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DIFFERENTIAL ACCUMULATION OF I^{131} FROM LOCAL FALLOUT IN PEOPLE AND MILK*

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ABSTRACT

Marked differences in accumulation of I^{131} in milk and people were recorded along fallout trajectories with origins at the Nevada Test Site. Iodine-131 in milk was measured from 39 dairy farms situated in geographically and ecologically different areas of Utah, and in 28 persons residing on these farms. Total I^{131} intake during this incident, assuming consumption of 1 liter of milk per day, ranged from 0 to 800,000 picocuries. Total body and thyroid burdens of people from farms parallelled levels in milk produced on their farms. Accumulation in milk was correlated with feeding practices, and highest levels occurred on farms at high altitudes. Highest accumulation was found in milk and people from farms where cattle were fed green chop alfalfa or were grazing on wet meadows. Little I^{131} appeared in the milk of cattle fed uncontaminated feed which had been stored prior to the arrival of fallout.

*This study was supported by funds from the Division of Radiological Health, Bureau of State Services, U. S. Public Health Service (RH-30).

Appreciable fallout was carried into Utah following the 100 kiloton "Sedan shot" at the Nevada test site on 6 July 1962. As a result, easily measurable activities of I^{131} appeared in milk and people. This was not the first time Utah has been contaminated with local fallout--that from Nevada tests in 1952, 1953 and 1957 was probably more severe--nor is this likely to be the last time, since the direction of the prevailing wind and relatively sparse population make this state a favored target for off-site fallout (1,2). Unlike previous contaminating events, suitable equipment for evaluation of the contamination was available, and a state-wide radiological ecology study was in progress.

Discovery of the incident was accidental. On 7 July 1962, the day following the Sedan shot, one of us (R.C.P.) had taken a group of students about 20 miles south east of Salt Lake City to measure the background radiation near various rock formations. A large dusty cloud was observed approaching, but this in itself is not an unusual event during the hot Utah summer. However, when the cloud first arrived, radiation levels rose to 2 milliroentgens per hour, or about 100 times higher than the normal background for this area.

After learning from the Utah State Department of Health that the gross beta activity in the air had reached 900 pc/cubic meter on 8 July, special milk samples were collected from several farms on 12 and 13 July. When analyzed on 15 July, I^{131} levels in excess of 2000 picocuries per liter (pc/$\underline{l}$) were discovered. On Monday, 16 July, we notified the Utah State Department of Health of this situation and suggested that highly contaminated milk be diverted to the production of cheese, powdered milk or condensed milk to reduce unnecessary exposure of the population. At the time of notification approximately 5% of the total I^{131} intake resulting from the July tests had been consumed. At the request of Dr. Grant S. Winn, Utah State Department of Health, we then began sampling milk from all of our stations to help delineate the extent and degree of contamination by I^{131}.

MEASUREMENT OF I^{131}

MILK. Rapid evaluation was possible because we had previously established a network of individual milk producers in a research study of the ecological factors affecting Cs^{137} uptake in milk and man. The

(Fig. 1) station number and location of each of these farms is shown in Fig. 1.

Raw whole milk was placed in a pair of 1 gallon plastic bottles and counted next to an 8 inch by 4 inch NaI (Tl) detector connected to a 400 channel pulse height analyzer. I^{131} was identified by its 0.364 Mev γ-ray. Appropriate correction was made for the scatter of γ-rays from other emitters. The standard was a calibrated quantity of I^{131} diluted in a gallon of distilled water. The accuracy (S.D.) of a measurement was about ±10% or ±20 pc I^{131}/liter, whichever was larger. All milk I^{131} measurements were corrected back to the day of sampling.

THYROID COUNTING. During 1-6 August 1962, I^{131} in the thyroid

(Fig. 2) gland of humans was measured as shown in Fig. 2. The standard was an Abbott Laboratory I^{131} radiocap placed in the thyroid position of a sugar filled phantom. The accuracy for a 20 minute thyroid count was about ±20% or ±150 pc I^{131}, whichever was larger.

TOTAL BODY COUNTING. During 20-31 August 1962, I^{131} in the total body was determined by measuring people inside an iron room in an

(Fig. 3) Argonne chair position (3) as shown in Fig. 3. The γ-ray spectrum

(Fig. 4) of an 11 year old child is shown in Fig. 4. Accuracy for a 40 minute total body count was about ±30% or ±400 pc I^{131} whichever was larger.

RESULTS

I^{131} IN MILK. The buildup and subsequent decrease of I^{131} in

(Fig. 5) milk taken from several individual farms is shown in Fig. 5. Because of the limited data available during the buildup period, we assumed that the concentrations of I^{131} in milk increased linearly from negligible values on 11 July to their peak values on 20 July. In equation form:

$$C_1 = C_p \quad 0.111 \text{ day}^{-1} \quad t_1 \qquad (1$$

where C_1 = I^{131} concentration during buildup phase
C_p = peak I^{131} concentration on 20 July 1962
t_1 = time after 11 July 1962

As will be shown later, a moderate error in Eq. 1 will cause only a small error in computing total I^{131} intake.

After 20 July 1962, the concentration of I^{131} in milk was evaluated serially for 7 separate stations. The concentrations (as of the dates of collection) decreased exponentially with effective half-periods ranging from 3.8 to 9.8 days and averaging 5.8 days. Thus, after 20 July the concentration of I^{131} in milk could be expressed as:

$$C_2 = C_p e^{-(0.12\ \text{day}^{-1})\ t_2} \qquad (2$$

where C_2 = I^{131} concentration during decreasing phase

C_p = peak I^{131} concentration on 20 July 1962

t_2 = time after 20 July 1962

The daily intake of I^{131} was obtained by multiplying Eqs. 1 and 2 by the volume of milk consumed per day. The total I^{131} intake was found by integrating the daily intake over the buildup and decreasing phases and is:

$$\text{Total } I^{131} \text{ intake} = 12.8\ V\ C_p \qquad (3$$

where V = volume of milk consumed per day.

