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AN EVALUATION OF THE RADIATION DOSE TO THE PUBLIC RESULTING FROM FMPC OPERATIONS AN ADDENDUM TO THE FEED MATERIALS PRODUCTION CENTER ENVIRONMENTAL MONITORING

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NLCO-1098 Addendum

Special

AN EVALUATION OF THE RADIATION DOSE TO THE PUBLIC RESULTING FROM FMPC OPERATIONS

An addendum to the

FEED MATERIALS PRODUCTION CENTER

ENVIRONMENTAL MONITORING ANNUAL REPORT

FOR 1972

Date of addendum: April 11, 1973

Based on the reasoning outlined below, it is concluded that radiation exposure to the public from activities at the FMPC during 1972 did not exceed one percent of AEC radiation protection standards.[1] Intakes of uranium from water, food, and air are considered as the only potential sources of exposure.

Water. Permissible intake for natural uranium in water, for persons living at the plant boundary, is 2×10^{-5} μCi/mℓ.[1] This limit applies to soluble or insoluble uranium.

The daily water intake for the ICRP standard man is 2200 mℓ/day.[2] Therefore, the total daily uranium intake permitted is 44,000 picocuries per day:

$$(2200 \text{ mℓ/day})\ (2 \times 10^{-5} \text{ μCi/mℓ}) = 4400 \times 10^{-5} \text{ μCi/day}$$
$$= 44{,}000 \text{ pCi/day}$$

Using the AECM-0524 definition of a curie of uranium, an intake of 44,000 pCi/day corresponds to 0.13 grams of uranium:

$$\frac{(44{,}000 \text{ pCi/day})\ (4.49 \text{ dpm/p Ci})}{1.5 \text{ dpm/μg}} = 1.3 \times 10^{5} \text{ μg U}$$
$$= 0.13 \text{ grams U}$$

As shown in Table 3 of this Report, the average concentration of uranium added to the Miami River was less than one microgram per liter (<0.001 mg/ℓ). If a boundary resident used water from the Miami River he would have a daily intake of less than 2.2 micrograms:

$$(<0.001 \text{ mg}/\ell)\ (2.2\ell) = <0.0022 \text{ mg U}$$

$$= <2.2 \text{ µg U}$$

This quantity of uranium is less than 0.001% of the permissible daily intake:

$$\frac{2.2 \text{ µg U (intake)}}{1.3 \times 10^5 \text{ µg U (permitted)}}\ (100\%) = <0.001\%$$

Food. If a local resident raises his own vegetables it is possible for those crops to contain some uranium from FMPC operations. The concentration of uranium normally present in vegetables is about 0.1 micrograms per gram of ash.(3) If we assume an ash content of 10% the uranium content on a wet basis would be 0.01 µg/g. Furthermore, assume that FMPC activities raise the concentration by tenfold, to 0.1 µg/g, and that a boundary resident consumes two pounds of such vegetables per day. His uranium intake would be 91 micrograms per day:

$$(0.1 \text{ µg U/g})\ (453.6 \text{ µg/lb})\ (2 \text{ lb/day}) = 91 \text{ µg U/day}$$

This amount of uranium is 0.007% of the intake permitted in drinking water:

$$\frac{91 \text{ µg}}{1.3 \times 10^5 \text{ µg}}\ (100\%) = 0.07\%$$

A less conservative estimate is obtained by considering the average daily intake of uranium. Based on analyses of basic foods, it has been estimated that the average person has a daily intake of <2 µg of uranium from all sources.(3) If we assume

that FMPC activities have caused a 100-fold increase due to soil contamination, our boundary resident would have a daily intake of 200 µg U from his home-grown vegetables. This amounts to 0.15% of the intake permitted from drinking water:

$$\frac{200\ \mu g}{1.3 \times 10^5\ \mu g}\ (100\%) = 0.15\%$$

Air. As shown in Table 1 of this Environmental Monitoring Report, the highest average concentration of uranium in air was at boundary sampling station No. 3. The average was 0.4% of the standard given in AECM-0524.

