Bull. Environm. Contam. Toxicol. 27, 806–809 (1981)

High Blood and Urine Levels of Cadmium in Phosphate Workers: A Preliminary Investigation

R. P. Sharma

MRC Toxicology Research Unit, Medical School, University of Otago, Dunedin, New Zealand

Cadmium is a highly toxic trace metal and extensive reviews on its toxicology have been published (FRIBERG et al. 1974; NOMIYAMA 1980). In view of the long half-life of cadmium in the body (KJELLSTROM 1979), and its deleterous health effects from chronic exposure to relatively small amounts of the metal (LEMEN et al. 1976), there is a growing concern and need in New Zealand to evaluate the extent of occupational and environmental exposure to cadmium.

New Zealand is an agricultural country with a high use of phosphate fertilisers. Consequently, large quantities of the fertiliser are locally milled and blended with other nutrients for use in agriculture. It was found recently that the phosphate fertilisers contained significant amounts of cadmium as shown in this report. A subsequent preliminary study has been carried out to determine the blood and urine levels of cadmium in phosphate workers exposed to the phosphate dust. The results of the investigation are described in this report.

MATERIALS AND METHODS

Chemicals: The cadmium standards were prepared using high purity reference standards obtained from Fluka AG, Switzerland. Ultrex grade nitric acid and methyl-isobutyl-ketone, MIBK, (J.T. Baker Chemical Co.) were used for sample digestion and cadmium extraction respectively. Ammonium pyrrolidinedithiocarbamate, APDC, (Sigma Chemical Co.) was used as the chelating agent for the extraction of cadmium. Distilled deionised (Millipore) water was used for the preparation and dilution of all solution.

Control Group: Whole blood and urine samples were taken from non-smokers who do not eat oysters regularly and have had no oysters in the last four weeks prior to sampling. In New Zealand, a species of oyster (Ostrea lutaria) consumed widely, contains significantly high levels of cadmium (NIELSON 1975). Therefore it was necessary to establish that the people used as control groups did not consume these oysters prior to sampling.

0007-4861/81/0027-0806 $01.00

Phosphate Workers: The blood and urine samples were taken from a cross-section of workers including the management staff. Blood samples were taken in heparinised vaccutainers and the urine samples were collected in acid cleaned polyproylene containers.

Phosphate Fertiliser: The samples of fertiliser were obtained from various sources and analysed for cadmium. Various blends of the phosphate fertiliser were analysed and these are denoted by the following codes; OR,NR,CR,NB,DCO and DS.

Measurement of Cadmium: Sub-samples of whole blood, urine and the fertiliser were analysed in duplicate. Known volumes or weights of sub-samples were digested in nitric acid at 70°C on a thermostatically controlled heating block. The digest was appropriately diluted and analysed by graphite furnace atomic absorption spectrometry. Concentrations of cadmium in the samples were determined using the standard addition calibration method. The analytical results were cross-checked through analysis of some duplicate samples by APDC/MIBK chelation and extraction method. The details of the analytical methods have been described elsewhere (SHARMA et al. 1981).

RESULTS AND DISCUSSION

The results of the cadmium analysis in phosphate fertilisers are given in Table 1. It was apparent from the data that relative to the average levels of cadmium in the earths crust, 0.2 ppm (CASARETT 1975), the concentrations in the fertilisers were significantly higher (42 to 147 ppm). The working environment in phosphate works have a high density of phosphate dust in the air and the workers participating in this study were not using any form of protective air-filters for breathing.

Table 1. Concentrations of cadmium in various blends of phosphate fertiliser used in New Zealand.

Blends of Fertiliser	OR	NR	CR	NB	DCO	DS
Mean Cd Levels ppm ± 6%	141	78	46	84	58	42

Blood cadmium levels in the phosphate workers were on an average 7.8 times those measured in control groups (Table 2). In some cases the cadmium concentrations were as high as 14.66 ng/mL whole blood. KJELLSTROM (1979) has reported that adults in Sweden had an average cadmium concentration of about 1.2 ng/g

blood. This compares well with the average cadmium levels (0.92 ng/mL) found in the control group of adult New Zealanders. In the phosphate workers however, even when compared with the average cadmium blood levels of unexposed workers in the U.S.A. (BAKER et al. 1979) and Japan (KJELLSTROM 1979), the levels were significantly high (7.21 ng/mL vs 3.8 ng/mL). In U.S.A. jewelry workers with similar levels of blood cadmium (9.3 ng/mL) were found to suffer from dyspnea, chest pain, dysuria and dizziness, and these symptoms were attributed to subacute cadmium intoxication (BAKER et al. 1979).