C_p = peak I^{131} concentration in milk.

About 1/3 of the calculated total intake occurred during the buildup phase and 2/3, during the decreasing phase. Thus a 30% error in the assumed buildup (Eq. 1) would produce an error of only 10% in the total intake.

Total I^{131} intakes resulting from the consumption of 1 liter of milk per day were computed for each of the stations shown in Fig. 1 as follows: First, for each measured milk sample the corresponding peak concentration on 20 July 1962 was computed by rearranging Eqs. 1 or 2. Second, the computed peak concentrations were averaged for each station. Third, the total I^{131} intake was calculated using Eq. 3. Results are

(Table 1) shown in Table 1.

Total intakes (for 1 liter milk/day) ranged up to 800,000 pc I^{131}, and for our stations averaged 58,000 pc I^{131}. However, our average may not equal the average population intake since our stations comprise only a small fraction of the Utah milk producers. An average total intake of 37,000 pc I^{131} from 1 September 1961 to 31 August 1962 for the Salt Lake City "milk pool" has been reported (4). However, individual exposures may be greater or less than the "pool average," depending on which dairy or producer supplies the individual. Our measurements of milk from local dairies gave a total intake of about 117,000 pc I^{131} for consumers drinking 1 liter of milk per day from one of the major dairies serving the Salt Lake Area, while for another major dairy, the total intake was only 3,400 pc I^{131}. It is evident that a considerable fraction of Utah residents exceeded the current yearly radiation protection guide of 36,500 pc I^{131} for the general population.

I^{131} IN PEOPLE. The I^{131} in humans determined by thyroid counting

(Table 2) and total body counting is listed in Table 2. In the last column the percent uptake of I^{131} has been calculated as a ratio of that measured in the body to that computed for 100% uptake from milk. The daily milk intakes were corrected from the day of consumption to the day of human counting for radioactive decay and biological elimination assuming a 7.6 day effective half-time for I^{131} in man (5). Appropriate transformation and integration of Eq. 1 and Eq. 2 give a computed retention for 100% uptake of I^{131} in milk of:

$$R = V C_p \left\{ \frac{a}{\lambda^2} \left[\lambda T_1 - 1 + e^{-\lambda T_1} \right] + \frac{1}{\lambda - b} \left[e^{(\lambda - b) T_2} - 1 \right] \right\} e^{-\lambda T_2} \quad (4$$

where R = computed I^{131} retention for 100% uptake from milk
V = volume of milk consumed per day
C_p = peak concentration of I^{131} in milk on 20 July 1962
a = coefficient of buildup curve = 0.111 day^{-1}
b = reduction constant of I^{131} in milk = 0.120 day-1
λ = reduction constant of I^{131} in man = 0.091 day-1
T_1 = time of buildup phase = 9 days
T_2 = time from 20 July 1962 to human counting

The fact that our average uptake of 17% is less than the commonly accepted value of 30% (5) is not surprising in view of the limitations in our methods such as unreliability of values reported by individuals for daily volume consumption of milk. However, our average uptake of 17% agrees well with the value of 20% obtained by integrating (over constant continuous exposure) Lushbaugh's single intake retention equation based on 26 normal subjects, most of whom were adults (6).

The cumulative dose to M gm of thyroid tissue resulting from the intake of A μc I^{131} of which a fraction U is taken up in the thyroid gland and retained with an effective half-time of T days has been given (7) as:

$$\text{Thyroid Dose} = 15 \frac{A\,U\,T}{M} \text{ rad} \quad (5$$

Young children 0-2 years old are regarded as most susceptible to I^{131} radiation damage because of (a) the small size of a child's thyroid, (b) its presumed greater sensitivity to irradiation at this stage, and (c) the long post-irradiation life span during which delayed effects could appear.

Using Eq. 5, the dose to the 2 gm thyroid of a child consuming 1 liter of milk per day from our station number 60, with a total intake of 800,000 pc I^{131} (0.8 μc), assuming a thyroidal uptake of 30% (5) and an effective retention half-time of 7.6 days, the thyroid dose is 14 rad.

Such doses might be of little concern except for the number of children involved. Extrapolating the 1950 and 1960 U. S. Census values, there were about 53,000 children between 0 and 2 years old in Utah in 1962. For adults whose thyroids weigh 20 grams, the dose would be about 10 times smaller than that of young children. The total population of Utah is presently slightly under 1,000,000 adults and children.

PREVIOUS INCIDENTS: Unfortunately, milk was not evaluated for I^{131} during the tests prior to 1962. Nevertheless, one can make an admittedly very crude estimate of the thyroid doses resulting from several previous tests for which gross beta concentrations in air were measured. Average air concentrations in picocuries per cubic meter for the 24-hour period in which levels from each shot peaked, were computed from data taken from Dunning (8) or kindly furnished by the Utah State Department of Health. To allow for different times of assay, concentrations were corrected from the time of beta assay to a common reference time of 1 day after detonation assuming a $(\text{time})^{-1.2}$ variation in activity. Time of assay of the Ogden air samples (8) (not given) was assumed to be 1 day. Concentrations in the St. George samples (8) were assumed to have been corrected back to the mid-times of collection. Each 1-day value for the 5 tests in July 1962 was summed because all 5 probably contributed to the I^{131} we measured in milk. Infant thyroid dosage was assumed proportional to air concentration and was normalized to the 1962 data (3400 pc beta/m^3 → 58,000 pc I^{131} intake →

1.0 rad to infant thyroid). The numbers of exposed children under 2 years of age were computed from 1950 and 1960 U. S. census values.

