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Arsenic Content of Small Mammals Indigenous to Old Orchard Soils

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Lead arsenate and calcium arsenate have been used as insecticides in apple orchards in the United States for many years. Arsenic compounds in sufficient concentration can be herbicidal and arsenic accumulation in soil from past spray applications has been associated with phytotoxicity in young fruit trees planted on such soils (BENSON 1968). Arsenic is rapidly fixed in soils, probably as insoluble precipitates of iron, calcium and magnesium (BOLT and BRUGGENWERT 1976) and in other unavailable forms associated with clays and organic matter. It therefore tends to concentrate in the upper few inches of the soil profile.

Small mammals such as mice and voles which inhabit the immediate surface of old orchard soils typically consume plant parts, insects, organic debris and necessarily adhering soil particles containing accumulated arsenic residues. In an earlier study it was shown that lead accumulated to concentrations up to 400 ppm dry weight in bone of pine voles inhabiting such orchard soils. High concentrations of lead were also found in liver and kidney of these mammals (ELFVING et al. 1978). Individual tissue samples were too small to permit analysis of arsenic. In the work reported, small mammals were trapped in a number of orchards in New York which had received multiple applications of inorganic arsenic compounds annually for many years. The entire body burden of arsenic was then determined in the animals.

EXPERIMENTAL

The mammals were caught with common baited mouse traps. The animals included meadow voles (*Microtus pennsylvanicus*), pine voles (*Pitymus pinetorum*) and white-footed mice (*Peromyscus leucopus*). Each animal was washed to remove external debris, dried, and weighed. The entire animal was dry ashed at 600° C overnight in a silica crucible. The ash was dissolved in 50 ml of 1N HCl. Arsenic was then determined in the ash solution by distillation of arsine and spectrophotometric determination using the silver diethyldithiocarbamate procedure (FISHER SCIENTIFIC CO. 1960).

RESULTS AND DISCUSSION

Table 1 lists data pertaining to the animal species and the residues of arsenic found in them and the associated orchard soils. The correlation coefficients (r) for the mean body burden of ar-

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TABLE 1

Total concentration of arsenic in soils, voles and mice in apple orchards which received applications of arsenic compounds for many years.

Orchard code	Animal	Maturity	Sex	Body weight (grams)	μg As (total body content)	As in soil (ppm dry wt)
A	meadow vole	adult	M	32.6	4.2	31
	meadow vole	adult	M	42.2	2.6	
	meadow vole	adult	M	62.3	3.2	
	white-footed mouse	juvenile	M	15.2	1.2	
	white-footed mouse	juvenile	F	12.9	7.6	
	white-footed mouse	adult	F	23.1	3.6	
	white-footed mouse	adult	F	32.7	8.4	
B	pine vole	sub-adult	M	32.5	5.2	34
	pine vole	sub-adult	F	25.0	13.6	
	pine vole	sub-adult	F	28.5	6.0	
	pine vole	adult	F	45.9	8.4	
	meadow vole	juvenile	F	11.2	2.4	
C	pine vole	adult	M	29.3	28.0	44
	pine vole	adult	F	27.6	14.0	
	pine vole	adult	F	29.9	26.2	
	meadow vole	adult	F	35.5	10.4	
	meadow vole	adult	F	38.7	24.4	
D	pine vole	adult	F	30.6	10.4	94
	pine vole	adult	F	36.5	26.0	
Control	pine vole	adult	M	25.1	0.4	2.4
	pine vole	adult	F	23.4	0.0	
	pine vole	adult	F	26.4	0.1	
	pine vole	adult	F	28.5	0.8	
	meadow vole	adult	M	19.3	0.1	
	meadow vole	sub-adult	M	33.8	0.0	
	meadow vole	sub-adult	F	23.3	0.1	
	white-footed mouse	sub-adult	M	16.8	0.1	
	white-footed mouse	sub-adult	M	18.8	0.4	
	white-footed mouse	adult	M	21.6	0.4	

senic in micrograms per gram (fresh) body weight of the voles versus ppm (dry weight) of arsenic in the specific soils they inhabited were 0.85 and 0.64 for meadow voles and pine voles, respectively. Both of these r values were significant ($p < 0.05$). The number of animals of a given species per orchard was too small to permit statistical examination for a possible relationship between sex and maturity of the animals and their body burden of arsenic.

About 80% of the arsenic absorbed by animals is stored in practically all tissues including liver, abdominal viscera, bone, skin and especially the hair and nails (BROWNING 1969). Excretion in urine and feces (KLASSEN 1974, CIKRT and BENCKO 1974) is slow. Methylation of arsenate or arsenite in cows and dogs has been shown with urinary excretion of the less toxic methanearsenate (LAKSO and PEOPLES 1975). Arsenate has been shown to cause fetal malformations when administered intravenously to pregnant golden hamsters (FERM and CARPENTER, 1968) and arsenite caused similar malformations when given intraperitoneally to mice (HOOD 1972). Arsenate administered to rats in their drinking water was shown to produce ultrastructural changes in proximal tubule cells of the kidney (BROWN et al. 1976). The animals in this study were not examined histopathologically.

This study indicates that prior applications of arsenic-containing compounds in orchards can result in the accumulation of arsenic in soils and small indigenous mammals. Whether this would result in serious deposition of arsenic in predator species such as foxes, domestic cats, hawks or owls requires further study.

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