Lead Concentrations in Selected Streams and Fishes of Central Indiana

NICHOLAS G. SCHMUTTE and PHILIP A. ST. JOHN
Department of Zoology
Butler University, Indianapolis, Indiana 46208

Abstract

Water and fish samples were collected from three stations along the White River, and from Fall Creek and Eagle Creek near Indianapolis, and analyzed by atomic absorption spectrophotometry for lead content. Water samples collected at low flow were found to contain up to 120% more lead than the level found to inhibit bacterial decomposition, and 460% more than the maintenance level proposed by the Indiana Stream Pollution Control Board and the maximum allowable level for drinking water set by the Federal Health Service.

Fish samples were found to contain as much as 350% more lead than the recommended concentration for sea foods.

Introduction

Among the adverse effects of lead are the inhibition of the activity of enzymes that are dependent on the presence of free sulfhydryl groups for their activity, such as those mediating the formation of heme. Enzyme inhibition is first noticed when the lead level in the blood rises above 0.3 mg/1 (2). When blood lead levels reach 1.5 mg/1 (ppm), there is an increased loss of amino acids, glucose, and phosphates in the urine due to damaged kidney tubule cells. Chronic nephritis, as well as peripheral nerve diseases affecting the motor nerves of the extremities, are results of long-term over-exposure to lead (2).

Most of the work on lead poisoning in aquatics has been done with acute toxicity levels, and very little is known of the ability of aquatic organisms to concentrate lead in their soft tissues. There is a need for long-term or chronic toxicity studies to investigate subtle changes in metabolism, appetite, or reproduction (3, 4, 5). Lead has been found to be concentrated at all levels of aquatic food chains (5), and some concentration factors have been determined (8), but there is a severe lack of data on residues of lead and concentration factors for fish (5).

While Indiana has no large-scale lead mining or smelting operations, it ranked fifth in the nation in total lead consumption in 1968 with 121,641 tons. Storage batteries and gasoline antiknock additives are the leading uses for lead (8).

Methods

Fish and water samples were collected from three sites along the west fork of the White River, one site on Eagle Creek, and one site on Fall Creek. The Fall Creek site was under the Interstate 465 bridge on the east side of Indianapolis, and samples from Eagle Creek were collected approximately 500 yards downstream from the I-465 bridge on the west side of the city. The White River sites were collected at the bridge north of Daleville (downstream from Muncie, Indiana), the bridge at Perkinsville (downstream from Anderson), and at the Southport Road bridge south of Indianapolis (approximately 500 yards downstream from the municipal sewage treatment plant discharge).

The White River sites were chosen for their location with respect to the major industrial centers of Muncie, Anderson, and Indianapolis, while the Fall and Eagle creek sites were chosen for the absence of industrial effluents, but proximity to major highways.

Fish were seined, transported to Butler University in stream water, identified, and placed at –20°C for preservation until analysis could be performed. Water samples were collected in polypropylene bottles acidified with nitric acid, and refrigerated at 4°C until analysis.

Standards were prepared by adding lead nitrate to deionized water in sufficient quantities to make 200 ml each of 0.1, 0.3, 0.5, and 1.0 ppm as lead. These standards, with a blank containing only deionized water, were processed with the 200 ml stream water samples by the method described by Fishman and Midgett (6).

Tissue samples were processed by the wet ash method of Hoover, Reagor, and Garner (7). Standard solutions of lead nitrate were prepared to give 1, 3, 5, 10, and 15 ppm lead each time the tissue samples were analyzed to establish absorption curves. One blank was compared with each set of samples to verify that no lead was added by the procedure. The samples were analyzed for lead content in a Unicam SP 1950 atomic absorption spectrophotometer at a wavelength of 217.0 or 283.3 nanometers.

Results

Table I illustrates the amount of lead found in each stream on each collection date. On June 17, all streams except Eagle Creek were exceptionally high and turbid. The lead concentrations therefore were very dilute at the White River and Fall Creek sites. The flow of Eagle Creek is controlled by a dam and is maintained at a moderate level, as indicated by the clarity of the water and the rate of flow.

On July 13, there was a slight but steady rain from early morning to late afternoon at all sites, though the stream levels were not visibly affected. Lead levels were considerably higher than on June 17. This may be accounted for by redissolved lead (4), or by tetraethyl lead from automobile exhaust emissions being washed down from roadside ditches.

By August 8 there had been a lack of rain for two weeks or more, and stream flow appeared to be about normal based on stream movement and turbiditry. Lead levels dropped from July 13, but were still much higher than June 17.

On August 20 the stream flow was very low at all sites, and the lead levels were at their highest along White River.