TABLE 3

FALLOUT IN UTAH FROM SEVERAL NEVADA TESTS

Explosion Dates	24-hr Av. Air Beta Concen.	Est. Av. Infant Thyroid Dose	Exposed Children Under 2 yrs	Air Sampler Location
7 May 52	20,000 pc/m^3	6 rad	41,000	Ogden, Utah
19 May 53	287,000	84	700	St. George
15 Jul 57	2,900	0.9	47,000	Salt Lake City
18 Aug 57	3,200	0.9	47,000	Salt Lake City
16 Sep 57	8,600	2.5	47,000	Salt Lake City
July 1962	3,400	1.0	53,000	Salt Lake City

A major limitation in these estimates of average infant thyroid dose is the uncertainty in how well a single air monitoring station can sample a fallout aerosol. It is probable that other heavy fallout trajectories have crossed the state undetected. An additional uncertainty in the St. George exposure is how local dairy practices there may have differed from those throughout the rest of Utah. Additional refinements in dose calculations should be made using data unavailable to us.

While these estimates are approximate, they indicate that significant exposures have occurred in the past and that studies for possible delayed effects might be indicated, especially in the St. George area. If the 1962 incident was typical, individual exposures may have been considerably higher than the averages given.

ECOLOGICAL FACTORS: The network of individual milk producers we were sampling at the onset of this incident had been established to study the effect of different ecological factors on the accumulation of Cs^{137} and Sr^{90} in milk. Consequently, sampling stations were chosen to contrast the effects of different feeding practices, altitudes, soils, presence or absence of grazing, quality of grazing, presence or absence of standing water in grazing lands, crop types, geographic location, rainfall, topography, etc. Stations were grouped in widely scattered areas, and replicates of as many different ecological types as possible were selected. Paired or grouped stations in the same geographic area were thus available for analysis during the iodine incident. Effects of ecological factors on I^{131} intake are shown in Table 4.

(Table 4) Geographic location relative to the fallout areas was, of course, the dominant factor, and higher altitudes (stations 9, 10; 31, 32; 51, 52; 59, 60) showed highest accumulation both inside and to the edges of the fallout pattern.

Feeding practices and the condition of grazing lands affected the accumulation of I^{131} in all areas. The effect of feeding crops grown in 1961 is especially well defined, but is in apparent contradiction to the results obtained by Thompson, et al (4) who showed no reduction in I^{131} levels as a result of shifting cattle to dry feed. Unfortunately, many of the producers (station 31 is a good example) took the cattle off grazing and fed alfalfa hay which was either still growing at the time of contamination or lying in the fields to dry. This hay was often more contaminated than the grass in the meadows.

Feeding of green chop alfalfa resulted in higher accumulation of I^{131} in all cases, (Stations 47-48, 57-58, 63-64, 70-71, 73-75). This practice had the greatest effect on the accumulation of I^{131} of all the factors other than location relative to the fallout pattern. Grazing poor or wet meadows was also indicated as a factor leading to accentuated levels.

Stations 1 and 2 show total intake values which suggest an exception to the effect of wet grazing on I^{131} content of milk. Feeding records, however, show that at the onset of contamination, station 1 was feeding hay from the 1961 crop, and station 2 was feeding hay produced in 1961 and grazing on an improved, but wet meadow. At this time (July 12), station 1 assayed 40 pc I^{131}/1, and station 2 had 100 pc I^{131}/1. On July 26 this situation had been reversed, and milk from station 1 contained 304 pc/1, while station 2 assayed below detectable limits. Between these sampling periods station 1 started feeding first crop alfalfa which had been in the field drying when contamination took place, while station 2 had removed the cattle from grazing and had not started to use hay produced in 1962.

Station 39, situated near stations 40 and 41 at about the same altitude, and near stations 51 and 52, all of which showed some accumulation of I^{131}, did not reach detectable limits. This station is situated in the lee side of the Tushar mountains in a valley separated from the northern valleys by a mountain barrier, and may not have been contaminated.

Effects of rainfall were not strongly apparent. Most of the heavily contaminated areas had no rainfall during the time the aerosol clouds were passing over them.

There is ample evidence to show that shifting dairy animals to uncontaminated feeds will result in greatly reduced intake of I^{131}, and that feeding practices can be modified to ameliorate accumulation of I^{131} in the human population.

~~Ecological~~ variation caused differences in total intake values ranging from 2 to 450 fold. It is obvious that evaluation of hazards from local fallout should be made on the basis of local, intensive monitoring of milk and people, rather than on fission yield, aerosol trajectories, or estimates based on air monitoring.

DISCUSSION

The Nevada tests responsible for the July 1962 I^{131} fallout in Utah (2)
(Table 5) are listed in Table 5. Because fallout was carried into Utah from all of them, it is difficult to determine exactly what fraction of the total contribution was made by each shot, although peak gross beta activities in air samples at Salt Lake City of 900 pc/cubic meter on 8 July 1962 and 450 pc/cubic meter on 16 July 1962 (4) strongly implicate the 6 July "Sedan" and 14 July "Small Boy" shots. The main trajectories of the other July shots appear to have gone west of Salt Lake City (2), although their contributions cannot be discounted completely. As Kelly has pointed out (9) the Sedan shot was not connected with weapons testing for national defense, but was used to investigate the use of nuclear explosives in excavations.