Table 2. Mean cadmium levels in whole blood of phosphate workers and control groups (ng/mL ± s.d.)

Sample Group	1	2	3	4	5	Overall Mean
Phosphate Workers	3.74 ±0.88	9.17 ±0.23	8.92 ±1.23	8.14 ±1.32	6.08 ± 0.94	7.21 ±2.05
Control Group	1.23 ±0.16	0.73 ±0.15	0.99 ±0.14	0.77 ±0.17	0.88 ±0.25	0.92 ±0.18

The mean concentrations of cadmium in the urine of phosphate workers and the control groups are shown in Table 3. In Sweden, U.S.A. and Japan the average cadmium levels in the urine of adults (non-smokers) are reported to be 0.3, 0.67 and 1.2 ng/mL respectively (KJELLSTROM 1979). The mean concentration of cadmium in the urine of non-smoking New Zealanders (the control group) was found to be 0.54 ng/mL. However, the urine cadmium levels in the phosphate workers were significantly higher, with an overall mean value of 5.24 ng/mL (ie about 10X the control value).

Table 3. Mean cadmium levels in the urine of phosphate workers and control groups (ng/mL ± s.d.)

Sample Group	1	2	3	4	5	Overall Mean
Phosphate Workers	6.20 ±0.12	4.97 ±0.23	4.81 ±0.47	5.44 ±0.85	4.78 ±0.40	5.24 ±0.53
Control Group	0.50 ±0.33	0.36 ±0.07	0.55 ±0.49	0.36 ±0.23	0.91 ±0.28	0.54 ±0.20

The absorption of cadmium by inhalation is of obvious significance for human exposure in the industrial environment. After deposition in the lungs, the metal or metal compound may be absorbed into the blood directly or transported by mucocilliary action into the gastrointestinal tract. The pulmonary absorption of cadmium has been reported to be 10 to 40%, depending on the particle size or the chemical form of the toxic metal. For example, cadmium chloride is easily absorbed through the lungs, while the absorption of the sulphide is practically nill (NOMIYAMA 1980). FRIBERG (1950) showed that industrial workers exposed to cadmium dust suffered from emphysema with increased residual capacity. At long-term inhalation or oral exposure to cadmium, the renal changes are usually the critical effect (FRIBERG et al. 1974).

In the present investigation no immediate symptoms of acute or subacute cadmium intoxication in the phosphate workers was observed. However, the cadmium levels measured in the whole blood and urine makes it imperative that a more detailed study be carried out to elucidate any long-term effects of exposure to cadmium containing phosphate dust.

REFERENCES

BAKER, E.L., W.A. PETERSON, J.L. HOLTZ, C. COLEMAN AND P.J. LANDRIGAN: Arch. Environ. Health. May/June, 173 (1979).

CASARETT, L.J., AND J. DOULL: Toxicology, the basic science of poisons. 1ed. New York: MacMillan 1975.

FRIBERG, L., et al.: Cadmium in the Environment, 2 ed. Cleveland: CRC Press (1974).

KJELLSTROM, T.: Environ. Health Perspect. 28, 169 (1979).

LEMEN, R.A., J.S. LEE, J.K. WAGONER, AND H.P. BLEJER: Ann. N.Y. Acad. Sci. 271, 273 (1976).

NIELSEN, S.A.: Intern. J. Environ. Anal. Chem. 4, 1 (1975).

NOMIYAMA, K.: Sci. Total Environ. 14, 199 (1980).

SHARMA, R.P., J.M. McKENZIE AND T. KJELLSTROM: J. Analyt. Toxicol. (1981) Submitted.