Canadian Network of Toxicology Centres
Metals In The Environment
Research Network

SCIENCE BRIEF (June 2004)

TO WHAT EXTENT ARE HUMANS RESPONSIBLE FOR THE PRESENCE OF METALS IN REMOTE LAKES?

ISSUE

Metals occur naturally in the environment as a result of processes such as weathering of minerals from the Earth's crust, forest fires and volcanic emissions. Human activities such as metal extraction, smelting and finishing, refuse incineration, fossil fuel combustion and agriculture also contribute to metal concentrations in the environment. Of particular interest are increases in atmospheric metal emissions that result in metal contamination on regional and even global scales following long-range atmospheric transport and deposition at remote sites. Many metals show enhanced concentrations in recent (last 50 years) lake sediments, where they can reach potentially harmful levels and may pose a risk to aquatic food chains. However, it is not clear what proportion of these metals in sediments is due to human activities, and which part is due to natural processes.

SIGNIFICANCE

This research determined the circumstances under which lake sediments can provide true historical records of metal loadings from the atmosphere, and provided methods to differentiate between metals of human origin in recent sediments and those of natural origin. A surprise finding was the major influence of local forest fires on mercury concentrations in the sediments. The findings of this research will allow proper use of sediments for assessing historical metal inputs and evaluating the effectiveness of controls on metal emissions, thus avoiding potentially serious ecological and economic implications from incorrect assessments.

BACKGROUND

Lake sediments are a repository for most metals and should record the history of their deposition. A common approach to determine metal deposition over time is to collect sediment cores in lakes, slice the cores and measure metal concentrations in each dated slice. Interpretation of these profiles of metal accumulation over time in terms of chronology of human emissions is, however, not trivial. Indeed, the observed depth-distribution of a metal in lake sediments is partly due to several complicating processes that occur after metal deposition at the sediment surface, such as mixing of sediments by burrowing animals and remobilization / relocation of metals. Other processes, such as variations in sediment deposition rates, for instance due to forest fires or deforestation, also complicate interpretation of the metal profiles. Due consideration is rarely given to these confounding factors, and sediment metal concentrations are commonly interpreted as faithful records of contamination from industrial activity. Although such an approximation may be correct in some cases, it is clearly wrong in many others.

FINDINGS

This research, carried out through the Metals in the Environment Research Network (MITE–RN) program, has made several significant findings. First, the choices of lake and sampling site are critical to minimize complicating processes that obscure metal deposition records in sediments. Remobilization / relocation processes are minimized when precautions are taken to avoid sites subjected to mixing by animals. Second, post-depositional mobility of metals such as mercury, zinc, and above all arsenic can alter their recent deposition history as inferred from measurement of their depth-distribution. Long-range atmospheric transport differs among metals, with the most extensive transport occurring for mercury, then lead and arsenic, then zinc and cadmium, and less for copper and nickel. For example, virtually no copper or nickel related to human activities was detected at the most remote site studied (700 km north-east of Montreal). Third, local perturbations, such as wildfires and beaver activity in the watershed, have marked effects on mercury profiles. Fourth, sources of atmospheric lead emissions from coal combustion, use of leaded gasoline, and industrial activities have been identified from their isotopic signatures, and the historical contributions from various lead sources have been established. Fifth, there has been a progressive and substantial decrease in metal deposition over the last 20 to 30 years, indicating the success of measures to control atmospheric metal emissions.

CONTINUING RESEARCH

The above research has focused on determining to what extent and under what circumstances lake sediments can provide useful records of arsenic, cadmium, copper, mercury, nickel, lead and zinc loadings from the atmosphere. Field and laboratory work have generated important information on lake characteristics, dating and sedimentation rates, and sediment geochemistry. Based on this information, investigations are being extended to other metals such as silver, thallium, indium, palladium and platinum. Efforts are also being devoted to identifying the sources of atmospheric metals to lake sediments. Such information is required to make rational environmental decisions concerning the most appropriate focus of efforts to reduce atmospheric metal emissions.

ADDITIONAL INFORMATION

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http://www.mite-rn.org/research/era/era.shtml

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