After 1 August 1962, the Utah State Department of Health recommended that milk producers in some of the high fallout areas (a) transfer their cows from contaminated pastures to stored feed which, presumably, contained less I^{131}, and (b) divert highly contaminated milk to milk product plants to insure a suitable decay period prior to consumption(4). Unfortunately, these measures reduced the exposure to the population only slightly because: (a) protective recommendations were delayed until over 80% of the potential I^{131} intake from this incident had been consumed and (b) as far as we can determine in questioning dairy farmers, relatively few changed to stored feed for more than 1-2 days, and their statements are supported by the lack of an abrupt drop of I^{131} in milk after the recommendations were announced. Many shifted from grazing to contaminated dry hay.

In defense of the delay in action by the State Department of Health, we wish to emphasize the fact that there was no precedent for similar control action in the United States, and there were considerable pressures from official and unofficial sources against taking action to reduce the exposure to the population. The nature of this opposition is illustrated by the statement of policy made by the Chairman of the Federal Radiation Council, ". . . The Federal Radiation Council does not recommend such actions under present circumstances."...(10).

For Utah, "present circumstances" include an increasing number of nuclear test explosions of increasing size, and a good prospect for numerous repetitions of the contamination levels under study. Fortunately, the 1962 Utah incident resulted in fairly light exposures to a relatively small population, but the same good luck cannot be guaranteed in future incidents. Perhaps the Federal Radiation Council may modify its policy (10) and recognize that "present circumstances" justify reduction of unnecessary radiation exposure. We believe that preservation of the freedom of our country necessitates continued weapons testing. However, we also believe that nearby populations should be protected from undue exposures resulting from these tests, and that there is no justification for over-exposure of the public by those tests not essential for national defense.

PROTECTION OF THE PUBLIC

Simple guidelines are essential for prompt effective action at the local level, and with a short-lived emitter such as I^{131}, the action must be prompt to be effective. Several measures can be taken to protect the public from I^{131} overexposure during essential weapons testing:

(a) Test large yield devices outside of the continental United States, i.e. in the Pacific.

(b) Schedule shots for late autumn or winter to prevent heavy contamination of growing plants.

(c) Improve prediction of fallout trajectories before detonation.

(d) Report explosion time, weapon size, and fallout trajectory to health departments and research organizations so that corrective action if necessary can be effective.

(e) Increase monitoring of milk for I^{131} when the gross beta activity in the air exceeds 100 pc/m^3.

(f) Divert milk containing over 1000 pc I^{131}/liter from the fluid market to the manufacture of cheese and other long shelf-life products.

(g) Recommend powdered or canned milk for infants and pregnant women until I^{131} in fresh milk returns to acceptable levels.

(h) Use uncontaminated stored feed to hasten the reduction of I^{131} in milk to acceptable levels.

Equation 3 indicates that for this incident, consumption of 1 liter of milk per day with a peak concentration of 1000 pc I^{131}/liter, caused a total I^{131} intake of roughly 1/3 of the current yearly radiation protection guide of 36,500 pc I^{131}. Thus, diversion of milk containing over 1000 pc I^{131}/liter from the fluid market should prevent the general population from exceeding I^{131} radiation protection guides, provided that not too many similar incidents occur within the year.

CONCLUSION

Our measurements of I^{131} in milk and people are less complete than desired because there was no advance warning. In particular, more data during the buildup phase are needed. There is, however, ample evidence that present methods for assessing hazards from local fallout are misleading. We suggest that monitoring by the "pooled sample" be supplemented with samples taken from individual tanker trucks.* Such sampling would not only show contamination build-up more rapidly, but would make application of control measures more effective with less economic loss to producers and distributors.

The striking differences in accumulation of I^{131} in milk produced on farms geographically close together indicate ecological factors have a strong influence on the rate of entry of iodine into the biosphere, and the marked influence of feeding practices shows that control measures we propose which are based upon changing such practices can be effective. The wide amplitude of variation engendered by ecological factors (450 fold) supports the proposal for increased monitoring designed to discover the maximum range as well as mean values.

We believe that prevention of unnecessary exposures from whatever source is a sound principle, and firmly support the Utah State Department

*Monitoring of tanker trucks was done with a portable γ-ray spectrometer in cooperation with several dairies. After orders to divert milk from contaminated areas had been given, several tankers laden with highly contaminated milk (> 5,000 pc/ℓ) arrived at the dairies. This milk was sent to cheese and powdered milk plants at considerable cost to the dairies.

of Health in its decision to apply controls. We further believe that this action will have to be taken by others similarly responsible for the health of the public.

ACKNOWLEDGEMENTS

Detection equipment was made available by the AEC supported Radiobiology Division, Anatomy Department, University of Utah. We appreciate services and support from Lionel M. West, Richard C. Straight, student assistants; University of Utah Isotopes Committee (Henry Eyring, Chairman); and Tracerlab Co. which loaned both the portable γ-ray spectrometer and the services of an engineer, Mr. Vern Roberts, to train us in its use. The splendid cooperation of milk producers and distributors is appreciated.

