I.7 Cycling of Elements in the Biosphere

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1 The Sources of Plant Constituents

1.1 Soil and Atmospheric Sources

Of the 18 or more elements required by plants or beneficial to their development, only carbon has its immediate source in the atmosphere. Except in a few special cases such as lichens and some aerial plants, other required elements are obtained from the soil. One exception to this is the fixation of N_2 by some symbiotic associations (Chapt. II.2). Under most circumstances the availability of elements is limited, however, and so the death and decomposition of plant material is essential to the maintenance of the supply of necessary elements for new growth (GOSZ et al. 1973).

The system is not a completely closed one, and there is a continual loss from the soil by volatilization, erosion and leaching. The replenishment of elements lost in this manner is required to maintain productivity. The atmosphere is the principal vehicle by which some of these elements are returned to the soil from the sea or other reservoirs where they have been concentrated. This process is not a complete one either. Some elements, such as phosphorus, which is present in seawater only at very low concentrations, must be provided by other means. Because phosphorus forms some compounds of exceedingly low solubility (explaining its low concentration in seawater), its mobility in soil is low and so the rate of its replenishment need not be as great as that of a more mobile element such as sulfur, even though the requirements of the two elements by plants are of the same order of magnitude (VAN WAZER 1961). Thus the weathering of soil materials although it takes place slowly under most circumstances suffices to resupply phosphorus as well as some other elements to the system.

1.2 The Weathering Process

Any effort to classify the mineral elements required by plants introduces some inconsistencies, but in considering the weathering process as a contributor to the nutrient requirements of plants it is helpful to distinguish between those elements which are volatile or form volatile compounds such as carbon, oxygen, hydrogen, nitrogen, sulfur and the halides (and which are of relatively low concentration in igneous rocks), as contrasted with the other elements which are igneous rock constituents. The sedimentary rocks that provide the parent material for many soils can have higher concentrations of the volatile elements.

A. Läuchli et al. (eds.), *Inorganic Plant Nutrition*

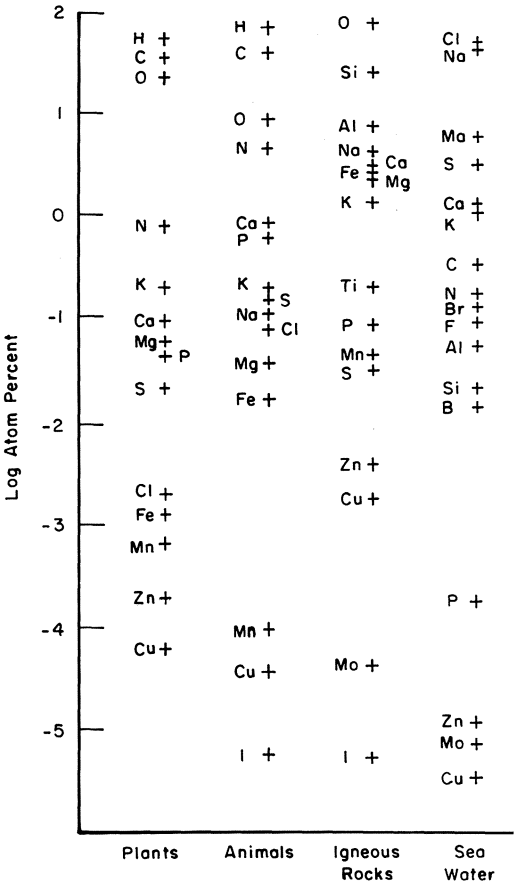

Fig. 1. Relative quantities of various elements in plants, animals, igneous rocks and seawater on a dry weight basis. Note that the scale is logarithmic

Carbon and sulfur are major constituents of some sedimentary materials (GARRELS and MACKENZIE 1971).

Figure 1 gives a comparison of the concentration of certain elements in biological materials, igneous rocks and seawater. It is not surprising that biological materials are made up of those elements readily available in the environment in which they evolved and roughly in proportion to their availability. What is of interest is the manner in which some elements commonly available in abundance have been shunned by the biological world and, if present in plants or animals, are there only as passive or apparently inadvertent constituents. An example of these is aluminum, which is quite ubiquitous but which serves no known biological role.

"Weathering" is a broad term including both the physical processes resulting from alternate heating and cooling, wind and water erosion, and other mechanical processes and the chemical processes of solution and reprecipitation. Elements liberated in the weathering process become available to plants, and plants are active participants in the weathering process. The organic constituents of plants and the products of microbial degradation of plant material participate