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THE NATURE AND PROPERTIES OF SOILS *8th Edition*

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PREFACE

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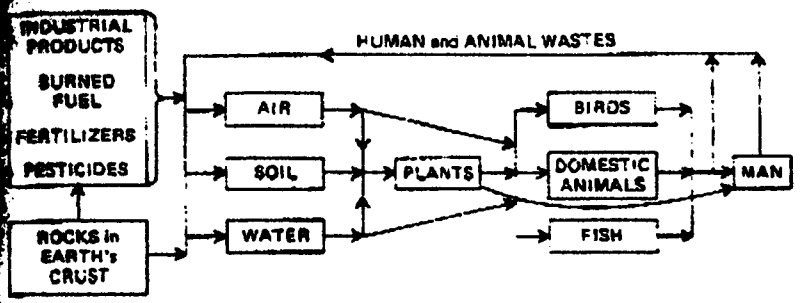

FIGURE 21:3. Sources of heavy metals and their cycling in the soil–water–air–organism ecosystem. It should be noted that the content of metals in tissue generally builds up as movement is made from left to right, indicating the vulnerability of man to heavy metal toxicity.

It is obvious that soils are only a part of the biological cycle relative to heavy metals and other inorganic toxin contamination. At the same time, soils are the ultimate depositories of large quantities of these compounds. Furthermore, the variety of chemical reactions which these elements undergo in soils controls to a considerable extent their rate of cycling if not their removal from the cycle altogether. A brief summary of these reactions follows.

21:6. BEHAVIOR OF INORGANIC CONTAMINANTS IN SOILS

There is considerable variation in the level of these elements present in soils and plants. This is borne out by the data in Table 21·6, which give the ranges commonly found. These relative concentrations are of particular significance as the behavior of each of these elements is considered.

Four of the heavy metals, zinc, copper, manganese, and nickel, have similar chemical characteristics and undergo similar reactions in soils and so will be discussed as a group. Each of the other elements is sufficiently different in its properties to be given specific consideration.

ZINC, COPPER, MANGANESE, AND NICKEL. The reaction of these elements in soils is definitely affected by the pH, organic matter content, and the oxidation–reduction status of the soil. Ordinarily at pH values of 6.5 and above they tend to be only slowly available to plants, especially if they are present in their high-valent or oxidized forms. Consequently, most soils will tie up relatively large quantities of these elements if the soil pH is high and the drainage good.

The tendency of the cations of these elements to "chelate" in the presence of organic matter decidedly influences their behavior (see p. 493). The relative strength of chelation is generally copper > nickel > zinc > manganese.

TABLE 21:6 *Range of Concentration in Soils and Plants of Inorganic Elements which Sometimes Occur as Environmental Contaminants*[a]

Element	Common Range in Concentration (ppm)	
	Soils	Plants
Arsenic	0.1–40	0.1–5
Boron	2–100	30–75
Cadmium	0.1–7	0.2–0.8
Copper	2–100	4–15
Fluorine	30–300	2–20
Lead	2–200	0.1–10
Manganese	100–4,000	15–100
Nickel	10–1,000	1
Zinc	10–300	15–200

[a] From Alloway [2]

Since iron is more tightly adsorbed than any of them, its presence in a soluble form reduces the chelation tendency of all these elements. However, high pH and good drainage reduce the probability that soluble iron will be present in appreciable quantities.

CADMIUM. Only in recent years has this element been suspected of being toxic to human populations. About ten years ago it was reported that hypertension of laboratory animals was associated with prolonged low-level feeding of this element. There has been too little research accomplished since then to determine the soil and other factors influencing the content of cadmium in food. Likewise, there is little information available on cadmium reactions in soils. Because of its chemical similarity to zinc, however, it would be expected to behave in soils much the same as does zinc. Further research will be needed to determine how cadmium behaves in soils and how its concentration in plants might be controlled.

MERCURY. Research in Sweden and Japan as well as the United States has called attention to toxic levels of this element in certain species of fish. This situation stems from soil reactions whereby mercury is changed from insoluble inorganic forms not available to living organisms to organic forms that can be assimilated easily. Metallic mercury is first oxidized by the following chemical reaction in the sediment layer of lakes and streams:

$$Hg^{\circ} \xrightarrow{ox} Hg^{++}$$

The divalent mercury is then converted by microorganisms to methyl mercury, which is water soluble and can be absorbed through the food chain by fish. The methylmercury can be changed to dimethylmercury through