

THE RADIUM CONTAMINATION IN THE SOUTHERN BLACK FOREST

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The high natural radium contamination prevailing in the Southern Black Forest was used to assess the degree of contamination of the environment, the mechanisms of radium transport to man, as well as the radiation impact on the population from natural Ra-226.

The Ra-226 concentration in the environmental air amounted to values between 0.16 and 1.2 fCi/m³. The mean value was 0.5 ± 0.2 fCi/m³. Considering the Ra-226 concentration in the soil, this value corresponds to about 150 µg of dust/m³.

The Ra-226 concentration in the drinking water was measured between March and December 1978. The mean value is 0.31 ± 0.03 pCi/l. The Ra-226 contamination found in the Krunkelbach, was likewise measured continuously during the same period. The mean value of the measured concentration was 0.5 ± 0.3 pCi/l. 23 water samples were taken from the Feldberger Alb brook, the most important tributary of the Krunkelbach brook; the average concentration was 0.19 ± 0.02 pCi of Ra-226/l.

In the Krunkelbach valley the Ra-226 contents were determined of 22 samples taken from several brooks. The concentrations found were < 0.03 to 2.6 pCi/l. In 23 water samples collected in the immediate and more distant vicinity of that valley the Ra-226 contents were determined. The results ranged from 0.03 to 1550 pCi/l. Generally speaking it can be stated that Ra-226 concentrations above 1 pCi are very rare, that the Ra-226 concentrations in a brook or river are maximum at its spring, and that high concentrations are observed when on account of extended dry periods the water stays longer in the soil or when in the winter season the salt concentration in the residual liquid increases by freezing of most of the water.

More than 100 soil samples were examined for Ra-226. In the topmost 20 cm soil layer the mean value was 2.9 pCi/g.

A great number of sediment samples from several brooks and rivers were measured to determine their Ra-226 content. The mean value found in the valley of the Menzschwander Alb was 3.2 ± 1.0 pCi/g. In other sediments a mean value of 1.1 ± 0.1 pCi Ra-226/g was measured. The Ra-226 concentrations in trouts were measured. The average concentration was 50 pCi Ra-226/kg of fresh weight. The maximum value was 211 pCi Ra-226/kg.

Milk samples were taken regularly from two farms and analyzed for their Ra-226 content. The results measured for one farm are plotted in Fig. 1. The Ra-226 concentrations scatter by more than one order of magnitude and take an average value of 11 pCi Ra-226/l. For the second farm a mean value of 7 pCi/l was measured. Random samples collected at other farms confirmed these results.

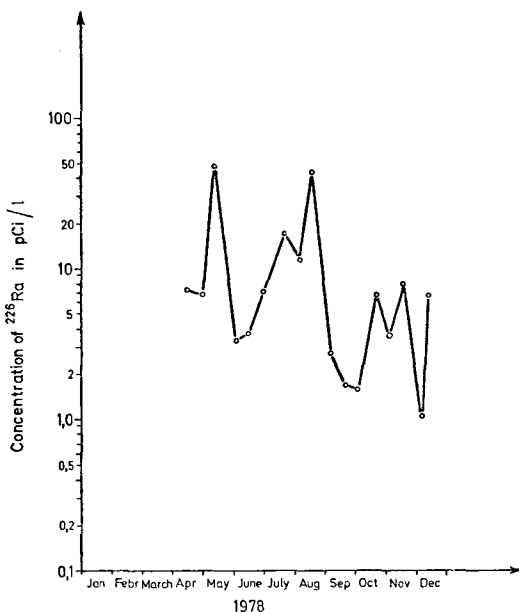


Fig.1: ^{226}Ra concentration in the milk from farm A, Menzenschwand.

Foodstuffs produced in the Southern Black Forest were measured for their Ra-226 content. Besides the milk and fish samples already mentioned, wheat, barley, oat, potatoes, salad, cabbage, beans, kohlrabis, blueberries, beef, entrails, venison, eggs, mushrooms and beer were investigated. A summary of values taken from the literature, compared with the radium contents found in the Southern Black Forest, is given in Table 1. The Ra-226 contents of corn, potatoes and milk are surprisingly high as compared with the published data. A more accurate examination is presently performed in order to find out which part of the corn has been contaminated with Ra-226.

