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Levels of Nine Potentially Toxic Elements in Idaho Fish Manures

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Soil amendments and fertilizers may include potentially toxic elements that may be accumulated by plants. The elemental composition of municipal sludges has been studied in great detail (Furr et al. 1976; Mumma et al. 1984). Fish hatcheries in south-central Idaho have been ordered by the U.S. Environmental Protection Agency to discontinue sweeping accumulated wastes downstream into the Snake River. Alternatives include landfilling and domestic use of the manures as lawn fertilizer. It has been proposed (Smith, 1982, 1985) that fish manures are suitable fertilizers for crops such as corn and sugar beets.

Sewage sludges and manures have increasingly been disposed of as soil conditioners and low grade fertilizers. In 1981 the U.S. Environmental Protection Agency proposed upper limits of certain heavy metals for sewage sludges suitable for land application. The following upper limits (ppm) were proposed: cadmium (25), chromium (1000), copper (1000), lead (1000), mercury (10), nickel (200), and zinc (2500). We determined the concentrations of these elements, plus arsenic and cobalt, in fish manures being evaluated as fertilizers for Idaho croplands. We also determined nitrogen, phosphorus, and potassium in fresh fish manures.

MATERIALS AND METHODS

Large wet samples of manure were obtained from four commercial trout hatcheries and the Federal Steelhead Hatchery, Buhl, Idaho. The trout manures were dried for 12 days on plastic-covered trays in a solar-heated drying area. Steelhead manure was transferred to a forced draft oven and dried for approximately 60 hours at 60°C.

All samples were screened using a 9-mesh (2mm) sieve. The samples were stored in quart-sized ice cream containers that were sealed with tape until analysis.

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Duplicate samples of manures were wet ashed with nitric and perchloric acids for analysis by atomic absorption spectrophotometry (Perkin Elmer Model 360) using the MHS-10 Mercury/Hydride system for Hg and As or by inductively coupled plasma emission spectroscopy (ARL [Applied Research Laboratories] 3500 C) of Cr, Pb, Co, Cu, Ni, Zn, and Cd. Recoveries of samples spiked at 10 or 20 ppm ranged from 84-87% (Cd) to 94-98% (Cu).

Table 1. Nine Potentially Toxic Elemental Constituents of Idaho Fish Manures

Element (ug/g dry weight	U.S. EPA[a] Upper Limit	Idaho Fish Manures	U.S. Municipal Sludges[b]	Cow Manure[b]
As	---	0.3-0.8	0.03-53	6.1
Cd	25	<2.5-5.0	3.3-203	2.5
Co	---	3.1-10	2.4-30.1	6.1
Cr	1000	18-41	50.5-13.349	180
Cu	1000	11-32	126-7,729	55
Hg	10	0.03-0.11	1.6-20.7	0.1
Ni	200	8-22	29-800	28
Pb	1000	4.2-11.7	80-676	17.5
Zn	2500	117-545	475-10,900	298

[a]U.S. EPA, 1981.
[b]Mumma et al., 1984.

Fertilizer analysis utilized standard procedures. Phosphorus was determined by the molybdovanadophosphoric acid spectrophotometric method (Kitson and Mellon, 1944). Nitrogen was determined by a Kjeldahl method (Carter et al., 1967). Potassium was analyzed by atomic absorption.

RESULTS AND DISCUSSION

Fish manures used for land application as fertilizers have a lower hazard from potentially toxic elemental constituents than municipal sewage sludges. Each of the elemental constituents was present in a lower concentration in fish manures than in sewage sludges (Mumma et al. 1984). Owing to their relatively high nitrogen content, fish wastes would likely be used at lower application rates than sludges to achieve equivalent fertilizer rates (nitrogen per acre), further reducing the likelihood of the occurrence of biologically significant elemental toxicants in soils or crops. In those cases where discharge of fish manures into water ways is prohibited (U.S. EPA, 1981), land application of fish manures as fertilizer is a potentially beneficial alternative.

Table 2. Nitrogen, Phosphorus, and Potassium Analyses on Rainbow Trout Manure

Sampling Location	Nitrogen	Phosphorus	Potassium
	Percent		
Clear Lakes	4.33	0.31	0.14
Valley Trout	9.28	0.61	0.06
Box Canyon	3.53	0.14	0.08
Big Bend	4.86	0.32	0.12
Federal Steelhead Hatchery (Steelhead Manure)	10.34	0.39	0.06

Cadmium is usually the primary concern in discussions of the consequences of widespread land application of municipal sludges. Soil amendments which might increase the amount of cadmium in the human diet are to be avoided. Present levels of cadmium in food are considered to be at a maximum safe level for Americans with respect to possible kidney dysfunction and cardiovascular effects (Kopp et al. 1982).

Mumma et al. (1984) reported cadmium concentrations of 3.3-203 ppm in 30 sewage sludges from 23 American cities. Cadmium levels of <2.5-5.0 ppm were present in the fish manures. These amounts were similar to the 2.5 ppm Cd of cow manure (Mumma et al. 1984). Soil cadmium levels are usually less than 1 ppm. Use of fish manure fertilizers at normal rates of application would not significantly increase soil cadmium.

The municipal sludges analyzed by Mumma et al. (1984) were classified as low analysis fertilizers based upon their average per cent nitrogen, phosphorus, and potassium concentrations of 2.6, 1.5, and 0.10 respectively. The fish manures (Table 2) contained higher nitrogen, lower phosphorus, and similar potassium compared to municipal sewage sludge. In cases in which the two were being considered, tha manures could be applied at lower rates than sludges to achieve a given fertilizer rate. The amounts of other elemental constituents such as cadmium would be correspondingly lower.

The analyses reported in this paper were obtained from fresh fish manure obtained from the raceways, and, as such, they represent a "worst case" situation. Fish manure that would be used in the fields would come from retention and dewatering facilities where the manure would be thoroughly leached, and where decomposition and denitrification could develop. Most retention facilities presently in use are ponds dug in the soil without structural lining. In these facilities, soil is also excavated from the ponds with the manure as the ponds are cleaned in preparation for using the manure. Under these conditions, the nitrogen content of the manure would be lower than those values reported here. The heavy metals would also tend to be lower than the reported values for the fresh manure because of soil mixing.

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