STUDIES ON SOME HEAVY METALS IN SOILS AND WATERS.

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1. INTRODUCTION.

The growth of urban areas has increased the problem of depositing human wastes at a time when a growing public awareness of environmental problems has stopped the emptying of crude sewage into rivers or the sea in many places. Meanwhile, in many arable areas, there are problems of decline in soil fertility and a deterioration in soil structure because of falling soil humus levels. It is apparent that soil is one of the nature's best decontaminating agents. Sewage materials have proved to be a valuable source of plant nutrients. Also, the effect of such materials in improving soil structure, aeration, water retention of soil and other soil physical properties is well-documented. Consequently, if sewage material can be used satisfactorily as a soil amendment, just as stable manure has been used over the ages, the land application of sludge will beneficially return waste material to land and make use of its nutritive value to crops. Crop yields will, very likely, be increased with a consequent saving in fertilizers. An increase in food production would be invaluable in a world which demands more food.

However, this practice offers a challenge in crop production, since sludge, depending on its source, contains certain heavy metal ions which may find their way in toxic levels into the edible plants and their products. Excessive and toxic concentrations of Cu, Zn, Ni, Co, Pb and Cd in plants growing in soils treated with sewage sludge were reported by many investigators. The danger in using sewage materials is now recognized in all industrial countries.

Chemical characteristics of sewage wastes, however, vary with the dietary habits of the locality, population density and the byproducts impurities of the industrial units. In addition, the availability of these heavy metals to plants, and therefore, their absorption and accumulation in plant tissues are largely affected by soil pH and genetic factors.

It is generally accepted that the levels of certain heavy metals which are potentially toxic to human and animal, particularly Cd, Hg and Pb,...etc. should be minimized in food plants to avoid hazardous health problems.

Therefore, a proper evaluation of the disposal of municipal wastes on agricultural land is urgently needed in terms of crop production, soil and water pollution and public health.

The present research is, therefore, directed to:-

1. Evaluation of heavy metal accumulation in soils under irrigation with sewage effluent for many years in El-Gabal El-Asfar area with a special reference to Cd and Hg.
2. Evaluation of heavy metal content in sewage sludge and sewage effluent with special reference to Cd and Hg.
3. Evaluation of Cd and Hg contents in field crops and citrus trees grown on soils under irrigation with sewage effluent.
4. Studying the effect of high rates of sludge application to soils on plant uptake of Cd and Hg.

2. REVIEW OF LITERATURE.

2.1. Cadmium content in soils.

Cadmium content in agricultural soils drew the attention of many investigators as a potentially toxic heavy metal. Mills et al. (1975) found that cadmium content of agricultural soils in Manitoba ranges from 0.4 to 1.7 ppm with an average of 1.0 ppm. Aichberger et al. (1982) found that cadmium content was 0.07-2.4 ppm at different geological regions of upper Austria. Aoyama et al. (1982) reported that in sediments of Kajima Bay, Japan and its associated rivers concentration of Cd was Trace-1.44 ppm.

Dudas et al.(1975) found that the total content of Cd in cherenozemic soils from Alberta was approximately 0.5 ppm, whereas the total content of Cd was as much as 16-48 times higher in the sewage samples. Gaynor et al. (1976) pointed out that the addition of sludge to sandy loam and clay soils increased DTPA-extractable Cd 2 to 5 times. Baerug et al.(1977) found that the sludge increased the content of total Cd and the content of readily soluble Cd in soils. Hinesly et al.(1977)and (1978) pointed out that sludge application resulted in significant increases of total and 0.1N HCl-extractable Zn and Cd in the soil. Williams et al.(1980) and El-Nennah et al. (1982) showed that the availability of metals added to soil in sewage sludge as measured by DTPA extraction of Cd, Zn, Pb and Cu largely increased. Hansen et al. (1983) pointed out that if normal Danish sludges (3-5 ppm Cd) are utilized as phosphorous fertilizers,the input of Cd to land will approximate the input from normal inorganic fertilization.

