Reports

Zinc-65 and Zirconium-95 in Food

Abstract. Zinc-65 has been found in small amounts in muscle and liver samples obtained from cattle raised in Nevada, and also in commercial hamburger and beef liver from the southwestern area. Zirconium-95 and niobium-95 were found in the liver samples but not in the muscle or hamburger. A trace of zinc-65 was detected in milk but none in people.

Zinc-65, while not a fission product, is produced by neutron interaction with stable zinc in both bomb tests and reactors. It has been found in people and aquatic organisms exposed to intense fallout (*1*) and in farm produce and animals obtained from an irrigated area about 30 mi downstream from the Hanford Project (*2*). It has been detected also in cyclotron workers exposed to Zn^{65} produced by (*d*, 2*n*) reaction on copper-65 in the dees (*3*). These are special cases involving specific local exposure conditions.

This isotope has now been detected (*4*) in muscle and liver samples from cattle raised in Nevada, and also in commercial hamburger (lean ground beef shoulder) and beef liver from the southwestern area. Zirconium-95 and niobium-95, a fission-product pair very common in fallout, were also detected in the Nevada and locally procured liver samples, but not in the muscle or hamburger. Examination of milk samples from two areas of relatively high fallout (northwest Washington and Louisiana, May 1959) showed little or no Zn^{65}. Careful measurement of two people at this laboratory failed to reveal anything but the usual Cs^{137} and K^{40}.

The results on the beef liver and hamburger obtained locally are given in Table 1. The amount measured in each case was 75 lb. The sample was arranged adjacent to the face and cylindrical sides of a 9½ by 6 in. NaI (Tl) crystal in a large steel room designed for measurement of the gamma-ray spectra of people (*5*). The milk samples (50 lb of nonfat dry milk solids) were measured in a similar way. The Washington sample showed a barely measurable Zn^{65} concentration (about 40 $\mu\mu$c/kg of powdered milk, or about 4 $\mu\mu$c/kg of reconstituted liquid milk), while none could be detected in the Louisiana sample. While these samples had normal potassium content (about 18 gm/kg of powdered milk), the Cs^{137} content was elevated (200 to 300 $\mu\mu$c/gm of potassium).

The two people who were measured had average Cs^{137} and K^{40} concentrations. They were measured at the same time, lying prone, side by side, with the 9½ by 6 in. NaI (Tl) crystal just over the center of the thigh region. It was felt that in this way the crystal would be closest to a large muscle mass. A 1-hour measurement showed that if any Zn^{65} were present, the amount was less than about 6 $\mu\mu$c/kg.

The fact that small amounts of Zn^{65} appear in cattle should not be surprising. It is known that this radionuclide is absorbed with high efficiency from the gastrointestinal tract of cows (*6*); total urinary and fecal excretion in the first 4 days was about 25 percent. Measurements at this laboratory (*7*) of Zn^{65} retention in people after oral ingestion showed that most of the isotope is absorbed, and retention ranged from 50 to 80 percent (after correction for physical decay) several months after ingestion. In the case of the very heavy fallout in the Marshall Islands after the thermonuclear detonation of March 1954, Zn^{65} and Cs^{137} were found (*1*) in the Rongelap residents in roughly equal amounts (ranging up to 0.5 μc). Thus, large quantities of Zn^{65} can be produced in bomb tests, and its entry into cattle and people is to be expected. It will not be surprising if more extensive measurements now or in the near future reveal small amounts in people.

The National Bureau of Standards Handbook No. 69 (issued 5 June 1959) lists the maximum permissible body burden of Zn^{65} for occupational exposure as 60 μc. This is double the current value for the maximum permissible body burden of Cs^{137}. Since the whole body seems to be the critical organ for both radioisotopes, the amount of Zn^{65} appearing in foods is considerably less significant than current Cs^{137} levels.

Zinc-65 is known to appear in the milk of cows exposed to this radioisotope (*2*, *6*); however, we find its content in milk to be an order of magnitude or more below its content in meat. It should be noted that the milk samples were obtained from different places than the meat, which comes from the southwestern area (mainly Texas, Oklahoma, New Mexico, and Colorado). In addition, Zn^{65} production may not be well correlated with the formation of fission products, since the former is the result of neutron interaction with stable zinc in bomb parts or the surroundings, or both. Thus, it is possible that the milk received its radioactivity from fallout with a low Zn^{65}/Cs^{137} ratio, while the meat represents fallout with a high ratio. This point is being investigated further.

Radioactive cerium, ruthenium, and zirconium are abundantly produced in fission and are prominent in ordinary dust and dirt. Grazing animals ingest large amounts of them (*4*) as foliar contamination. It is reasonable to expect levels of these radionuclides in the tissues of grazing animals in proportion to their gastrointestinal absorption and body retention. Current work at this laboratory (*8*) indicates that absorption of Zr^{95} and Nb^{95} by rats is about 2 percent of the ingested dose. Absorption of Ce^{144} and Ru^{106}, however, is an order of magnitude less. Retention of absorbed zirconium and niobium is nearly 100 percent. The liver is a major organ of deposition. Expected levels in milk and people would be much reduced because of the large discrimination factors that exist at each step up the food chain.

As more radioactivity is introduced into the environment and more sensitive methods of measurement are developed, the detection of these and other intermediate- and long-lived radioisotopes in

Table 1. Approximate radioactivity of beef liver and hamburger (lean ground beef shoulder) obtained locally (Los Alamos).