In spite of the differences in stream conditions on the dates of collection, certain patterns are evident. On all collection dates except June 17, the stream lead levels were found to be as much as 460% higher than the maximum level proposed by the Indiana Stream Pollution Control Board (11). The lead level for Eagle Creek was higher

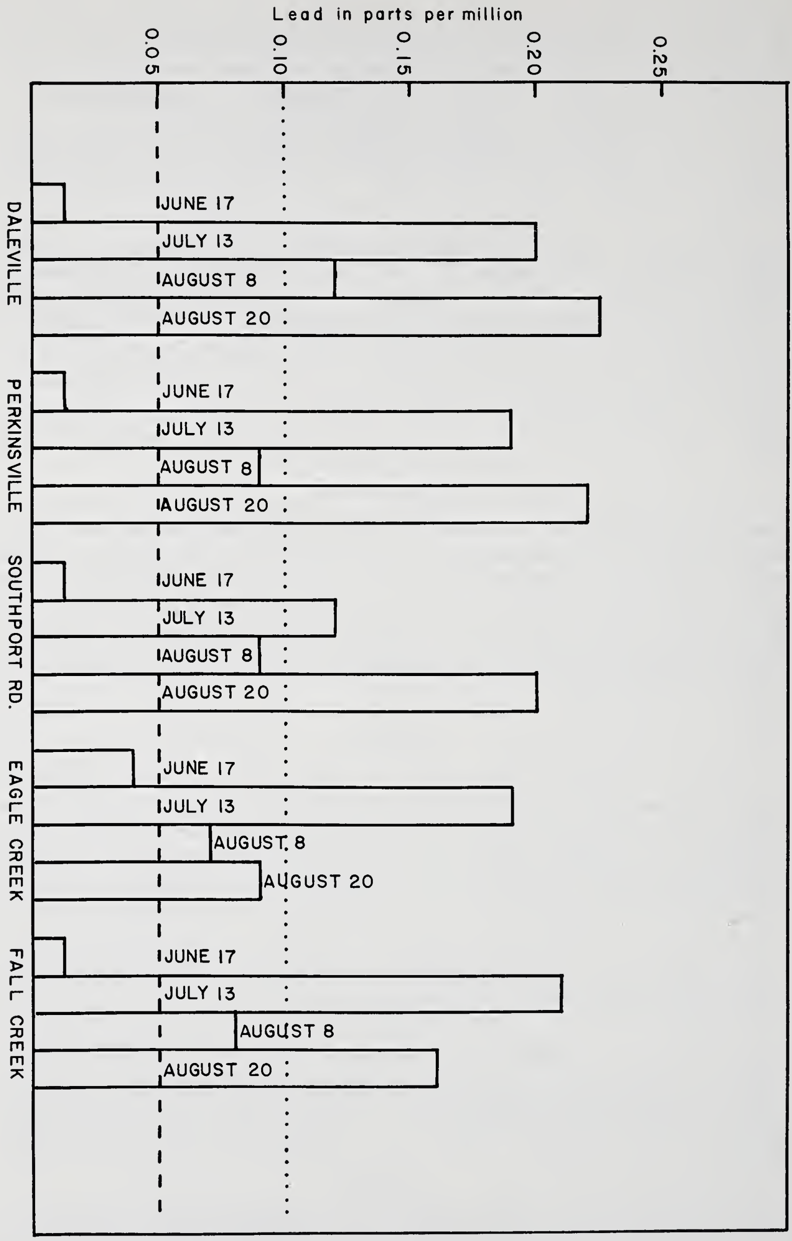

TABLE 1. *Lead concentration (ppm) in stream water.*
(. . . .) concentration at which bacterial decomposition is impeded.
(_ _ _ _) maximum allowable concentration in drinking water.

than the 0.05 ppm level prescribed by the Federal Health Service for drinking water (5). The town of Speedway obtains its drinking water from Eagle Creek, and normal treatment processes for drinking water fail to remove significant quantities of lead (8).

The highest readings, on July 13 and August 20, were as much as 120% higher than the level of 0.10 ppm at which bacterial decomposition is impeded (5).

A possible explanation for the high lead levels on Eagle and Fall creeks on July 13 is the proximity of these sites to major highways. About ½ of the lead introduced into the atmosphere by automobile exhausts falls out again within 100 feet of the roadway (1). Since it was raining on that day, it is possible that this high level was caused by much of this precipitated lead being washed into the stream.

Dilution plays an obvious role in the lead concentrations, as seen by the fact that with the exception of July 13, as the stream level dropped from a high on June 17 to a low on August 20, the lead concentration rose from a low on June 17 of 0.02 to 0.04ppm to a high on August 20 of 0.23 ppm.