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TABLE I

TOTAL I^{131} INTAKE
OF PERSONS DRINKING 1 LITER MILK/DAY
FROM STATIONS SHOWN IN FIG. 1

STATION	pc I
1	6,100
2	5,300
4	17,000
5	500
9	130,000
10	66,000
19	28,000
31	150,000
32	130,000
33	0
34	4,400
35	7,600
37	600
39	0
40	300
41	8,400
45	0
46	200
47	2,000
48	0
51	9,200
52	6,600
53	1,500
54	4,700
56	71,000
57	390,000
58	13,000
59	236,000
60	800,000
61	0
63	128,000
64	500
66	0
70	30
71	14,000
73	6,000
74	1,200
75	12,000
76	11,000
Average	58,000

TABLE 2

I^{131} IN UTAH DAIRY FAMILIES MEASURED BY THYROID COUNTING AND TOTAL BODY COUNTING*

Person	Sex	Age	Liters Milk/Day	Day Counted	pc I^{131}	% Uptake
9-a	M	19	3.0	1 Aug 62	11,000	8
9-a				22 Aug 62	2,900	8*
9-b	F	11	0.7	1 Aug 62	6,300	19
10-a	F	7	0.7	2 Aug 62	4,100	26
10-b	M	5	1.1	2 Aug 62	4,200	17
10-c	M	30	2.1	2 Aug 62	7,600	16
10-d	F	26	0.5	24 Aug 62	760	28*
31-a	F	11	0.8	1 Aug 62	7,800	19
31-a				24 Aug 62	2,200	23*
31-b	F	8	0.8	1 Aug 62	10,200	24
31-b				24 Aug 62	1,800	19*
31-c	F	4	0.5	1 Aug 62	4,000	15
31-d	M	35	1.0	1 Aug 62	3,600	7
32-a	M	10	1.5	6 Aug 62	4,900	9
32-b	F	14	4.0	6 Aug 62	7,300	5
32-b				22 Aug 62	3,600	7*
32-c	F	13	1.7	6 Aug 62	4,200	7
32-d	M	41	1.7	6 Aug 62	3,700	6
32-e	M	9	1.7	6 Aug 62	4,100	6
32-f	F	45	1.0	22 Aug 62	710	5*
57-a	M	61	1.0	25 Aug 62	2,800	9*
57-b	F	49	1.0	25 Aug 62	3,000	10*
59-a	M	48	0.5	25 Aug 62	4,200	46*
59-b	F	13	0.7	25 Aug 62	2,200	18*
60-a	M	27	2.0	31 Aug 62	10,900	14*
60-b	F	16	1.0	31 Aug 62	8,700	23*
63-a	F	41	1.0	29 Aug 62	2,400	34*
63-b	M	42	1.0	29 Aug 62	3,400	47*
Average						17

*Starred numbers represent whole-body counts.

Footnote to Table 4

The following farming terms are explained:

DRY, IRRIGATED: The normal condition of crop production in this desert area. Irrigation is by rill, overhead sprinklers or flooding for short periods.

IMPROVED GRASS PASTURE: Fields planted to selected grasses and maintained by regular fertilization, etc.

WET MEADOWS: Sub-irrigated (either natural or artificial) areas in which the water table is essentially at the surface, and root systems are generally shallow (< 1 foot).

PARTIALLY FLOODED: These areas have sections that are either permanently flooded or flooded most of the year. The major vegetation is sedges and wet-land grasses.

NATURAL PASTURE: Areas used for grazing, but having only the native vegetation, weeds or successional plant types that appear by natural seeding. Fertilization is rarely practiced, and is limited to return of animal manures.

GREEN CHOP: Alfalfa cut at about 8 - 10 inches and fed wet.

TABLE 4

ECOLOGICAL FACTORS AFFECTING I^{131} ACCUMULATION IN MILK

Station Number	Nearest city or town	Total Intake pc I^{131}	Feeding Practices and Crop Production Year	Ecological Conditions	Altitude ft above M.S.L.
1	Draper	6,100	Dry feed (1961 and 1962)	Dry, irrigated	4,505
2	Draper	5,300	Dry feed (1961) and grazing	Wet, improved grass pasture	4,505
4	Magna	17,000	Dry feed (1962) and grazing	Dry, poor pasture	4,461
5	Woods Cross	500	Dry feed (1961)	Dry, irrigated	4,292
9	Snyderville	130,000	Wet grazing only	Natural wet meadows partially flooded	6,550
10	Snyderville	66,000	Dry feed (1961) and limited dry grazing	Dry, irrigated	6,550
31	Oakley	150,000	Dry feed (1962) dry grazing	Improved drained grass pasture	6,517
32	Kamas	130,000	Wet grazing and dry grazing	Natural, flooded pasture and dry natural pasture	6,475
33	Ephraim	0	Dry feed (1961)	Dry, irrigated	5,514
34	Chester	4,400	Wet grazing	Natural, partially flooded pasture	5,460
35	Milburn	7,600	Wet grazing	Improved wet grass pasture	6,252
39	Marysvale	0	Wet grazing	Natural, partially flooded pasture	5,866
40	Monroe	300	Dry feed (1961)	Dry, irrigated	5,375
41	Beaver	8,400	Dry feed (1961) and wet grazing	Wet, improved grass pasture	5,970
45	Cedar City	0	Dry feed (1961)	Dry, irrigated	5,834
46	Cedar City	200	Dry feed (1961)	Dry, irrigated	5,834
47	St. George	2,000	Dry feed (1961) green chop	Dry, irrigated	2,760
48	St. George	0	Dry feed (1961) limited dry grazing	Improved grass pasture	2,760
51	Bicknell	9,200	Dry feed (1961) wet grazing	Dry, irrigated and natural, partially flooded pasture	7,125
52	Loa	6,600	Dry feed (1962)	Dry, irrigated	7,000

Continued on next page

TABLE 4 (continued)