Maximum Potential Exposure. The total estimated maximum potential exposure to a local resident living just within the plant boundary is less than one percent of the AECM-0524 standards

Source	% of Standard
Water	<0.001%
Food	0.15
Air	0.4
	0.55

Maximum Dose To An Individual. Since the nearest resident to boundary station No. 3 lives about 1000 feet away, it is reasonable to expect that the resident's actual intake of uranium was less than the amount indicated by air samples from that

station. If he drank water from the river and ate the same vegetables described above, his exposure would be less than 0.55% of the relevant AECM-0524 dose standards.

Maximum Dose To A Population Group. In addition to providing limits for boundary residents, AECM-0524 also stipulates that the limits must be reduced by a factor of three when applied to a suitable sample of the exposed population. The community of Ross, Ohio, is located about 2.5 miles from the center of the FMPC production area. If these residents qualify as a suitable sample of the exposed population, their airborne uranium exposure limit should be one-third of the limit used in Table 1 of this report, or 0.7×10^{-14} µCi/mℓ. Boundary Station No. 2 is the nearest station to Ross. During 1972, the average airborne uranium concentration at this station was 0.6×10^{-12} µCi/mℓ. This is 0.86% of 0.7×10^{-14} µCi/mℓ. The actual concentration in Ross would have been much lower since the 2.5 miles between FMPC and Ross is about six times the distance from the production area center to the boundary sampling station. At this distance we conservatively assume a reduction to one-fourth of the boundary concentration, or 0.22% of the applicable limit.

Exposure due to uranium in home-grown foods would be less for these urban residents than for farm residents along the plant boundary. If we assume that a Ross resident buys about one-half

of his produce from the boundary resident, then we can assume an intake of 100 µg U per day. Since this group has a lower permissible intake, this quantity of uranium amounts to 0.23% of the standard:

$$\frac{100\ \mu g/day}{(1/3)(1.3 \times 10^5\ \mu g/day)}\ (100\%) = 0.23\%$$

This community is upstream on the Miami River from the FMPC outfall and there would be no contribution to their uranium intake from drinking water. Therefore, this groups' exposure would also be less than one percent of the applicable standard.

Source	% of Standard
Water	<0.001
Food	0.23
Air	0.22
	0.45

50-Mile Man-Rem Value. An estimated 2.5 million people live within a 50-mile radius of the FMPC. Airborne uranium is the only exposure source which might be of any importance for this group.

The whole-body exposure dose limit given for this group in AECM-0524 is 0.15 rems per year. In assessing whole-body exposures, the applicable limit for airborne uranium is 1×10^{-10} µCi/mℓ.[4] The average concentration found at the FMPC boundary,

calculated from data in Table 1 of this Report, was 0.67×10^{-14} µCi/mℓ. It appears reasonable, and conservative, to assume that the average concentration throughout the entire 50-mile radius would be no more than 1% of the boundary line concentration, or 0.67×10^{-16} µCi/mℓ. On this basis, the exposure within this 50-mile radius caused by airborne uranium from the FMPC would be less than 2 man-rem:

$$\frac{0.67 \times 10^{-16} \text{ µCi/mℓ}}{1 \times 10^{-10} \text{ µCi/mℓ}} (0.15 \text{ rem})(2.5 \times 10^{6} \text{ people}) = 1.7 \text{ man-rem}$$

Addendum References

(1) U. S. Atomic Energy Commission, AEC Manual Chapter 0524, Standards for Radiation Protection, February 4, 1969.

(2) ICRP Publication 6, Recommendations of the International Commission on Radiological Protection, 1964.

(3) G. A. Welford and R. Baird, Uranium Levels in Human Diet and Biological Materials, Health Physics 13: 1321 (1967).

(4) ICRP Publication 6, p. 45.