Bull. Environ. Contam. Toxicol. (1985) 35:689–695
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Environmental Contamination and Toxicology

# Background Elemental Content of Animal Feeds, Ontario, Canada, 1978-82

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Metal additions to soils have greatly accelerated over the last two decades from a variety of sources. In the production of food these have come from the use of fertilizers, pesticides, trace elements and mineral additives in feed, inadvertent additions to soil have come from the disposal of sewage sludges, and the aerial fallout from industrial, urban and transportation activities.

The uptake of these added metals into crops intended for direct human consumption was studied by Elfving *et al.* (1982) and Chaney (1973) and elevations have been reported. Studies of uptake into livestock feed have been conducted by Bingham (1979), Alary *et al.* (1981), Baker *et al.* (1979), and Garcia *et al.* (1974) and Hansen and Hinsley (1979), and Sharma *et al.* (1979) into livestock tissue and accumulations of Cd have been noted.

Guidelines on the addition of metals to land are being developed in many countries. The Province of Ontario is no exception, and a program of sewage sludge utilization on agricultural land has been implemented between 1979 and 1982 (O.M.A.F. - O.M.E. 1978). Unfortunately, a good base on background levels in soil, animal feed and livestock tissues were not available. The intent of this study was to determine the background levels of the soil - feed - livestock system across the Province. Elemental contents for Ontario soils have already been published (Frank *et al.* 1976, 1979) and this paper is intended to supply the feed part of this system.

## MATERIALS AND METHODS

Field Collection. Grass-legume hays, grain corn, and corn silage were collected from farms across the Province between 1978 and 1982. Samples of 0.5 to 1 kg were taken at random from hay, grain storage bins and corn silage silos at each of the farm locations. Collections were carried out by members of the Plant Industry Branch of the Ontario Ministry of Agriculture and Food. At the time of collection records were kept on location of the farm and the soil type on which the crop was raised. Farms receiving urban or industrial waste were avoided as were those farms close to any industrial fall-out. Subsamples from the 20 random sites were composited and sent to the laboratory.

Samples were dried, ground and mixed before a subsample was taken for analysis.

Five grams of feed were digested in 15 mL of 1:2 mixture of $H_2SO_4$ and $HNO_3$ by gently boiling until white sulforous fumes began to evolve. 20 mL of distilled water were added and content was warmed for 10 min, filtered through a coarse porosity sintered glass filter and made up to 50 mL with distilled water. The metals were measured with flame AAS Varian Techtron Model 1200, with background corrector Model BC-6, using $H_2$ and $N_2$ gases and a hydride generator kit Model 64. The wavelengths used to measure the metals were - As 197.0, Sb 217.0, Se 195.0 mm. Recoveries by the described optimized extractions at 85% As, 85% Sb and 96% Se.

One gram of feed was digested with 10 mL of concentrated $HNO_3$. The flask contents were gently boiled until the acid evaporated to 1 mL. 5 mL of distilled water were added, content was warmed for 15 min, transferred into tube and made up to 10 mL with distilled water. Ag, Cd, Co, Dr, Cu, Ni, Pb, Zn were measured with flameless AAS Varian Techtron Model AA5, with background corrector Model BC-6. The method for the flameless AAS was a slight modification of the procedure described by Amos *et al.* (1971). Molybdenum was measured with the flame Varian Techtron AAS Model 1200 with a background corrector Model BC-6 and using $N_2O$ and $C_2H_2$ gases. The wavelengths used to measure the metals were Ag 328.1, Cd 228.8, Co 240.7, Cr 357.9, Cu 327.4, Mo 313, Ni 352.4, Pb 283.3, Zn 306.6 mm. Recoveries by the described method optimized extractions at 71% Mo, 81% Co, 97% Ag, 98% Cu and Zn, 99% Cd, Cr, Ni and Pb.

One gram samples of feed were digested with 20 mL of concentrated sulfuric and nitric acids (4:1) for 1 h in a shaker bath at 60°C. A 0.1 or 0.2 g aliquot was made up to 100 mL with distilled water. Hydroxylamine sulfate solution (2%) was added and the contents were allowed to stand until the colour disappeared. Stannous sulfate solution (5 mL of 10%) was added and the effluent was passed through a mercury analyzer as a cold vapor. Mercury content was determined from peaks produced by an atomic absorption spectrophotometer set at 253.7 nanometers and attached to a recorder (Hatch and Ott 1968). Recovery from spiked sample was 93%.

