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RADIOACTIVE CONTAMINATION OF CERTAIN AREAS IN THE PACIFIC OCEAN FROM NUCLEAR TESTS « « «

By GM Donning as editor
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CHAPTER VI

Return of Rongelapese

One of the major consequences of the heavy fallout on some of the Marshall Islands in March 1954 was the evacuation of their inhabitants. The 154 personnel from Utirik were returned to their island in June 1954. However, the contamination of the Rongelap Atoll was appreciably greater than at Utirik, therefore it was not advisable to return the Rongelapese at that time. Since then the contamination has decreased, as shown by the data from the foregoing surveys, to a level where return was permissible. The discussion below summarizes the factors that led to this decision.*

A. *Medical Status of Rongelapese*

Relevant to the considerations for the return of the Rongelapese to their home island was the body insult they previously suffered from radiation following the fallout of March 1, 1954 and their present body burden of radioactive isotopes. Below are summaries of the findings over a two-year period.

Of the Rongelapese exposed, 64 received about 175 roentgens, and 18 people about 69 roentgens whole body external gamma radiation. The clinical findings showed, ". . . The more seriously irradiated individuals had initial symptoms of anorexia, vomiting and diarrhea which subsided without treatment within 2 days. The same individuals slowly developed granulocytopenia and thrombocytopenia unassociated with secondary complications. The only other manifestations of radiation exposure observed were skin lesions and epilation, . . . The incidence of infectious and noninfectious disease in the more severely exposed groups was no greater than that in the least exposed group. . . ."[8]

*The Rongelapese were returned to their home island on June 29, 1957

The skin damage observed was as follows:

45 individuals—superficial lesions
13 individuals—deep lesions
6 individuals—no lesions
35 individuals—some degree of epilation

As the Marshallese continued to live on the contaminated islands for the two days before evacuation some radioactive materials were taken internally by inhalation and ingestion. Table 45 shows the results of urinalysis of Group I (the 64 Marshallese exposed to 175 roentgens) and Table 46 the estimated body burden.[8] The major findings on internal contamination were as follows:

". . . The total amount of radioactive material in the G. I. tract at one day post detonation was estimated to be 3 mc in people from Rongelap. This activity was contributed chiefly by isotopes of short radiological and biological half-life and limited solubility, and thus the levels of activity in the tissues of the body were relatively low. The concentration of radioisotopes at 6 months post detonation was barely detectable in the urine of most of the exposed individuals.

"The estimated dose to the thyroid from I^{131} and other short-lived iodine isotopes was 100 to 150 rep for the Rongelapese. Iodine is probably the most hazardous internal radioemitter at early times after exposure. The dose to the thyroid, although greater than tolerance, was low compared to the partially or totally ablating doses of I^{131} used in the treatment of hyperthyroidism or carcinoma." [8]

At one day post detonation, the concentration of Sr^{89} was calculated to be near the maximum permissible level for this nuclide. At later times following exposure, this longer-lived fission product presents the greatest potential internal hazard.

Table 45—Gross Beta Activity in Urine of Group I on 46th Day Post Detonation

Case No.	Total Volume 24 hrs (ml)	Beta Activity d/m/24 hrs	Case No.	Total Volume 24 hrs (ml)	Beta Activity d/m/24 hrs
Age < 5 yrs			*Age > 16 yrs*		
2	120	712	4	455	634
3	150	894	7	810	1700
5	155	313	9	355	201
23	40	223	10	980	549
33	260	0	11	450	1583
54	80	385	13	340	1677
69	455	301	14	780	2460
			18	455	1670
Mean	165	404	22	47	77
			30	960	438
			34	750	570
			37	480	792
			40	550	1450
			46	330	495
			49	425	0
			52	780	0
			55	320	1080
			56	700	3220
			57	550	1095
Age 6–15 yrs			58	750	2170
20	265	1900	60	810	580
24	550	0	62	980	1985
26	650	1032	63	635	2260
35	255	0	66	855	1715
36	190	236	68	300	2010
39	280	1100	71	290	1450
47	650	1705	73	230	0
67	450	674	78	965	52
72	110	507	79	465	2038
75	440	0	80	540	1353
76	980	1180	82	670	2140
Mean	439	758	Mean	581	1208

Values corrected for decay.