Table II illustrates the average lead content in fish muscle tissue, broken down according to collection site and feeding habit. The lead concentrations in fish at each site reflected very little variation during the investigation period, indicating that short-term fluctuations of stream lead levels apparently have little effect on the lead concentrated in muscle tissue.

While there are no regulations governing the amount of lead in sea foods (8), it has been suggested that a maximum concentration of 2.0 ppm wet tissue be imposed (10). Lead levels found in fish seined from areas known to be frequented by fishermen were as much as 350% higher than this recommended concentration.

There were 37 carnivores, 15 bottom feeders, and 4 herbivores examined for lead content during this investigation, and while there appears to be a higher concentration of lead in muscle tissue of bottom feeders than in carnivores, and more in herbivores than in bottom feeders, a statistically valid statement cannot be made in this regard due to insufficient data.

Conclusions

Lead contamination of the environment is widespread and increasing (9). Currently, water analysis is the only monitoring technique utilized with any degree of regularity. These findings indicate that stream lead levels are less than stable and, depending on stream flow and local precipitation, may vary greatly from well within the "safe" limit to 400% or more above this limit. Fish may be exposed to doses well above the norm as precipitated lead redissolves (4) or is washed down from roadside ditches after a rain.

An area for further study would be an investigation of streams remote from heavy traffic as well as industry, to obtain some idea of a background or "normal" lead concentration for fresh water and fish.

Another area of interest would be a study of washout from roadside ditches to determine to what extent lead from exhaust emissions contribute to stream lead levels.

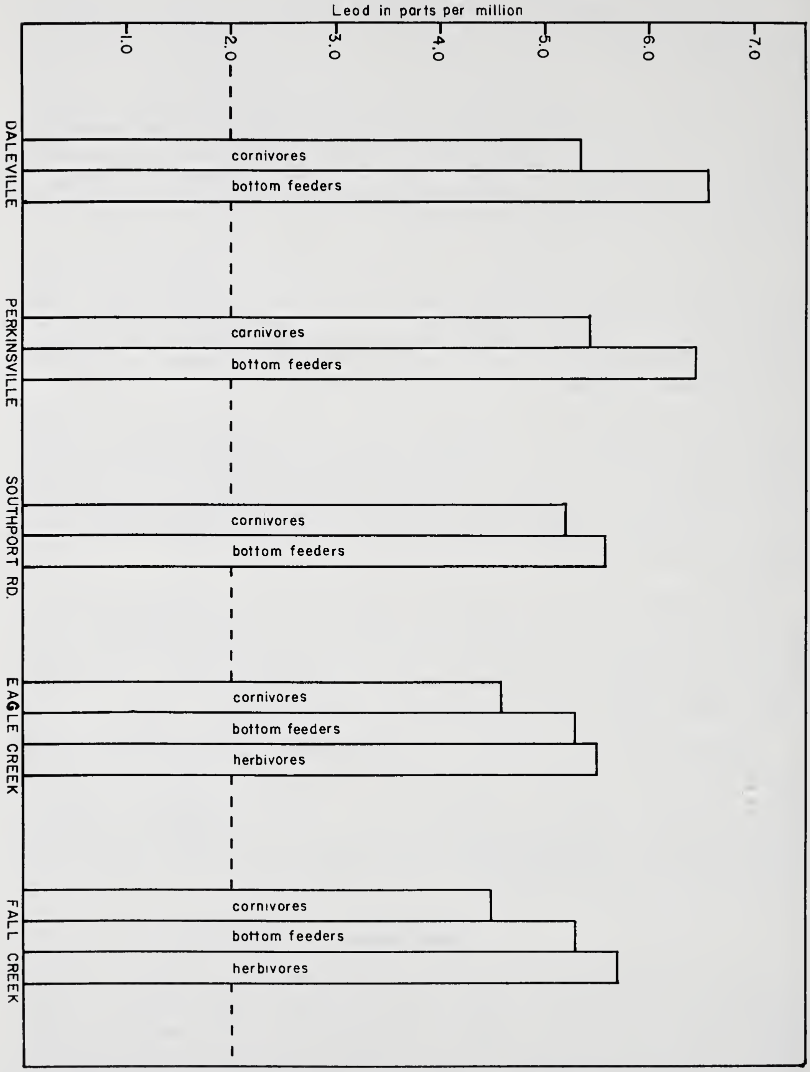

TABLE 2. *Lead concentration (ppm) in fish muscle.*
(_ _ _ _) proposed maximum concentration in sea foods.

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