Sample	Radioactivity ($\mu\mu$c/kg)			K (gm/kg)
	Zn^{65}	Zr^{95}	Cs^{137}	
Beef liver	50	30	180	2.8
Hamburger	30	<6	200	2.3

various foods, in animals, and in man may be expected. Their mere detection is not necessarily cause for alarm. The important point is to be able to measure their levels in the biosphere in order to assure the safe development and use of nuclear energy (*9*).

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Use of Long-Chain Polymers in Preparation of Soil Extracts for Soil Testing

Abstract. A method is described for the preparation of soil extracts for analysis which eliminates filtration. The procedure is based on the flocculating characteristics of very small amounts of polyacrylamides on inorganic and organic colloids. Amounts of plant nutrients extracted from soils by this method compare favorably with those obtained in filtered soil extracts.

The use of long-chain polymers (polyacrylamides) as flocculating agents in industrial processes has been described by Booth, Carpenter, and Hartjens (*1*) and by Linke and Booth (*2*). The application of this principle to soil-testing procedures appeared worthy of trial, in an effort to eliminate filtration in the preparation of soil extracts for the determination of inorganic nutrient elements available for plant growth.

Table 1. Comparison of results of analyses of soil extracts prepared by the method of the Pennsylvania Soil Testing Laboratory (PSTL) and by the new method (*5*).

Method	Item	P* (lb/acre)	K† (lb/acre)
PSTL	$\bar{X}$	11.3	162
New	$\bar{X}$	11.3	164
	t	0‡	1.050‡
	df	28	65
	r	.9958§	.9920§

*N = 30. †N = 67. ‡Not significant. §Significant at the .001 level.

Generally, extracts of soil samples are prepared by shaking the soil with an extracting solution or solvent, then filtering. A satisfactory extract is not always obtained by this method; filtering is often slow, and the resulting filtrate may be cloudy, thus interfering with subsequent analytical determinations.

Preliminary tests indicated that small amounts of commercially available long-chain polymers are highly effective in producing a clear supernatant extract of soils when the polymers are added to the usual extracting mediums. Under these conditions the flocculated soil samples would usually settle in 2 to 3 minutes, producing an extract superior to that obtained by filtration.

Tests with Superfloc 16 were good with soils high in clay, but a slight cloudiness resulted when the organic matter of the soil was high. Aerofloc 3171 gave the opposite results with these soils, but the use of equal amounts of the two polymers in the extracting solutions resulted in a highly satisfactory extract with both types of soils.

Numerous tests were made to determine the most satisfactory ratio of polymer to soil, and in general 0.5 mg to 5.0 gm of soil, or 1 part of polymer to 10,000 parts of soil, was found to give best results for routine work.

The procedure consisted first, of dissolving 0.25 gm of Superfloc 16 and an equal amount of Aerofloc 3171 in 500 ml of $0.753N$ sodium acetate solution adjusted to a *p*H of 4.8. The polymers dissolve in the acetate solution readily if they are mixed and slowly added to the acetate while it is being stirred by a mechanical stirrer. When all the polymers were dissolved, the solution was diluted to 1 lit. with the acetate. Then 416 ml of this solution was added to 20 lit. of $0.753N$ sodium acetate, and mixed. The resulting extracting solution was designated solution A and contained 0.25 mg of mixed polymers per 24 ml.

An additional solution was prepared by diluting 400 ml of the solution of mixed polymers to 800 ml with the $0.753N$ sodium acetate. This solution was designated solution B; 1 ml contained 0.25 mg of mixed polymers.

The soil extract was prepared by weighing or measuring 5 gm of a 20-mesh, air-dry soil sample into a 50-ml Erlenmeyer flask containing 24 ml of the extracting solution A. The flask was shaken gently in a mechanical shaker for 5 minutes, 1 ml of solution B was added, and shaking was continued for exactly 30 seconds. The flask was removed from the shaker and allowed to stand a few minutes before aliquots for analysis were taken with an automatic pipet; care was exercised not to disturb the soil sample in the bottom of the flask when the sample was taken.

The soil sample must always be added to the extracting solution—never the reverse.

When a cloudy extract was obtained in the procedure described above, 1 ml of solution B was added, and the mixture was shaken gently for a few seconds. A clear solution was usually obtained in this manner.

Extracts from a number of miscellaneous soils were prepared for analysis of phosphorus and potassium by the usual method in the Pennsylvania Soil Testing Laboratory and by the new polymer method. To increase the accuracy of the phosphorus determination, soil samples were weighed instead of measured. In all, 30 samples of soil with a phosphorus content ranging from 2 to 55 lb/acre were analyzed. A modified Deniges (*3*) procedure was used to develop color intensities, the colors being measured in a Bausch and Lomb No. 20 colorimeter, with matched tubes.

Potassium was determined in 67 soils containing from 30 to 325 lb of potassium per acre. The determination was carried out by means of a Perkin-Elmer flame photometer, with lithium chloride as an internal standard. The results are presented in Table 1, with appropriate statistical analysis.

The data included in Table 1 indicate that there is an extremely high correlation between the amounts of phosphorus and potassium found in the extracts prepared by these two procedures. Of particular interest is the fact that no phosphorus was occluded in the flocculated soil when the mixed polymers were added to the extracting solution. These results show that soil extracts prepared by this suggested procedure are as satisfactory for analysis as those prepared by filtering, and there are the added advantages that no filtering or refiltering is required, extracts are prepared more rapidly, and considerable cleaning of glassware is eliminated.

Tests were conducted with mixed polymers in distilled water, with normal neutral ammonium acetate, and with Bray's solution as extracting solutions, and satisfactory soil extracts were obtained, but no analyses of extracts were undertaken (*4*).

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