"Analysis of the internal contamination indicates that the dose to the tissue of the body was near, but, with exception of the dose to the thyroid, did not exceed the maximum permissible dose levels. The activity fixed in the body decreased rapidly as a function of time. The contribution of the effects of internal contamination to the total radiation response observed appears to be small on the basis of the estimated body burden of the radio-elements. In view of the short half-life of the most abundant fission products in the situation, the possibility that chronic irradiation effects will occur is quite small. . . . "[8]

These data suggest a low relative hazard from internally deposited radioisotopes since the values for maximum permissible concentrations are based on the concept that these levels will be maintained indefinitely.

The report stated, "—The total white count increases during the first *2 or more* days and then decreases below normal levels. —The count becomes stabilized during the 7th or 8th week at low levels, and minimum counts probably occur at this time. A definite trend upward is apparent in the 9th or 10th week; however complete recovery may require several months or more.

"The neutrophile count parallels the total white blood cell count. Complete return to normal values does not occur for several months or more. The initial rise in total white count is due to a neutrophilic leukocytosis.

"The drop in lymphocytes is early and profound. Little or no evidence of recovery may be apparent several months after exposure, and return to normal levels may not occur for months or years.

"The platelet count, unlike the fluctuating total leukocyte count, falls in a regular fashion and reaches a low on the 30th day. Some recovery is evident early; however, as with the other elements, recovery may not be complete several months after exposure. . . ."[8]

At one year later the Marshallese were reexamined with the following conclusions:

"—In general, the Marshallese have recovered satisfactorily from the radiation injury received during March 1954. Visible residual effects are limited to a few areas of depigmentation and two small, distinct scars from radiation burns, one of which will possibly require plastic repair.

"Neutrophil values have returned to the normal range of the control population. All

Table 46—Mean Body Burden of the Rongelap Group

Radioisotope	Activity at 82 Days μc (USNRDL)	Activity at 1 Day* μc (USNRDL)	Activity at 1 Day* μc (LASL)
Sr^{89}	0.19	1.6	2.2
Ba^{140}	0.021	2.7	0.34
Rare Earth Group	0.03	1.2	
I^{131} (in thyroid)	0	6.4	11.2
Ru^{103}			0.013
Ca^{45}	0	0	0.019
Fissile material	0	0	0.016 (ugm)

*Extrapolated from 82d day.

other members of the leukocyte population and the platelets remain below the levels for the control population; however, levels are higher than at 6 months and, presumably, will soon be in the normal range."[13]

At two years the examination showed that, "In general, the people of both exposed and control groups appear to be in good health and nutritional status."[14]

A 77-year old man showed a history of paresis of the lower extremities. The symptoms suggested that, "These findings can best be explained on the basis of a cerebrovascular accident."[14] An 11-year old boy was hospitalized with acute rheumatic fever and cardiac decompensation. "The diagnosis of rheumatic heart disease with mitral stenosis and insufficiency was substantiated and at the time of the examination, the boy was fully active without evidence of decompensation."[14] A 46-year old man died on May 13, 1956, of heart failure. It was concluded that, "With the exception of the residual of skin lesions, none of the clinical findings in the exposed group could be attributed to the effects of irradiation."[13]

In regard to skin lesions it was reported, "Some residual lesions are present in the Rongelap people. . . . The majority of all show improvement. Almost all of the early superficial lesions are completely healed at this time without any apparent residual changes. . . . There appears to be no evidence of any change which would suggest malignancy."[14]