## RESULTS AND DISCUSSION

Ninety samples of each of the animal feeds were analyzed; 30 from each of three soil types (1) clay and clay loam, (2) loam and silt loam, and (3) sands and sand loams. The results of the elemental analyses appear in Tables 1, 2 and 3. The contents of the 13

Table 1. Elemental analyses of 90[1] mixed hay samples collected from across Ontario, 30 from each of the three major soil types

| Elements | elemental content in hay | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Clay & Clay Loam | | Loam & Silt Loam | | Sand & Sandy Loam | | All Soils | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| | (ug/kg) | | | | | | | |
| Ag | 2.2 | 2.1 | 5.2 | 4.1 | 3.8 | 2.5 | 3.7 | 3.3 |
| As | 353 | 427 | 219 | 185 | 126 | 69 | 233 | 182 |
| Cd | 68 | 45 | 64 | 40 | 72 | 43 | 68 | 42 |
| Co | 128 | 134 | 128 | 137 | 107 | 100 | 119 | 124 |
| Hg | 56 | 15 | 50 | 14 | 41 | 19 | 49 | 17 |
| Sb | 131 | 81 | 191 | 99 | 129 | 79 | 150 | 90 |
| Se | 87 | 50 | 62 | 49 | 75 | 43 | 75 | 48 |
| | (mg/kg) | | | | | | | |
| Cr | 3.48 | 1.56 | 4.08 | 1.07 | 3.98 | 3.99 | 3.85 | 2.53 |
| Cu | 7.87 | 3.77 | 8.39 | 4.00 | 10.71 | 7.86 | 8.99 | 5.62 |
| Mo | 1.51 | 1.21 | 1.59 | 1.08 | 1.29 | 1.26 | 1.46 | 1.01 |
| Ni | 2.07 | 1.31 | 1.73 | 1.21 | 2.16 | 2.01 | 1.99 | 1.54 |
| Pb | 2.20 | 1.72 | 1.43 | 0.81 | 1.63 | 1.31 | 1.75 | 1.36 |
| Zn | 42.1 | 37.9 | 26.9 | 28.4 | 28.9 | 17.5 | 32.6 | 29.6 |

[1]Samples came from the southern (20), western (18), central (38) and eastern (14) regions of the province

Table 2. Elemental analyses of 90[1] grain corn samples collected across Ontario, 30 from each of three major soil types

| Elements | elemental contents in grain corn | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Clay & Clay Loam | | Loam & Silt Loam | | Sand & Sandy Loam | | All Soils | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| | (ug/kg) | | | | | | | |
| Ag | 4.1 | 7.3 | 6.3 | 6.0 | 3.9 | 3.2 | 4.8 | 6.2 |
| As | 111 | 74 | 116 | 64 | 114 | 62 | 114 | 66 |
| Cd | 53 | 42 | 20 | 22 | 34 | 20 | 36 | 32 |
| Co | 103 | 98 | 61 | 54 | 46 | 56 | 70 | 76 |
| Hg | 53 | 14 | 46 | 36 | 38 | 34 | 46 | 30 |
| Sb | 103 | 49 | 176 | 107 | 135 | 91 | 138 | 91 |
| Se | 56 | 35 | 42 | 26 | 53 | 24 | 50 | 29 |
| | (mg/kg) | | | | | | | |
| Cr | 2.60 | 1.09 | 2.90 | 1.37 | 1.23 | 1.60 | 2.24 | 1.54 |
| Cu | 3.05 | 1.89 | 3.36 | 1.97 | 2.57 | 1.99 | 2.99 | 1.95 |
| Mo | 0.55 | 0.36 | 0.75 | 0.44 | 0.70 | 0.37 | 0.67 | 0.40 |
| Ni | 1.84 | 1.87 | 1.40 | 1.19 | 0.71 | 0.89 | 1.31 | 1.45 |
| Pb | 0.39 | 0.71 | 0.14 | 0.22 | 0.10 | 0.14 | 0.21 | 0.45 |
| Zn | 78.2 | 79.9 | 37.4 | 41.0 | 25.6 | 17.6 | 47.0 | 56.9 |