ECOLOGICAL FACTORS AFFECTING I^{131} ACCUMULATION IN MILK

Station Number	Nearest city or town	Total Intake pc I^{131}	Feeding Practices and Crop Production Year	Ecological Conditions	Altitude ft above M.S.L.
53	Orangeville	1,500	Dry feed (1962)	Dry, irrigated	5,772
54	Ferron	4,700	Dry feed (1962) limited wet grazing	Dry, irrigated and pasture	5,970
56	Huntington	71,000	Dry feed (1962) wet salt grass grazing	Dry, irrigated and wet natural salt grass meadow	5,791
57	Bridgeland	390,000	Dry feed (1962) green chop	Dry, irrigated	5,297
58	Duchesne	13,000	Dry feed (1961 and 1962)	Dry, irrigated	5,504
59	Altonah	236,000	Dry feed (1962) dry grazing	Dry, irrigated and dry, improved grass	7,075
60	Altonah	800,000	Dry feed (1962) wet grazing	Dry, irrigated and flooded natural wet grazing	7,075
63	Wellington	128,000	Dry feed (1961 and 1962) green chop	Dry, irrigated	5,415
64	Wellington	500	Dry feed (1961)	Dry, irrigated	5,415
70	Mendon	40	Dry feed (1961)	Dry, irrigated	4,434
71	Cornish	14,000	Dry feed (1961) green chop	Dry, irrigated	4,482
73	Amalga	6,000	Dry feed (1961) wet meadow grazing	Dry, irrigated and partially flooded pasture	4,425
75	Lewiston	12,000	Dry feed (1961) green chop	Dry, irrigated	4,490
74	Cove	1,200	Dry feed (1961) dry meadow grazing	Dry, irrigated and dry, improved grass pasture	4,632
76	Hyrum	11,000	Dry feed (1961) wet grazing	Dry, irrigated and natural partially flooded pasture	4,706

TABLE 5

JULY 1962 NEVADA TESTS CAUSING I^{131} FALLOUT IN UTAH

Date	Name	Type	Kiloton Yield
6 July 62	SEDAN	635 ft underground	100 kt
7 July 62	LITTLE FELLER II	slightly above ground	Less than 20 kt
11 July 62	JOHNNIE BOY	shallow underground	Less than 20 kt
14 July 62	SMALL BOY	few ft above ground	Less than 20 kt
17 July 62	LITTLE FELLER I	slightly above ground	Less than 20 kt

FIGURE CAPTIONS

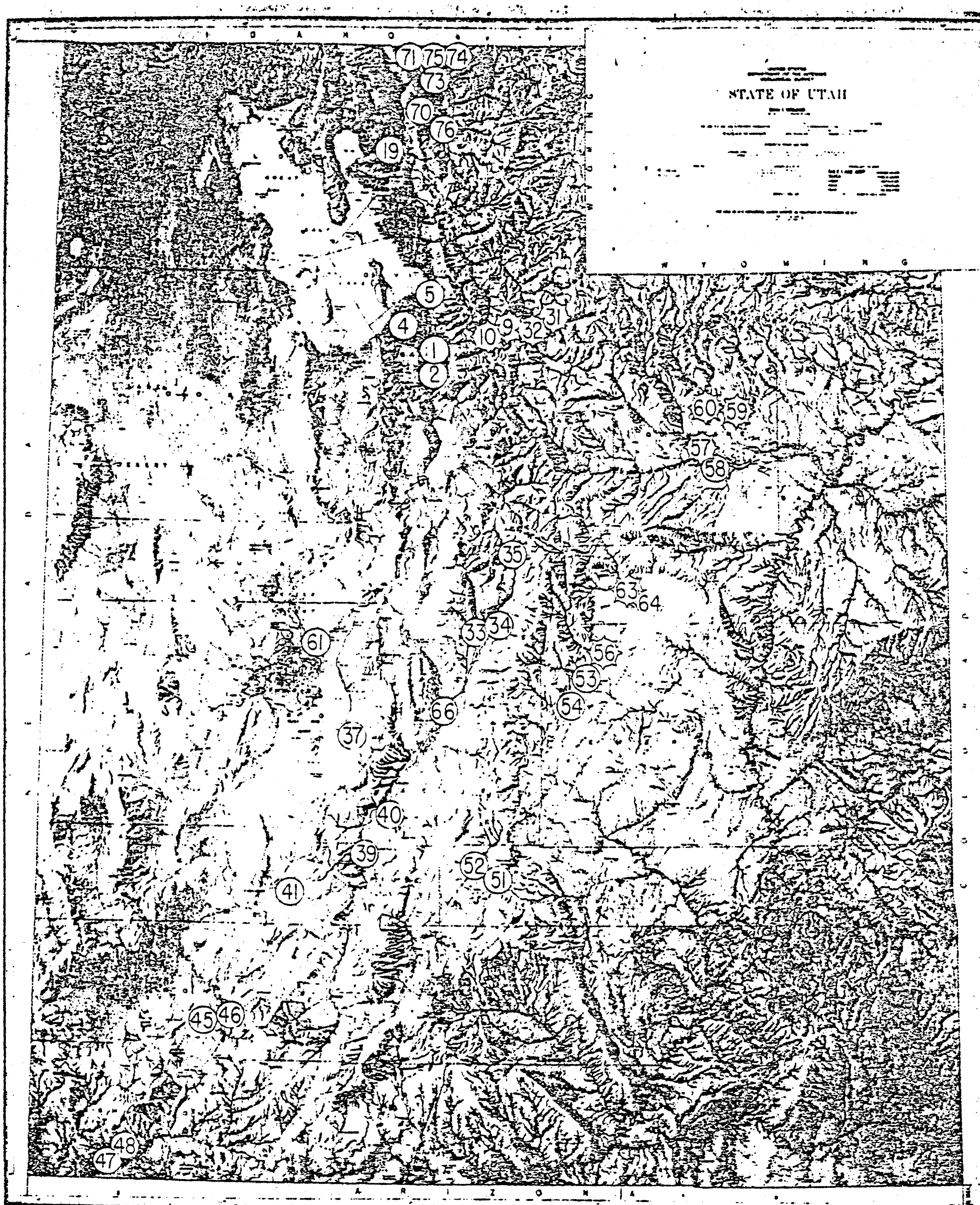
Fig. 1 Map of Utah showing locations and station numbers of milk producers. The yearly radiation protection guide of 36,500 pc I^{131} was exceeded by persons drinking 1 liter of milk per day from the stations marked with stars.