Urinalysis was made about two years after the March 1954 detonation, for people living on Utirik and Likiep Islands, for the Rongelapese living on Majuro Island and for personnel at HASL (Table 47).[5, 14] It is recognized that these are limited data, but the values for the HASL group show the general world-wide distribution of the fallout debris, and indicates that the Sr^{90} activities found in the Pacific group are probably more the result of living in

Table 47—NRDL Marshall Island Resurvey—1956 Results of Analyses of Human Urine Performed at HASL

HASL No.	NRDL No.	Sampling Location	Collection Date	Name	Age	Total Volume Received (ml)	C-Date Total Activity	Total Activity d/m/l *	Total Activity d/m/l **	Sr^{90} d/m/l	Cs^{137} d/m/l
3399	6	Utirik	2-11-56	A	4	190	3-25-56	4800±240			
3400	1	do	2-11-56	B	2	250	3-25-56	3600±280			
3401	4	do	2-11-56	C	12	570	3-25-56	3360±320			
3402	9	do	2-11-56	D	27	440	3-25-56	3320±300			
3403	10	do	2-11-56	E	22	135	3-25-56	7600±240		3.4±0.3	720±15
3404	7	do	2-11-56	F	5	180	3-25-56	4400±280			
3405	2	do	2-11-56	G	16	285	3-25-56	8200±360	170±100		
3406	3	do	2-11-56	H	6	310	3-25-56	2200±320			
3407	8	do	2-11-56	I	16	340	3-25-56	3480±240			
3408	11	do	2-11-56	POOLED		620	3-25-56	7600±320	≤100	6.8±1.4	2540±63
3409	4	Likiep	2-11-56	J		260	3-25-56	4400±320			
3410	1	do	2-11-56	K	3	360	3-25-56	4400±320			
3411	8	do	2-11-56	L	8	160	3-25-56	4800±320			
3412	9	do	2-11-56	M	1	225	3-25-56	4000±240		5.3±0.3	1487±23
3413	5	do	2-11-56	N	26	235	3-25-56	4800±320			
3414	3	do	2-11-56	O	13	410	3-25-56	9800±360	600±100		
3415	2	do	2-11-56	P	35	600	3-25-56	2920±280	≤100		
3416	7	do	2-11-56	Q	45	190	3-25-56	8800±320			
3417	10	do	2-11-56	POOLED		990	3-25-56	9200±360	≤100	4.7±0.7	2862±45
3418	9	Majuro***	2-29-56	R	24	980	3-25-56	2600±240			
3419	40	do	2-29-56	S	31	990	3-25-56	2400±240			
3420	36	do	2-29-56	T	8	1,000	3-25-56	1160±200		2.4±0.2	33±8
3421	26	do	2-29-56	U	13	930	3-25-56	2200±240			
3422	76	do	2-29-56	V	11	990	3-25-56	1360±280			
		Control	3-26-56	Pooled sample collected at HASL.		1,000		4250±250	≤100	1.6±0.4	29±8
		do	June 1956	do		5,000				1.4±0.2	
		do	June 1956	do		5,000				1.9±0.2	
		do	June 1956	do		5,000				1.0±0.2	
		do	June 1956	do		2,000					30±8

*Direct plating. **Carbonate precipitation. ***Rongelap natives.

an environment of continual intake and excretion rather than the results of body elimination of previously deposited Sr^{90}.

B. *Medical Surveillance*

When the Rongelapese were returned to their home island, it was planned to inaugurate a program of continuing medical inspections. The Rongelapese would be examined once a month by a Marshallese practitioner and complete medical examination performed once a year by an American physician. Arrangements would be made for urine collections and analyses every three months for the first year and afterward on a yearly basis unless the findings indicate the necessity for more frequent analyses. A radio would be provided on Rongelap for communication with the Trust Territories Office on Ebeye (Kwajalein Atoll) where a plane would be available at all times for any emergency. A fully equipped dispensary would be provided on Rongelap and an experienced health aide (a Marshallese) would be present at all times. Before their return, the Marshallese would be given a complete medical examination, and immunized against smallpox, typhoid and tetanus.

