Biogeochemical Monitoring Of Heavy Metals In Food Webs: Sources, Deposition, Pathways And Bioaccumulation

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Long-term accumulation of lead (Pb) in the biosphere, including human tissue, has resulted largely from anthropogenic activities. The average concentration of lead in adults and children is 100 times greater than the natural encumbrance, and existing rates of Pb absorption are 30 times the level in pre-industrial society. The biotic exposure problem is increased significantly in the arid and semi-arid environments where dry conditions and episodic torrential rainfall produce barren, highly eroded mine sites. Techniques are needed that can identify (i) the most important sources of metal contamination, (ii) off-site transport mechanisms and, (iii) pathways of bioaccumulation and biomagnification and (iv) the efficacy of alternative remediation strategies.

We utilized high-precision analyses of radiogenic isotopes (Pb) combined with high-precision analyses of stable isotopes (C and N) to investigate bioavailability, bioaccumulation and specific source(s) of Pb and by proxy, other metal (e.g., Zn, Hg, Cu, Cd, Ni, As, and Se) contaminants in surface waters, lichens and the aquatic food web of the Aravaipa Creek Riparian Area, Arizona, USA.

Lead concentrations and isotopic ratios were determined for mine wastes, soils, and sediments from the Grand Reef and Klondyke mines and in the upper perennial reach of Aravaipa Creek. There are distinct Pb (and Sr) isotopic values between the Grand Reef mines and the Klondyke mine site group; and Pb contamination in Aravaipa Creek waters was predominantly the result of Pb runoff from the Klondyke mill site. Consistent with a model of lead entering the aquatic system through runoff.

The Pb concentration and isotopic ratios were also measured from samples of four fish species (900-75000 ppb) at differing trophic levels and two invertebrates (500-2000 ppb) from Aravaipa Creek, and the concentrations exceed levels of concern for a number of the species. More importantly, the the dominant source of Pb in these organisms can be traced to the Grand Reef mine and based on the locations of the samples are most likely the result of wind erosion and airborne deposition of heavy metals.

Although the sample populations were small, the study has demonstrated the value, and indeed the necessity, of using the Pb isotopic system for determining the source(s) of Pb contamination, it remains unclear whether airborne or water borne forms of metal contaminants are equally threatening and bioaccumulate in a similar manner.