CHEMISTRY OF SOME HEAVY METALS IN POLLUTED SOILS

BY

OMNIA FAROUK AMIN
B. Sc. (Soil Sciences), Fac. Agric, Cairo University, 2001

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ABSTRACT

The present study was under taken to evaluate the content of Cd , Pb , Cu and Zn , their mobility , various chemical forms and active portion of Cd^{2+} .
The soil profile samples were collected; from Abou – Rawash farm which managed as a sole source of irrigation with sewage sludge and from Helwan area, which characteristic of industrial activities.

The obtained results show that :
Total carbonate (TCC) and soil PH are slightly decreased with increasing period of using sewage effluent in irrigation . However organic matter increased.
Total content of Cu , Zn , Pb and Cd increased in the surface layer of soil profile.
The bio-available portion of the tested metals increased in the studied areas which represent a great deal of the total contents . The results reveal that the tested metals could be arranged according to their mobility along soil profile starting from the highest as : In the sludged soil Cd > Pb > Cu > Zn and in the industrial contaminated soil Pb > Cd > Cu > Zn.
Fractionation results reveal that the average percentage value of each particulate – bounded Cd species follows the order :
In the sludged soils: residual (32.56%) > organic (30.48%)> carbonate (17.2%) Oxides (13.78%) > exchangeable (6.01%).
In the industrial sail residual (29.290) > oxides (25.6%) > carbonate (21.28%) exchangeable (12.42%) > organic (11.5%).

The measurement of Cd^{2+} concentration in the sludged soil ranged averaged $8.05\text{x } 10^{-9}$ which higher than those of the industrial contaminated soil $2.92\text{x } 10^{-9}$ by 63.72% attributing to the lowest PH in the former one.

DEDICATION

I dedicate this work to whom my heart felt thanks; to my ***parents*** *and sisters* ***Eman*** *,* ***Amal*** *for all the support they lovely offered along the period of my post graduation.*

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INTRODUCTION

People have caused pollution for as long as their history can be traced. Contamination of soil by heavy metals can be result from anthropogenic metal inputs due to industrial activities such as mining, smelting and refining which can result in widespread dispersal of heavy metals throughout the environment,(Alloway 1995). Anthropogenic metal inputs can be broadly classified as point or non-point sources.

The point sources are those in the vicinity of metal-polluted soils and thus traceable as a source of pollution such as, traffic, brins, mining, smelters, and radio-nuclides which are usually unintentional, while non-point sources are due to deliberate application of wastes, fertilizers, pesticide, etc.

It is widely recognized that soils adjacent to highways have enhanced Pb concentrations. Emission of Pb compounds by vehicles that use fuels with Pb additives is the source of such contamination.

Urban and industrial soils are known to contain higher metal concentrations compared with rural soils. This, in part, reflects emissions from various industrial activities together with household sources, such as fossil fuel residues and bonfire ash. Elevated levels of Pb, Zn, Ni, Cu have been observed in surface soils near various industrial facilities.

Disposal of swage sludge on agricultural lands has been in practice on a limited scale for several decades. Such use has been encouraged due to the fertilizing and soil conditioning value of these materials. One of the potential problems of such sewage sludge disposal on land is the accumulation of toxic concentrations of heavy metals in soils (Bidwell and Dowdy,1987). Based on sewage sludge applications at agronomic rates, metal uptake by higher plants from sewage sludge-treated soils have been classified into low-hazard and serious-hazard categories (CAST,1976). Manganese, Fe, Al, Cr, Pb and Hg are considered to be low-hazard metals. Cadmium, Cu, Mo, Ni and Zn are considered to be potentially deleterious metals.

Metal pollution of soils is assessed through measurements that include metal concentrations in soils solutions, on exchange and adsorption sites, in solid phases and the sum of metal concentrations in all of a soil system. Total metal concentrations is the most useful index to assess the degree of accumulation of metals in soils. Also, metal availability to plants is better reflected from soil solution composition.

There is also a growing awareness that knowledge about metal fractionation in soils is a better means to assess the impact of metal pollution and predicting bioavailability, metal leaching rates and transformations between chemical forms (Tessier et al., 1979; Miller and Mc Le, 1983).

