September 9, 1988

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Health Consultation: Soil Cadmium Levels in Vegetable Gardens Associated with Adverse Human Health Effects, Marathon Battery Site, Putnam County, New York

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BACKGROUND

The former Marathon Battery facility is located in Cold Springs, Putnam County, New York, and previously operated as a manufacturer of nickel-cadmium batteries. Since 1981, the property has been used as a distribution storage facility. A Health Assessment was released by OSHA on July 16, 1987. The site is approximately eleven acres with restricted access. Twenty-nine single family homes are within 100 feet of the site perimeter, and cadmium has migrated off-site into residential yards. The Environmental Protection Agency (EPA) has requested that The Agency for Toxic Substances and Disease Registry (ATSDR) evaluate the public health concerns from exposure to cadmium (Cd) in residential gardens. A site visit was performed by Ms. Denise Johnson and Dr. David Mellard on August 25, 1988. In the Health Assessment by ATSDR and in previous health consultations with Dr. David Mellard, ATSDR has requested that additional residential soil samples be collected to better characterize off-site levels of Cd in residential soil. Because these samples were not performed, this consultation must assume that the limited residential soil data to date characterizes conditions in the residential areas. This assumption may or may not be valid.

DISCUSSION

Residential soil levels of Cd range from non-detectable to 67 ppm with most values below 24 ppm. Cd is known to bioaccumulate in plants to various degrees; therefore, concern for potential human health effects has been expressed for consumers of garden vegetables grown in cadmium-contaminated soil. At renal cortex levels between 200-400 μg/g, damage to renal tubules results in proteinuria and glucosuria. An age-adjusted increased excretion in the urine of beta_2-microglobulin (B_2-MB) can serve as subclinical evidence of renal tubular damage. Increased in urine B_2-MB are not considered a severe health effect, but rather a biochemical sign that continued cadmium exposure could lead to more severe health problems. Typical U.S. concentrations of cadmium in the kidney cortex are between 20-35 μg/g with smokers having almost twice the level of non-smokers. Cadmium toxicity was brought to
the forefront in recognizing the causal association between the consumption of cadmium contaminated rice and drinking water and the Japanese disease Itai-Itai. Most individuals affected were women above the age of 40 years who had born several children, although more recent studies have detected biochemical effects in adult males. Dietary Cd intake in these women has been estimated at 300–600 ug/day (Friberg, 1971). The factors believed to have contributed to the susceptibility of this subpopulation are listed below:

1. a diet relatively low in calcium and fat-soluble vitamins, such as vitamin D,
2. the loss of bone minerals during pregnancy and lactation,
3. increased Cd absorption because of iron deficiency and lactation, and
4. trace mineral imbalances.

The World Health Organization has estimated that an intake of 200 ug/day of cadmium over a 50-year period could produce subclinical kidney damage in the most sensitive individual and has recommended a maximum acceptable daily intake of 70 ug/day. The EPA has recently reported in the July 1988, Superfund Public Health Evaluation manual, a value of 70 ug Cd/day as an acceptable chronic intake in food. While WHO's 200 ug/g Cd in the kidney cortex has been generally accepted as the threshold level for planter, other investigators have evidence that the critical concentration of Cd in kidney cortex is higher (Roels, 200–250 ug/g, humans; Nomiyama, 380–470 ug/g, monkeys; and Cole, 300–400 ug/g humans) (Ellis, 1981; and Cole, 1983). In contrast, Kjellstrom (Friberg, 1985), in a review of several human and animal studies concludes that 10% of people with an average Cd renal cortex concentration of 200 ug/g could develop renal tubular damage with low molecular weight proteinuria.

The question has been raised as to what levels in residential garden soil will lead to plant residue concentrations that can cause kidney problems. Two plant categories are present in evaluating cadmium sorption. Lettuce, cabbage, spinach, kale and other such leafy type vegetables are considered high accumulators of Cd. Typical concentrations range from 5–10 ppm (dry weight) in these vegetables when grown in soil containing 70 ppm cadmium (Davis, 1984). At soil concentrations of 15 ppm, Smilde et. al. (1982), find levels of 3 ppm (dry weight) in carrot and potato leaves and 9 and 5 ppm (dry weight) in radish and lettuce leaves, respectively. A non-linear relationship is shown to exist between soil Cd levels of 5 to 16 ppm and the green leafy portions of radish, lettuce, carrot and potato plants with higher soil concentrations of Cd leading to non-proportionally higher foliar Cd levels. Vegetable crops such as tomatoes, onions, leeks, turnips, potatoes, sweet corn, beans, beets, radishes, peas, carrots, and grains are low accumulators of cadmium. A linear relationship has been shown to exist for the root of radishes and carrots for soil levels between 5 and 16 ppm Cd (Smilde et. al., 1982). From 5 to 16 ppm soil Cd, levels typically increased 2 to 4 times in lettuce, radishes, carrots and potatoes. At these same levels, potato tubers did not accumulate increased levels of Cd. Similar results were reported by Davis (1984) for soil levels between 1 and 12 ppm. Davis also found that a ten-fold increase in soil Cd levels will result in approximately a three to four fold increase in plant residue levels. Therefore, a one-to-one relationship does not exist between soil Cd levels and plant residue levels. Hence, an increase
Both WHO and EPA have established an acceptable daily intake of 70 ug Cd/day. At soil Cd levels around 20 ppm, consumption of garden vegetables and fruits are unlikely to lead to kidney problems from dietary Cd intake.

**RECOMMENDATIONS**

1. Remediate areas with potential use as residential gardens where soil Cd levels are around 20 ppm.

2. Additional residential soil analysis should be conducted to determine the extent of Cd in residential soils.

3. Alleviate residential fear of consuming home grown vegetables by analyzing Cd content of vegetables grown in remediated, residential soil at this site.

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**REFERENCES**


