Trace Metals in the Laurentian Great Lakes: Toxic or Tonic?

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A central tenet in limnology is that phytoplankton production in lacustrine systems, including the Great Lakes, is limited primarily by availability of phosphate. Limitation by other macronutrients (N, C), let alone by trace metal micronutrients (Fe, Zn, Mn, Ni, Cu), is seldom accorded consideration. Related to the latter is a pervading attitude that most lakes are subject to a high degree of coastal and anthropogenic influence thereby ensuring a constant and plentiful supply of metals to these lakes. However, adoption of ultraclean metal sampling protocols by geochemists working on the Great Lakes has begun to clarify the status of trace metal abundance in these waters. Rather than accumulating at levels considered toxic for phytoplankton, it appears that concentrations of many trace metals are low and within the range reported for the open ocean. In this context, it is notable that low availability of trace metals, particularly Fe, is now thought to ultimately constrain oceanic phytoplankton growth and standing crop on a global scale. In this contribution, I report preliminary data obtained from surveys conducted in Lake Erie and Lake Superior during summer 1998 that addresses the Fe status of the endemic phytoplankton assemblage. Exploited in this research was a novel biochemical marker, flavodoxin, that provides an in situ assessment of phytoplankton Fe deficiency. Under conditions of Fe deficiency, the Fe-containing redox protein ferredoxin is replaced by flavodoxin as a means of reducing the cellular Fe burden. Employing an immunochemical approach for the detection of flavodoxin, results from field surveys demonstrate differential accumulation of flavodoxin over spatial and taxonomic scales in both lakes. Flavodoxin was not detected in surface water samples collected by filtration in the western basin of Lake Erie and in waters off the Keweenaw Peninsula in Lake Superior. In contrast, flavodoxin was detected in samples obtained by vertical net tow (i.e., sampling bias for large cells) both in Lake Superior and in the eastern basin of Lake Erie. The pattern of Fe deficiency that emerges from these surveys is one of a "patchy" phenomenon and one which is likely related to hydrologic and other physical parameters.