Since the Ra-226 transfer from the soil to the grass is very significant for the contamination of milk, a great number of grass and hay samples were examined for Ra-226. Moreover, in search of a bioindicator for Ra-226, quite a number of wild plants were measured to determine their Ra-226 content. The average concentration of the grass and hay samples found was 0.30 ± 0.04 pCi/g of dry substance. For the other wild plants values were found of 0.7 to 22 pCi Ra-226/g of dry substance. A clear bioindicator for Ra-226 was not identified.

Since water and fish samples, grass and milk samples, soil and grass samples as well as soil and plant samples were always taken jointly, it was possible to calculate many transfer factors. The following transfer factors were determined: The transfer factor for fish / water was 28 ± 12 . In the guts, on the one part, and in the meat and heads + bones, on the other part, $1/3$ each of Ra-226 was contained. The ratio of water to sediment concentration was calculated for a settling tank to be 11×10^{-5} and for the brooks and rivers

26×10^{-5} . The grass to milk transfer factor indicates the percentage of Ra-226 contained in one liter of milk consumed daily. A value of 0.3 ± 0.1 % per liter was calculated from the measured grass and milk concentrations. The milk to grass transfer factor is 0.20 ± 0.05 . The transfer factor calculated for grass to soil was 0.027 ± 0.005 . Slightly higher values were determined for the wild plants. For the milk to soil transfer factor the value 0.005 ± 0.002 can be calculated from the data indicated. The transfer factors calculated for the individual foodstuffs vary from 0.003 for the white of egg up to 0.2 for corn.

Sampling Material	^{226}Ra concentration in pCi/kg	
	Menzenschwand	[1]
Soil:	1200 - 1500	150 - 3100
Water:		
river and lake water	0.03 - 2.5	0.002 - 62
ground and spring water	0.1 - 1549	0.001 - 237800
drinking water	0.11 - 0.57	0.005 - 50
Foodstuffs:		
potatoes	30 - 40	0.8 - 2.8
corn, flour	20 - 240	1.9 - 2.8
meat	2	0.01 - 1.1
milk	0.3 - 48	0.3
vegetables	5 - 170	0.5 - 3.8
fish	1.4 - 211	5.1
eggs	80	3.1 - 6.1
entrails	10 - 200	0.1

Table 1: ^{226}Ra concentration in environmental samples taken in and around Menzenschwand, as compared with values taken from the literature [1].

Taking into account the average habits of consumption in Germany the maximum possible intake per annum of radium was calculated for the population living in the region under investigation. It amounts to 7.1 nCi/a if one assumes that the total demand for foodstuffs is satisfied by local produces. This value is higher by the factor 12 than the annual Ra-226 ingestion value of 580 pCi permitted by the German Radiation Protection Ordinance. The body burden corresponding to this annual intake should amount to 7.4 nCi of Ra-226. To verify this conclusion, 28 members of the local population were measured in a body counter to determine the amount of Ra-226 incorporated. All 28 measuring values were below the detection limit

of about 7.5 nCi of Ra-226. If one takes these 28 measuring values as part of a random sample, the mean value and its error can be calculated for the Ra-226 body burden received by the whole group from the measured values, taking into account the standard deviations according to the counting statistics. The value so determined was 0.3 ± 0.7 nCi of Ra-226. A comparison of the most probable value of 0.3 nCi of Ra-226 with the calculated maximum value of 7.4 nCi of Ra-226 for the body burden yields that either only 4-5 % of the foodstuffs consumed by the group examined can stem from local production or that the radium transport from the gastro-intestinal tract into the blood according to the ICRP model [2] is overestimated.

To assess exactly the body burden of the inhabitants of the Southern Black Forest, the Ra-226 contained in the teeth of people living there is presently examined.

REFERENCE

- [1] K. Aurand et al., "Die natürliche Strahlenexposition des Menschen", Georg Thieme-Verlag, Stuttgart, 1974
- [2] Report of Committee II on Permissible Dose for Internal Radiation, International Commission on Radiological Protection, ICRP Publ. 2, Pergamon Press, London, 1959