C. *Environmental Contamination*

The degree of contamination on the home islands of the Rongelapese was considered

according to the external gamma dose rate and the amount of strontium–90.

1. External Gamma Dose Rates on Rongelap Atoll

The external gamma dose rates at three feet above the ground on the Island of Rongelap are shown in Graph I. It would be expected that this curve would flatten out with time due to the dominance of the cesium–137 with its half-life of 27 years. The latest survey of the Rongelap Island at the end of July 1956 showed a range of values from 0.2–0.5 milliroentgen per hour, with an average of 0.4 mr/hr. However, the graph suggests an anticipated dose rate at the July 1956 survey of about 0.1 mr/hr. The higher value found is undoubtedly due to the small additional fallout that occurred during Operation Redwing. Since this was relatively fresh radioactive material, the decay should be more rapid so that the dose rates on Rongelap Island at the time of repatriation should be less than 30 milliroentgens/week.

The maximum permissible external gamma exposure to adult workers recommended by the National (U. S.) Committee on Radiation Protection is 0.3 rems/week with an added restriction that the maximum permissible accumulated dose in rems, at any age is equal to five times the number of years beyond age 18, provided no annual increment exceeds 15 rem. (This applies to all critical organs except the skin, for which the value is double.) The maximum permissible exposure for the population as a whole from all sources of radiation, including medical and other man-made sources, and background shall not exceed 14 million rem per million of population over the period from conception up to age 30, and one-third that amount in each decade thereafter.

It is difficult to extrapolate precisely far into the future, but the data suggest that the gamma doses on Rongelap Island would not greatly exceed (if at all) 0.5 roentgens for the first year of reoccupancy, with lesser doses in subsequent years, plus some additional whole body dose from internally deposited cesium-137.* The gamma dose rates on other island of Rongelap Atoll have not been followed as closely as on Rongelap but the data suggest the *relative* dose rates now are the same as measured in the first part of March 1954; i. e., the highest activity on any island is about a factor of 12 higher than Rongelap. The Rongelapese go on fishing expeditions to other islands, including those showing both higher and lower activity. However, these Rongelapese spend an appreciable part of their time in boats over water where the external gamma activity is near background values. Thus, the yearly average for these probably would not differ greatly from those on Rongelap Island.

2. Strontium–90

a. *Food Supply*

The basic data on the normal food supply of the Rongelapese are contained in Table 48. There are wide variances in the data so that estimated average values are used. This is not an unreasonable approach since it would be expected that the food actually consumed would be about as variable as the individual samples collected for analysis. As will be seen below, these estimates could be in error by a factor of several without changing the conclusion.

The isotope of principal concern in the food chain is strontium–90. For an adult worker the maintained maximum permissible body burden is 1,000 Sunshine Units (1,000 micromicrocuries of Sr^{90} per gram of calcium). Values for maximum permissible exposures to the general population are 1/10 that for adult workers, or 100 Sunshine Units, maintained level in the body. The National (U. S.) Academy of Sciences report stated, ". . . There seems no reason to hesitate to allow a universal human strontium—burden of 1/10 of the permissible . . ." for adult workers. This corresponds to the 100 Sunshine Units.

