

ENVIRONMENTAL ASSESSMENT OF HEAVY METAL CONTAMINATION
IN YELLOWSTONE NATIONAL PARK

Stephen Klein
Civil and Environmental Engineering
University of Colorado
Boulder

55027

Objectives

The sources, concentrations and biological effects of heavy metals in aquatic ecosystems are topics of concern to resource managers and environmental researchers as well as the layman. Numerous studies have shown toxic responses in aquatic biota and man due to the discharge of heavy metals into the aquatic environment. The high automobile traffic densities in National Parks increase the potential for heavy metal contamination of roadside waters which may result in adverse ecological and human impacts.

The objective of this study is to determine the extent and effect of anthropogenic heavy metal contamination in the roadside waters of Yellowstone National Park. Specific objectives which provide a basis for assessing the contamination and its significance to the health of the aquatic ecosystem and the Park visitor include:

1. Determination of metal (Pb, Cd, Ni, Cu and Zn) concentrations in lakes and streams by analysis of water, sediment and biota;
2. Establish transport distances of heavy metals from their source to their fate;
3. Assess bioaccumulation within foodchains and health implications of fish consumption in the study areas; and
4. Examine historical patterns of heavy metal accumulation in lake sediments.

The first year of the study was spent surveying the Park's water and biota contamination to locate areas of maximum potential impact. The second year's efforts have been to make a detailed study of heavy metal dynamics and impact in the areas shown to be most severely contaminated by human activity.

Methodology

Field sampling techniques during the summer of 1985 remained the same as the previous year, however, based on the first year's results, sampling emphasis at the thirty-five stream and lake sites was changed. Parkwide sampling of water was performed on a monthly basis to compare the influence of wet and dry

years on metal concentration in the water. Several areas in the Park that showed the highest contamination are Bridge Bay Marina, Scaup Lake, Sylvan Lake and Lewis Lake. Unfortunately, lack of time and resources allowed for the definition of metal contamination in only one of these areas. Although Bridge Bay showed extremely high sediment contamination in one spot, it was restricted to the Marina. Scaup Lake also showed significant contamination but is too small and nonproductive to support fish and is thus a minor resource. Sylvan Lake showed moderate levels of sediment and water contamination and was of interest since it is the headwater of Clear Creek, a major cutthroat trout spawning stream. Lewis Lake showed the most widespread contamination of water and sediment in the Park.

Lewis Lake was selected for the more detailed study for several reasons, while Sylvan Lake received secondary emphasis. Of the areas, Lewis Lake is the largest contaminated water body where consumptive fish use is permitted. Additionally, Lewis Lake would also be a good model macrocosm to study heavy metals since it is representative of Park waters being low in alkalinity, hardness and is oligotrophic. To determine the extent of metal contamination in Lewis Lake, water samples and about thirty-five sediment cores were collected on a grid of 550 meter spacing. To help assess the biological impact, ten tissue samples each of Utah chubs, lake trout and brown trout were also collected. Water, trout and sucker samples were collected at Sylvan Lake.

Results

The cadmium and lead concentrations in the four areas of interest all exceeded Environmental Protection Agency Water Quality Criteria for the protection of cladocerans and salmonid fish. In Lewis Lake water, the Criteria were exceeded by factors of at least five and as much as thirty. At none of the study sites in the Park were the Criteria for zinc, copper or nickel exceeded. Sediment cores from Lewis Lake, Sylvan Lake and Bridge Bay all showed similar lead contamination profiles. Figure 1 is a representative core profile from Lewis Lake and shows the increased concentration of lead and cadmium in the more recent sediments. Lead enrichment factors, the concentration of lead in recent versus older sediments, were as high as eight in Lewis Lake. The uneven spatial distribution of lead and cadmium found in Lewis Lake sediments can be explained through a combination of transport and chemical processes occurring in the Lake. Analysis of biological samples is not yet complete so the impact of this contamination is not known.

The major source of heavy metal contamination in the Park appears to be automobiles. Based on gasoline sales in the Park, the estimated emission of lead during the summer visitation months is currently ten kilograms per day. Considering that two decades ago nearly all cars used leaded gasoline, that gasoline lead concentrations were twice as high as they are now and that gas mileage was lower then, lead emissions were probably at least five times greater than today. The persistence of lead emitted during past decades is seen in the lake sediments.

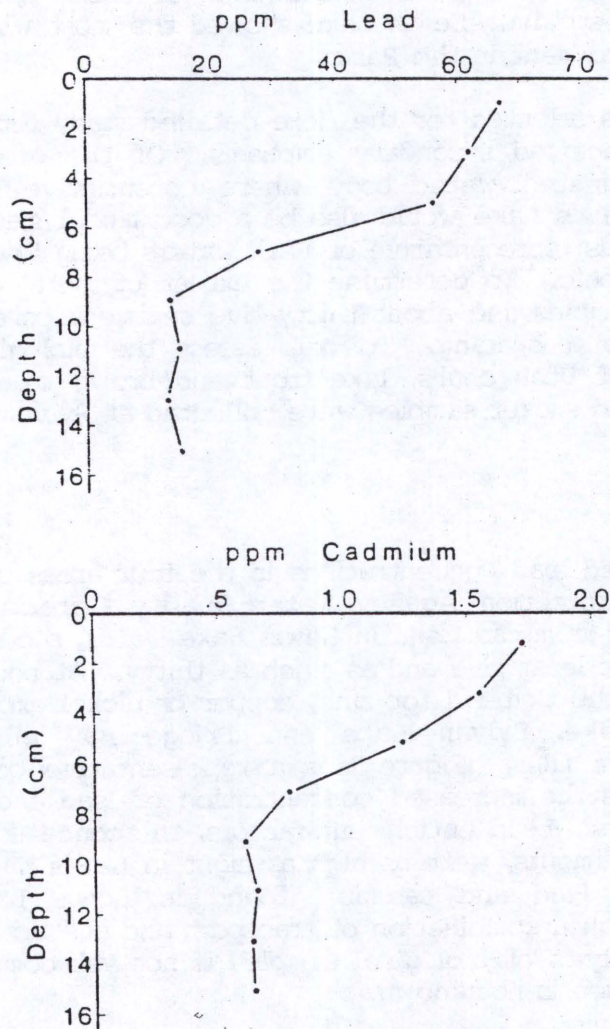


Figure 1. Lead and cadmium sediment contamination profiles in a Lewis Lake core, showing recent increases in contamination.

Conclusions

Significant increases of lead and cadmium contamination in Lewis Lake as well as other areas in the Park have occurred in the last forty years and may be attributed to automobile and boat use. Although the concentrations of lead and cadmium are low and of no hazard for human consumption, they do exceed the recommended concentrations for sensitive aquatic biota and are potentially toxic to them. The sediment in parts of Lewis Lake can be classified as "highly polluted" based on other researchers bioassays with similar sediments. The accumulation of heavy metals in the Lake's sediments over the years now represent a significant potential source of contaminants for the water column and the foodchain. Whether sediment bound metals are getting into the fish at this time is unknown and conclusions regarding biotic impact cannot be made until further analysis is completed.