Chemical Mobility and Reactivity of Some Soil Components and Pollutants and Their Impact on Crops in the Western Desert Ecosystems

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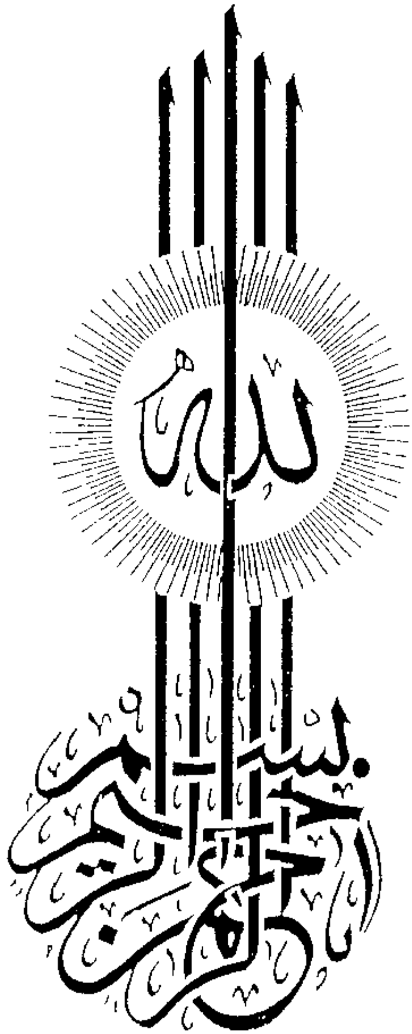
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1 - INTRODUCTION

The Western Desert is one of the major axes of development and habitation in Egypt. Therefore, extensive efforts were devoted to its land reclamation and range management projects within the national development plans during the last few decades and will remain prominent in national endeavour. Its ecosystems include different soil deposits of variable origins, depositional regimes and stages of soil formation along with some problems associated with suboptimal land conditions of water logging, salinization, soil erosion and reduction of perennial cover that contribute to the deterioration of the ecosystems productivity. Therefore, the North Western portion of this desert area is chosen for study.

Due to the importance of Cd as a soil contaminant and Mg as a principal soil element particularly in marine and lacustrine deposits and as the fifth essential nutrient for plants, there are compelling reasons for a through investigation of their effect, either individually or in combination, on other soil and plant elements. Therefore, the current study restricted emphasis on their chemistry in soil, with special respect to mobility reactivity and relationships to soil variables and nutritive elements for plants. Since lettuce plant is among the popular vegetables for Egyptian citizens, it is chosen as an indicator plant for the assessment of the effect of Cd, Mg and their interactions on growing plants and their nutrient elements.

It is hoped that the current achievement sets forth an understanding and monitoring of the role of Cd and Mg and their interactions in desert-agric-ecosystem in order to impede their hazardous effect on uptake and translocation of elements to edible plant parts, and this will serve as a guide for recommendations to similar environments elsewhere.

2 - REVIEW OF LITERATURE

Once heavy metals are introduced into crop land, they can be taken up by plants and subsequently become incorporated into the food chain. If heavy metals leach through the soil, they may also contaminate ground water. In recent years, the plant uptake of heavy metals has received a great deal of attention due to its potential health effects on human, Emmerich et al., (1982).

The environmental presence of Cd is normally linked to that of Zn because of their geochemical kinship and incomplete technical separation. While Cd is present in mineral form in the earth's crust at an average concentration of 0.18 ppm, it is also ubiquitous as a contaminant.

Lagerwerff, (1972) mentioned that the relationship between trace elements and environmental quality is based upon the need to safeguard man's health. Trace elements are linked to health because of the functions they fulfill in physiological processes. Where these functions are of a catalystic nature, the trace elements involved always will be heavy metals.

Much concern over heavy- metal contamination has centred on cadmium as an element which, relative to other metals, displays both exceptional toxicity (Friberg et al.,1971) and a high mobility within soils and plants (Frankland and Khan, 1983). In this context, concentrations in soils of over 1700 mg Cd g^{-1} have been recorded (Buchauer,1973). Agricultural activity also contributes to Cd accumulation in soil, through the addition of superphosphate with 50-170 mg Cd g^{-1} (Stenstroem and Vahter, 1974, De Haan and

Zwerman, 1976) and Sewage sludge (Fulkerson and Goeller 1973). In this accord. The mean concentrations of Cd metal in different polluted and non -polluted soils are given by Berrow and Webber (1972), Lund et al., (1981) stated that the highest concentration of Cd in soils was found in soils developed in shale or in alluvium derived from shale. He added that this should be used as an indicator of other areas that should be investigated to delineate high- Cd soils.

2.1.Effect of soil pollution on plants

Plants don't take up only essential elements, necessary for their normal development, but also other ones if these are present in the growth medium in a sufficiently mobile form. According to Cottenie et al., (1982), the uptake of mineral elements shows various patterns and the following different situations may be distinguished:

a- high concentration increase in plant tissue, when the soil is enriched : Zn, B, Mo, Co, Cd, Ni, F.

b- Limited increase of tissue contents, even when the soil is highly enriched: Fe, Cu, Pb, Cr.

c- Increase of tissue content largely dependent upon physico-chemical factors pH, redox potential etc. Al, Mn.