*Gamma dose rates at three feet above the ground on the Island of Rongelap in June 1957 were as follows:
Highest reading 0.13 mr/hr
Lowest reading 0.01 mr/hr
Average reading 0.03 mr/hr

Table 48 indicates that the average concentration of strontium–90 in the total food supply might be less than 360 Sunshine Units. (The data on land crabs shown in Table 48 are from the Island of Kabelle which is more heavily contaminated than the Island of Rongelap).*

Table 48—Estimates of Contamination of the Normal Food Supply of Rongelapese

	A Daily Intake Pounds/ Day/ Person	B Calcium Content (gms Ca/gm wet weight)	C Daily Intake of Ca (gms)	D Fraction of Total Ca Intake	E Strontium-90 Content (S. U.)[a]	F Contribution To Sr^{90} Intake (S. U.) (Column D X E)
Fish	1.22	0.001	0.56	0.645	12	7.73
Pandanus	0.36	0.001	0.16	0.184	[b] 500	[b] 92.0
Clams	0.1	0.004	0.018	0.021	5	0.11
Arrowroot	0.09	[d] 0.0006	0.025	0.029	250	7.26
Wild birds (muscle)	0.09	0.0001	0.004	0.0046	300	[b] <1.38
Land crabs	[c] 0.03	0.004	0.055	0.063	[b] [c] (4000)	(252.0)
Coconut meat and milk	0.02	0.0004	0.004	0.0046	40	0.02
Bread fruit	0.01	0.0006	0.003	0.0034	260	0.88
Imported:						
Rice						
Flour						
Canned beef						
Milk	0.1	~0.0001	~0.045	~0.046	Few	Small
Sardines						
Shoyu						
Coffee						
Tea						

[a] Average values.

[b] These data are from island of Kabelle (no date from island of Rongelap for July 1956 survey). General contamination of island of Rongelap is about one-fifth that of Kabelle. Lagoon water around these islands do not show as great a difference in activity.

[c] These are land crabs from island of Kabelle. The strontium-90 concentration is higher than from earlier surveys, which is contrary to the plant activity as well as to the soil, and marine life data. (It has been estimated that about one-third of the intake of crab meat is from ocean crabs which have very little strontium-90 content.)

[d] Estimated.

[e] An unknown part of this intake may be sea crabs (which contain considerably less Sr^{90}) but is assumed here to be all land crabs.

However, if crabs were eliminated from the diet, the intake might average about 107 Sunshine Units. Further, elimination or restriction of the consumption of pandanus would reduce the strontium–90 intake to well under 100 Sunshine Units.

b. *Estimated Future Body Burden of Strontium–90*

Three principal factors are operative in estimating the future body burden of strontium–90 of the Rongelapese:

(1) Although precise values have not been established, there may be a discriminatory factor of several between Sr/Ca ratio in the food supply and that found in the bones.[15]

(2) If the Rongelapese were returned to their home island, their diet would be supplemented by imported (relatively uncontaminated) foods, especially rice. Also, the cisterns would be cleaned out and refilled with fresh water as well as having new cisterns built.

(3) Despite the wide variances in the data, analysis of the results from all of the surveys on the Pacific Islands shows a general decline

*There is some doubt concerning the correct strontium-90 activity in the land crabs, since the values are higher than for previous surveys which is contrary to all other data. Additional surveys should clarify this point. In any event the land crabs tested are from the island of Kabelle. (There were no collections of land crabs made on Rongelap Island during the last survey.) The general contamination on Rongelap is about one-fifth that of Kabelle. The difference in strontium-90 content may not be as great as this, but since these are land crabs it would be expected those on Rongelap Island to be lower than on Kabelle Island.

of Sr^{90} with time in the food chain (except the land crabs).

Although there is obviously a certain degree of uncertainty, the above data and estimates indicate that if land crabs are eliminated from their diet, the estimated future body burden of the Rongelapese would be substantially less than 100 $\mu\mu c$ of Sr^{90} per gram of calcium. Limiting the intake of pandanus would further reduce the estimated Sr^{90} intake. By means of the continuing medical examinations described below it would be possible to note any tendency of untoward accumulation of strontium–90 with time, and appropriate action could be taken before excessive levels were reached.

c. *Radiological Resurveys*

Plans are currently being developed for a continuing and long-range program for radiological resurveys on and around the Marshall Islands. The principal objective will be to monitor the environmental contamination especially for strontium–90.