Fig. 2 Human positioning for thyroid counting.

Fig. 3 Human positioning for total body counting. The center of the crystal face is 50 cm from the seat and back of the chair.

Fig. 4 Total body γ-ray spectrum of an 11 year old girl. I^{131} was still prominent although over 4 half-periods of I^{131} had elapsed since its concentration in milk had reached its peak.

Fig. 5 Buildup and subsequent decrease of I^{131} in milk. Concentrations are relative to their peak values which we observed on 20 July 1962. The numbers designate the farms from which the samples were taken (see Fig. 1).


STATE OF UTAH
W Y O M I N G
A R I Z O N A
71 75 74
73
70
76
19
5
4
1
2
10
9
32
31
60
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58
35
63
64
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52
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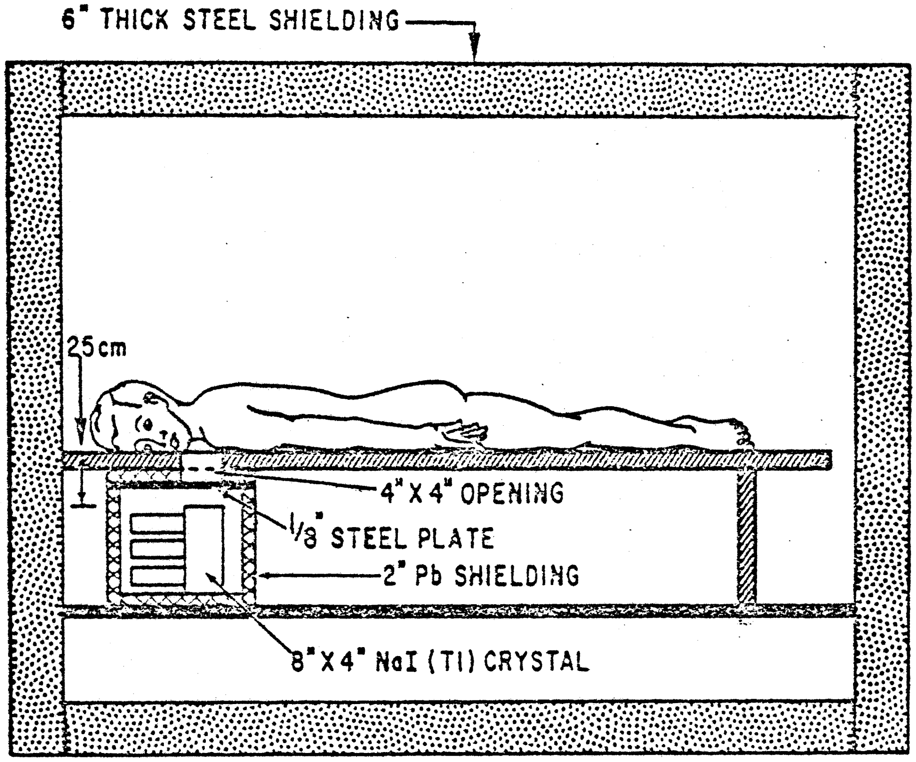
48
47

FIGURE 1



SUBJECT POSITIONING FOR HUMAN THYROID COUNTING

FIGURE 2

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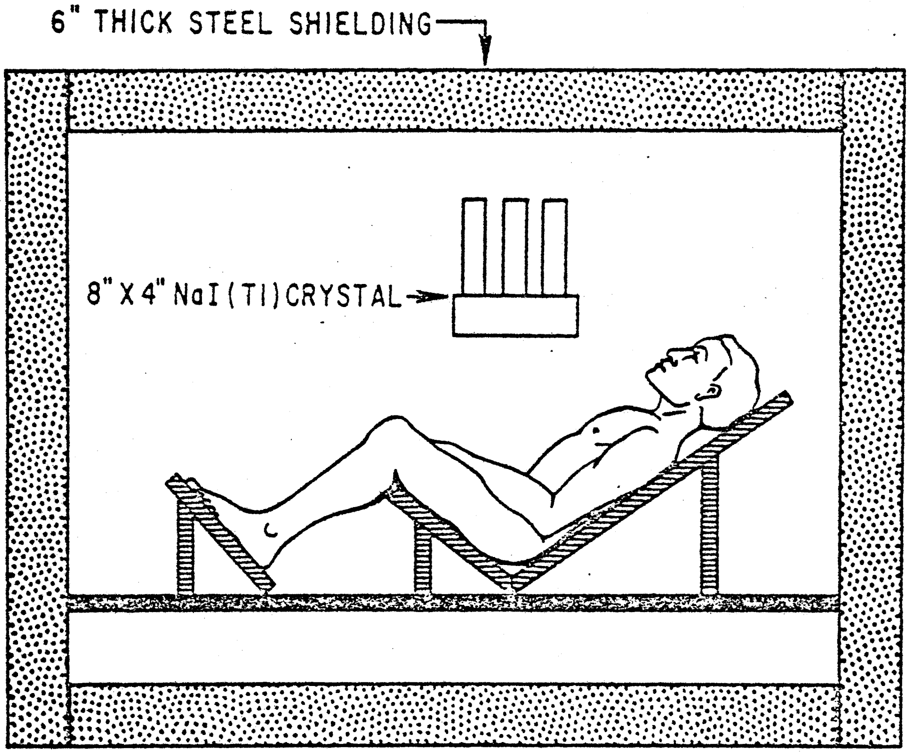