Cadmium is one of toxic heavy metals which causes potential hazards to the health of animals and human beings. So ;

The objectives of the present study are:

1. To evaluate the content of Cd, Pb, Cu and Zn in both highly-industrial and sludged polluted areas in Egypt.
2. To assess the behavior and chemistry of Cd in the tested soils:
   a- Mobility of Cd in soils.
   b- Various chemical forms of Cd in both locations.
   c- Estimating the active portion of Cd^{2+}

REVIEW OF LITERATURE

1. The background levels of the tested heavy metals

Conceptually that, any element found in soils, water, plants, and other environmental matrices not impacted by pollution can be regarded as natural, normal or background content

a. Cadmium (Cd)

The background levels of Cd in the world soils is largely depended by the amount of Cd in the parent material, Page and Bingham (1973) ranked Cd levels in soils derived from various rocks (in ppm) as follows; igneous rocks (0.1-0.3); metamorphic rocks (0.1-1.0) and sedimentary rocks (0.3-11). In the same concern, NRCC (1979) reported that there is little difference among the different igneous rock in Cd content. They also added that among the sedimentary rocks, the carbonaceous shale's, formed under reducing situations contain the highest Cd.

Lund et al., (1981) reported that residual soils developed from shale parent materials had the greatest Cd levels, with a mean of 7.5 ppm, whereas soils originating from sandstone and basalt had the lowest concentrations, with a mean of 0.84 ppm.

Reviewing the reported data for Cd levels in the world soils indicate that, in soils of Denmark, Cd varied from 0.03 to 0.9 ppm (Tijell and Hovmark ,1978). In England and Walles Archer (1980) reported that the median of Cd was less than 1.0 ppm .Meanwhile in Swedish soils, it was 0.22 ppm (Anderson, 1977).

Adriano (1986) stated that Cd background levels in Canadian soils, was ranged from (0.01 to 1.0 ppm) meanwhile its median in Japanese soils was 0.45 ppm

In Egypt, there were extensive studies on Cd background levels .For example; El-Sherif and Hanna (1977) concerned of that Cd level ranged from (0.4 to 0.6 ppm) and (0.7 to 1.7 ppm) in alluvial and costal desert soil, respectively. In the same connection, El-Gala et al., (1990) studied Cd level in Eastern delta (Ismailia Governorate) and stated that Cd background level averaged from (0.4 to 2.30 ppm). Meanwhile the averaged value reported for Cd in some soils of Egypt by El-Sokkarry and Lage (1980) was 0.34 ppm.

In general, it can be concluded that the total background of Cd in Egyptian soils ranged from (0.3 to 2.30 ppm) mean while the maximum background reported for Cd in the world soils around 1.0 ppm.

b. Copper (Cu)

The data reported by Adriano (1986) ranked Cu content in parent rocks, (in ppm), as follows :Igneous rocks (10-100); limestone and dolomite (0.6-13); sand stone –(6-46); shale and clay (23-67). They also cited 30 ppm as the background level of Cu in the world soils; with values ranging from (2 to 250 ppm) .

Also, Shorrocks and Alloway (1987) mentioned that, the highest value of Cu was found in soils developed from basalt rocks, (40-150 ppm) where it was (2-10 ppm) in sandy soils derived from granite rocks.

Mckeague and Wolynetz (1980) reported the following means values of Cu, in ppm, Canada-22 (range 5-50); united states-25; British soils and France soils -20 mg/kg.

In Egyptian soils, the maximum value stated for Cu – Background levels was 78.0 mg kg^{-1}, as mentioned by (Rashad et al., 1995; El-Toukhy ,1995).

The common characteristic of Cu distribution in soil profiles is its accumulation in the top horizons. Cu concentration in surface soils reflects the bioaccumulation of the metal and also recent anthropogenic sources of the elements Pendias and pendias (1992).

c. Lead (pb)

Lead content in soils varied widely, it ranged from less than 1.0 mg kg^{-1} to over than 10% in raw materials Adriano, (1986). Some authors observed that Pb showed the greatest potential accumulation in surface horizons of soils in eastern Canada, other authors have reported Pb accumulation in surface horizons of uncontaminated soils (Alloway, 1995).

In the same connections, Nriagu (1978) reported that the following total Pb contents (in mg kg^{-1}) of non-contaminated soils for several regions; United States -18; USSR-17; Canada -12; Europe; from 10 of Spanish to 42 of Scottish soils; Australia and New Zealand –15; Japan-11; Africa; from 12 of South African to 21 mg kg^{-1} of Egyptian soils. In the same concern, Mills and Zwartich (1975) reported that Pb content in different horizons of some of Manitoba soil was 17, 15, and 16.5 mg kg^{-1}, in A, B and C horizons, respectively.