[1]Samples came from the southern (26), western (12), central (40) and eastern (12) regions of the province

Table 3. Elemental analyses of 90[1] silage corn samples collected across Ontario, 30 from each of the three major soil types

| Elements | elemental contents in silage corn | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Clay & Clay Loam | | Silt & Silt Loam | | Sand & Sandy Loam | | All Soils | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| | (ug/kg) | | | | | | | |
| Ag | 5.9 | 6.7 | 7.8 | 6.9 | 8.4 | 4.6 | 7.4 | 6.3 |
| As | 148 | 69 | 138 | 62 | 168 | 102 | 151 | 81 |
| Cd | 91 | 67 | 78 | 63 | 132 | 204 | 101 | 130 |
| Co | 186 | 242 | 63 | 70 | 72 | 101 | 107 | 165 |
| Hg | 55 | 15 | 48 | 29 | 66 | 136 | 56 | 80 |
| Sb | 144 | 72 | 152 | 83 | 122 | 37 | 139 | 67 |
| Se | 72 | 65 | 68 | 50 | 61 | 26 | 67 | 49 |
| | (mg/kg) | | | | | | | |
| Cr | 4.31 | 3.05 | 2.78 | 2.19 | 1.94 | 1.94 | 3.00 | 2.61 |
| Cu | 8.12 | 4.99 | 8.35 | 5.08 | 5.21 | 2.64 | 7.23 | 4.57 |
| Mo | 1.03 | 0.81 | 1.05 | 0.41 | 0.78 | 0.42 | 0.95 | 0.59 |
| Ni | 2.54 | 2.11 | 1.60 | 2.20 | 1.93 | 2.79 | 2.02 | 2.39 |
| Pb | 2.08 | 0.95 | 1.16 | 1.00 | 1.46 | 3.87 | 1.56 | 2.38 |
| Zn | 82.0 | 79.3 | 49.3 | 66.0 | 43.5 | 51.3 | 58.3 | 68.0 |

[1]Samples came from the southern (26), western (27), central (22) and eastern (15) regions of the province

elements spanned five orders of magnitude with the lowest being Ag (1-10 ug/kg) and the highest Zn (10,000+ ug/kg). Between these extremes Cd, Co, Hg and Se fell mainly into the 10-100 ug/kg level, As and Sb into the 100-1000 ug/kg level and Cr, Cu, and Ni into the 1000 to 10000 ug/kg level. Mo fell into two levels, the lower level in grain (100-1000 ug/kg) and the higher level in hay and silage (1000-10000 ug/kg).

In general grain corn contained lower elemental contents than either hay or silage and silage had marginally higher contents than hay for most elements, with others the reverse was true. Pb contents were markedly lower in corn grain than in either hay or corn silage. As, Cd, Cr, Cu, Mo and Ni were considerably lower in corn grain than the other two feeds.

It was difficult to ensure that true background contents were being measured. This was noted with As and Cu. As levels were considerably higher in hay grown on clay soils than other soils or other feeds grown on similar soils, whereas the highest levels of Cu appeared in hay grown on sandy soils.

Baker *et al.* (1979) has reported levels between 2 and 15 ug/kg of Cd in grain corn where no known additional Cd has been added to the soil. Where sewage sludge contaminated with Cd had been applied contents in corn grain rose to 25-120 ug/kg. In our search for a background level for Cd the level average 36±32 ug/kg overlapped the two levels found by Baker *et al.* (1979). These workers reported that two years after the application of sewage sludge corn grain had Cd contents ten times the background level.

The farms sampled in our study were unaware of metal additions to their properties and hence the levels developed in this paper are considered to be background levels for the province. Obviously it was not possible to exclude aerial fallout on these crops, however, they should serve as baseline numbers to measure future changes as a result of practises leading to increased deposition of these elements on foodlands.

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Received October 30, 1984; accepted December 6, 1984.