



Biogeochemistry of iodine in aquatic and terrestrial systems

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Understanding the environmental behaviour of iodine, an element with relatively low abundance in the Earth's crust, is of interest in different respects, of which the most eminent are:

- the importance of iodine in the formation of thyroid hormones for higher animals (at least all mammals) and the necessary nutritional supply in dependence of various atmospheric, hydrologic, and geochemical processes
- the release of considerable amounts of iodine radionuclides: mainly the relatively short-lived I-131 (radioactive half-life 8.05 days) and the longlasting I-129 (15.7 million years), both released by the intensive atmospheric atomic weapon tests in the late '50's and early '60's, as well as by continuous effluents and exhausts from nuclear fuel reprocessing plants; smaller amounts of I-125 (60 days) from medical and scientific applications are also found in the environment.

Especially the concern of a radioactive contamination and the related radiological burden has caused a boom in investigations of the environmental behaviour of radioiodine (in this respect the natural iodine, the stable I-127, behaves identically) and the dependence of transport pathways on this behaviour. These investigations have yielded a lot of insights into the transport and distribution processes of (radio)iodine, but in view of their wide variations the understanding of these processes is still incomplete.

It is generally accepted that iodine undergoes a global cycle starting from one of its main pools, the ocean water (50 to 60 ppb) and transition to the atmosphere, being deposited with dry and wet precipitation on land surfaces, and finally returning to the oceans through surface runoff and to a even greater extent after passing through various geomedias and environmental compartments with different residence times (e.g.,

D. C. Kocher, *Environ. Int.* 5 (1981) 15).

While iodine concentrations in fresh water (rain, rivers and lakes, groundwater) are generally low (about 0.5 to 2 ppb), in one of the compartments, the surface soils, a remarkable high content of iodine is found, mainly in the range of 5 to several 10 mg/kg (with some exceptions), indicating a strong sorption of iodine by soil materials. By correlation, it has been established that organic soil matter is involved in the iodine fixation and that microbial activity may play a role in the process. Using radiochemical techniques (tracing with radioisotopes I-125 and I-131) we have found that iodination of humic material under aerobic condition, mediated by extracellular enzymes (peroxidases) which are provided by the microbial biomass, is responsible for the observed iodine fixing process (H. Behrens, Speciation of radioiodine in aquatic and terrestrial systems under the influence of biogeochemical processes, in: Speciation of fission and activation products in the environment, Eds. R. A. Bulman and J. R. Cooper, Elsevier Applied Science Publishers, 1985, 223-230). So far this is comparable to well known biochemical iodinations like the formation of thyroid hormones by enzymatic iodination of thyrosine in the thyroid gland. It is suggested that iodination in geomeia occurs as a covalent binding of iodine mainly in the aromatic structures of humic materials, as well in solution as also in the solid phase. This is a dynamic process with iodination and deiodination running simultaneously, leading to equilibrium distribution between dissolved iodide and organoiodine with very high K_d values and accordingly long residence times. Iodate appears to be involved via reduction to iodide.

However, if a soil system switches to anaerobic condition, as occurs in water-logged soils (e.g., rice fields), the oxidative iodination comes to an end, while the continuing deiodination results in a release of the formerly bound iodine as dissolved iodide into the water phase. This way, the iodine that had formerly been bound becomes highly mobile and, among other aspects, also more available for uptake by plants.

Various processes of the distribution and transport of the redox-sensitive element iodine in the terrestrial and aquatic environment become explainable on the basis of the discussed biogeochemical reactions.