2.2. Cadmium behaviour in soil.

Bingham et al.(1976) found that greatly reduced cadmium concentration in soil solutions under flood management may account for the greater tolerance of rice to soil Cd under flood culture. This reduced availability of Cd in flooded soils is attributed to precipitation of CdS. Bingham et al.(1983) reported that the distribution of estimated Cd species in the saturation extract changed with Cl treatment. The treatment caused the percentage of estimated Cd^{2+} to decrease and that of estimated $CdCl^{+}$ to increase. Herms et al. (1979) showed that in soil rich in organic matter increases in the Cu, Zn, Cd and Pb content of the soil solution occurred as a result of the presence of microbially formed soluble organic complexes. Khan (1983) reported that a very high proportion of Cd and Pb added to the soil in water soluble form became insoluble with one hr. of contact with the soil.

Webber et al.(1975) reported that it is known that when cadmium is added to a soil, it may be; (a) precipitated as relatively insoluble compounds when the soil pH is greater than 6.5 to 7.0; (b) weakly chelated by soil organic matter as low solubility complexes and (c) adsorbed on the cation exchange sites of organic matter. Singh et al.(1979) showed that soils exhibit large capacities to adsorb Cd, however, a major portion of adsorbed Cd was released by NaCl extraction. The amount of Cd not released (fixed Cd) was correlated to the cation exchange capacity, pH and organic carbon content of soils. Soon (1981) reported that cadmium adsorption increased with increasing soil pH.

Dudas et al.(1975) stated that in poorly drained soils cadmium content ranges from 0.13 to 0.92 ppm. The high values obtained from many of the poorly drained soils could additionally reflect the influence of ground water flew. Biddappa (1982) mentioned that the Pb and Cu ions were less mobile than those of Zn and Cd and that Ni, Cd and Zn might pose a greater threat of ground water pollution than Cu and Pb. The specific migration properties of each metal ion varied depending on the nature of the ion and leaching solution . Tyler et al.(1982) reported that the least mobility of metals was observed in a mineral soil with a relatively high pH, C.E.C. and exchangeable base content. The liming of an acid mineral soil reduced metal mobility, but not to the extent expected from the very low mobility observed for a naturally non acid mineral soil. The order of mobility of the metals in the soils was; Cu $\ll$ Zn $<$ Ni $<$ Cd. Alekseev et al.(1982) concluded that the mobility of Cd and its availability for plants are substantially greater in acid soils than in non-calcareous soils with neutral and alkaline pH's. On the other hand, Kuo et al.(1983) pointed out that the mobility of Cu, Zn and Cd in the soils was limited as evidenced by a sharp reduction in concentrations of the three elements with depth. Comparing subsoil concentrations of these elements with those from areas relatively unpolluted by smelter fallout revealed that Cd was more leachable than Cu or Zn under western Washington conditions. Herms et al.(1983) reported that the addition of fresh and slightly decomposed organic material affected heavy metal solubility in the order; $Cu \gg Cd \gg Zn > Pb$ at pH 4-8 and the results indicate that after mixing decomposable organic matter (e.g. sewage sludge, manure) with soils, heavy metal solubility increased due to the formation of soluble, low molecular weight organic complexes. After a mobilization phase, the immobilization of heavy metals takes place.

2.3. Cadmium uptake by plants.

2.3.1. Effect of pH.

Bates et al.(1975) reported that soil pH did not affect the Cd concentration in ryegrass where the sludge was re-applied after each crop. Hyde et al.(1979) concluded that the concentration of Cd at the highest sludge application rate (160 metric tons/ha) was not substantially different from the concentrations of the same metal in grain from plants grown on the acid soil without sludge treatment. The results show that metal entry into plants can be minimized by growing plants on calcareous soils. Bingham et al.(1980) found that the Cd content of rice grain to be dependent upon the addition rates of Cd with sewage sludge and soil pH only. The maximum permissible Cd addition was found to be strongly pH dependent. Preer et al.(1980) pointed out that cadmium elevated in leafy vegetables from plots in community gardens (soil in Washington D.C.) with low soil pH and/or elevated soil Cd. In leafy vegetables Cd varied inversely with soil pH. Hansen et al.(1983) mentioned that the source of Cd in the soil is probably of minor importance in determining plant uptake of the metal, compared to the governing parameters pH, soil type and presence of competing cations.

2.3.2. Accumulation of cadmium in plants.

Webber et al.(1975) reported that the concentrations of Zn and Cd are lower in corn grain than in the straw. The distribution of Cd between the roots and shoots of 23 species was examined by Jarvis et al.(1976) in a nutrient solution containing 0.01 ppm Cd. They concluded that in all, except 3 species,i.e., kale, lettuce and water cress, more than 50 percent of Cd taken up was retained in the roots. The concentration in the