SUBJECT POSITION DURING HUMAN TOTAL BODY COUNTING

FIGURE 3

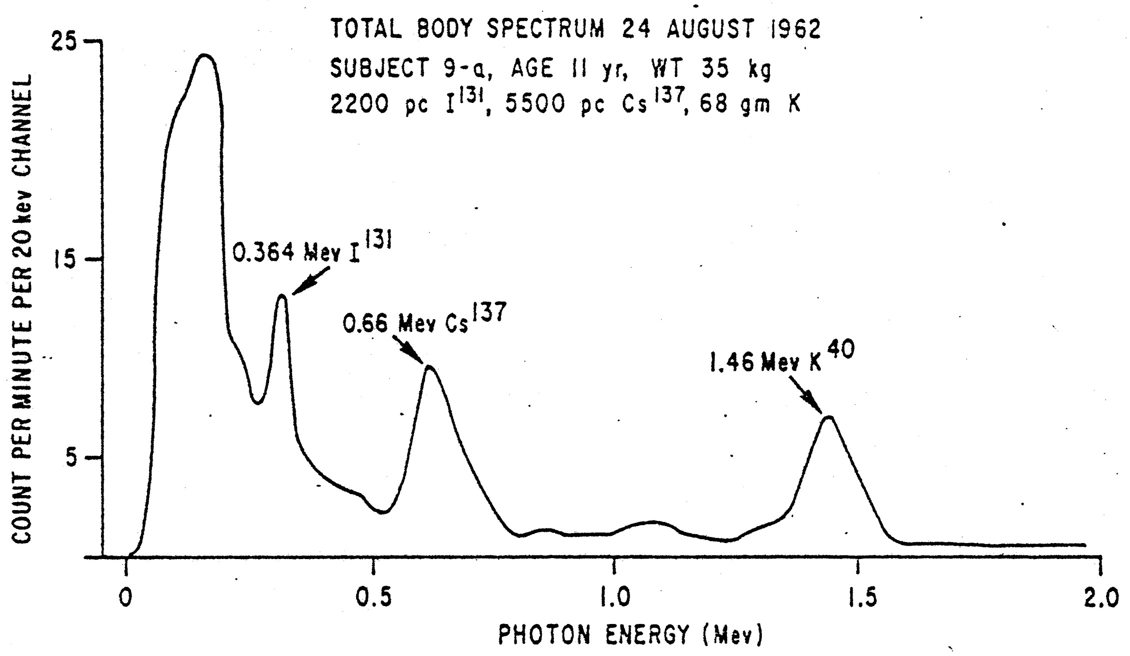

FIGURE 4

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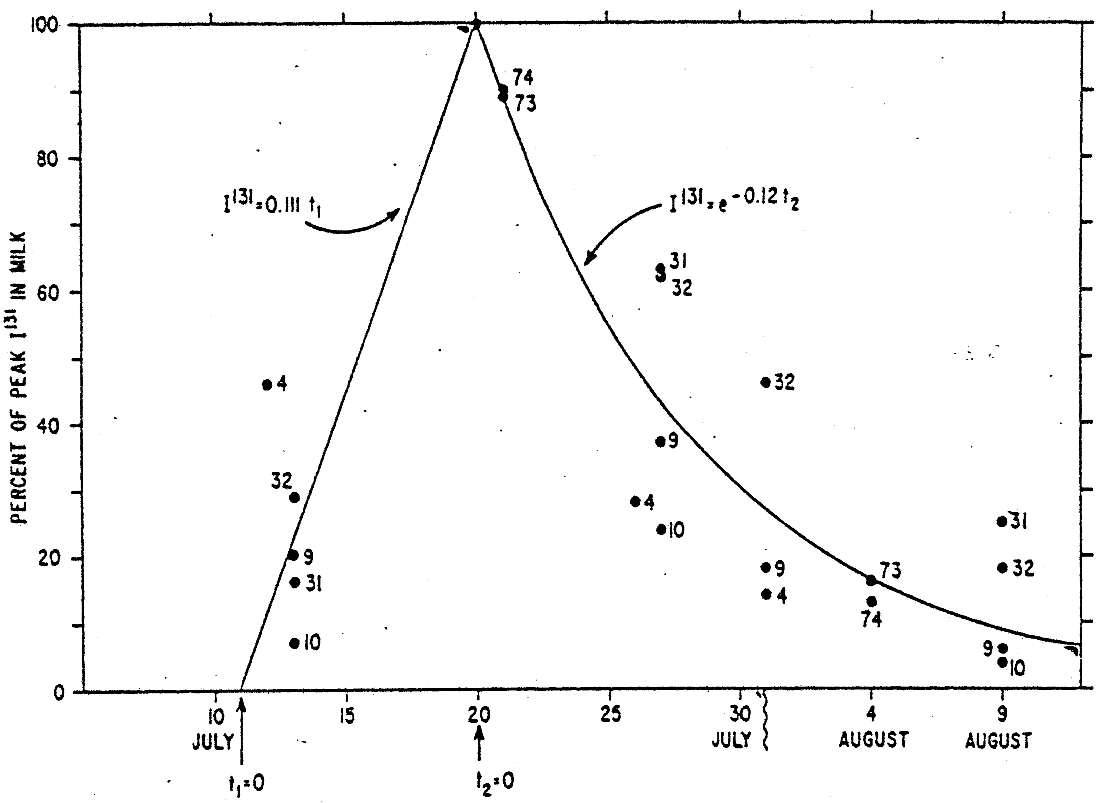

FIGURE 5

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