According to the element, a pronounced excess may cause phototoxicity or inhibition of the plant growth itself, or toxicity towards men or animals being nourished with these plants. They presented the trace element ranges found in the leaves. Tolerance indexes of ryegrass with regard to some trace and toxic elements, determined with pot experiments, are also given. Such tolerance indexes are different from one species to another and are strongly specific for each element.

Tolerance of ryegrass to cadmium accumulation was studied by Dijkshoorn. (1974) who found that Cd concentrations of 50-100 ppm in dry matter reduced top growth, while 100 to 500 ppm was attained when plants died.

Based on the previous studies some specific problems are given as follows:

1- Trace element concentration in plant parts often show poor correlation with soil concentrations of the element (Piperno 1975; Babu 1975; Davies and Ginnever 1979).

2- Concentrations of elements in plants that cause yield depression vary for given situations (Wallace and Romney 1977; Wallace et al., 1980 a, b).

3- Toxicity of mixtures of trace elements may result from interactions among elements. "The interplay may result in a mixture being more toxic than predicted on the basis of an appreciation of the potency of each of its toxic constituents". (Anderson and Webber 1975).

4- Iron -deficiency chlorosis can appear from all kinds of trace-element imbalances in soil. (Brown and Jones 1975; Terry 1981; Dekock 1956; Crooke et al., 1954).

5- The coefficient of variation for trace element composition of a uniform population of plants can be 100% (Wallace and Berry 1979). This implies that sampling problems can complicate understanding of threshold levels and multiple toxicities.

6- Frick (1985) reported that a toxicity of a two-way combination of trace elements, such as Mn and Mo, could be prevented in the presence of a third, such as Zn with high levels of all three.

In the dose response curve for Zn, there was a threshold for toxicity at about 80 meq L^{-1} Zn. steep with no apparent. When 3.3 meq L^{-1}Cd was superimposed on the Zn background, there was about 20% reduction in phase1 and about the same in phase 2, where an additive interaction was apparent.

Wallace and Berry (1989) assembled Large amount of information indicating that at least under some conditions the effects of one trace element in excess on lettuce can be confounded when a second or a third is also in excess. They showed that Ni curve is somewhat more complex than for Zn in that in the toxic zone it has two toxic phases compared to only one phase for Zn in the toxic zone. In the Ni curve, as in the Zn curve, there was no interaction between the two elements until Ni reached its toxic threshold at 20 meq / L^{-1} Ni.

Berry and Wallace (1989) studied zinc phytotoxicity with lettuce seedlings in solution culture and showed that zinc absorption in lettuce consisted of two distinct uptake phases; a slow uptake and a rapid uptake of solution Zn. In both phases the absorption rate, increased with solution concentration, but the rate of increase was much faster in the second phase. They further stated that Zn absorption during the first phase was not materially affected by the Ca concentration while the second phase of Zn absorption was substantially decreased as solution Ca concentration was increased. Zinc phytotoxicity appeared to be a direct result of the accumulation of Zn in tissues to toxic levels. This accumulation of Zn was associated with the second uptake phase and the time required to accumulate Zn is determined by the uptake rate functioned by both Zn and Ca concentrations.

Wallace and Berry (1989) concluded from the dose response curves of Zn, Cd and Ni that extremely important consequences can average. One is a decrease in the threshold level of an element that can cause severe injury to an organism or an ecosystem. Another consequence is an increase in the amount of toxicity per unit of trace element is a change in the amount of trace element taken up by a plant per given level present in the environment (Cottenie and Camerlynck 1979; Stratton and Corke 1979; Saito and Takahashi 1979). All consequences are of considerable importance in environmental considerations.

When Cu was superimposed upon a toxic level of Cd (60% yield reduction for Cd), the effect of Cu was protective (Cu+Cd= 49% yield reduction). The 31 mg. Kg^{-1} Cu in leaves in this treatment was associated then with a 28% yield increase compared with the control with Cd.

With various levels of six different trace elements (Li, Zn, Cu, Co, Ni, Cd), these was no barley yield reduction for them when applied singly (Wallace et al.,1980 a) when all six were applied together at the same concentrations, however, there was a 40% yield reduction plus synergistic effects in uptake of the metals. The growth effect was an apparent synergism due to interaction with P.Results did differ for other species; individual elements caused toxicity for corn and soybeans in contrast to barley.

The combination of six elements variously gave additive and synergistic effects. Levels of six different elements (Cd, Cu, Zn, Mn, Co, Ni) with bush beans caused no observable toxicity when used alone, but when combined, resulted in considerable toxicity expressed largely as Fe chlorosis (Wallace 1982 b).

Wallace and Abou-Zamzam (1989) applied a test in solution culture with bush beans to give added assurance that low levels of toxicity with different trace elements simultaneously, each with little effect, do interact in a less intense manner than do multiple trace elements, each at a high level of toxicity. The low levels usually give protective effects because some trace elements antagonize the uptake of others (Wallace 1982). The concentrations of trace elements were quite low and therefore may be much more conducive to protection rather than to additivity.

Species differences are indicated in that when various amounts of $Cd\ Cl_2$ were added to unlimed and limed soil, Cd was concentrated more in the tops than in roots of radishes (John,1972). Increasing the soil pH by liming suppressed the uptake of Cd (John, 1973). Addition of Ca salts had the same effect (Koshino,1973). Corn plant concentrations of Cd were 10 to 50 times that of the nutrient solution (Root, et al. 1975). Cadmium uptake and toxicity were incresed by the