

THE INVESTIGATION OF RADIOACTIVITY
LEVELS IN CROATIAN CISTERN WATERS

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The levels of radioactivity in cistern waters in the areas along the Adriatic coast have been investigated since 1962 when high total beta activity and ^{90}Sr were detected. A rapid decline followed after the nuclear moratorium. Since 1970 a small increase due to Chinese nuclear weapon tests has been registered. Several cistern waters in the villages around Zagreb were investigated while the nuclear power station was still under construction. Very low alpha and beta radioactivity originating from fall-out was detected.

Due to the extension of the carst along the entire Adriatic coast, the insignificant and erratic amount of water in scarce rivers and wells makes a part of the Croatian population dependent solely on cisterns for their water supply. These are the people living in the area along the Adriatic coast, several miles from the coast, and on most of the islands.

During the last few years more and more cisterns have been built inland, in hill country, where periodically people depend on such water supply. Cistern water, mainly rainwater, has a very low content of calcium. Occasionally this may prove to be a very serious defect when ^{90}Sr is present, considering the number of people which might get affected. ^{90}Sr taken with cistern water into the human or animal organism is deposited in bones in place of calcium in larger quantities than in the presence of calcium in water, due to different eating habits of the coastal population compared with the continental one. This is the reason why ^{90}Sr was monitored simultaneously with total beta activity (1).

To follow the pattern of radioactivity distribution we have performed several investigations of the radioactivity level in cistern waters around Zagreb in the last 2—3 years (2).

MATERIAL AND METHODS

Samples of cistern waters are collected four times a year, on 12 locations on the Adriatic coast and 12 samples yearly are taken inland, near Zagreb.

The samples are prepared for total beta activity counting from 1 L of cistern water, on a thin layer of cationic and anionic exchangers (3), and counted as such in a G. M. low level anticoincidence counter. For alpha activity measurements, 0.5 L of cistern water is evaporated to minimum liquid, containing suspended solids which are transferred to a tarred planchet and dried. The planchet is flamed to a dull red, then cooled, weighed and counted in an NMC proportional counter (4). ^{90}Sr is only determined in samples where the total beta activity is greater than 55 mBq/L.

Until 1969 ^{90}Sr was radiochemically separated with the fuming nitric acid (5) and since then TBP extraction has been used.

RESULTS

The variations in levels of total beta activity in cistern waters along the Adriatic coast are presented in Figures 1-3 for regions divided in Northern, Middle and Southern Dalmatia. The results are the maximum values for a given region during a three-month period. Figure 4 gives the median value of total beta activity for each year and all locations along and near the designated latitude.

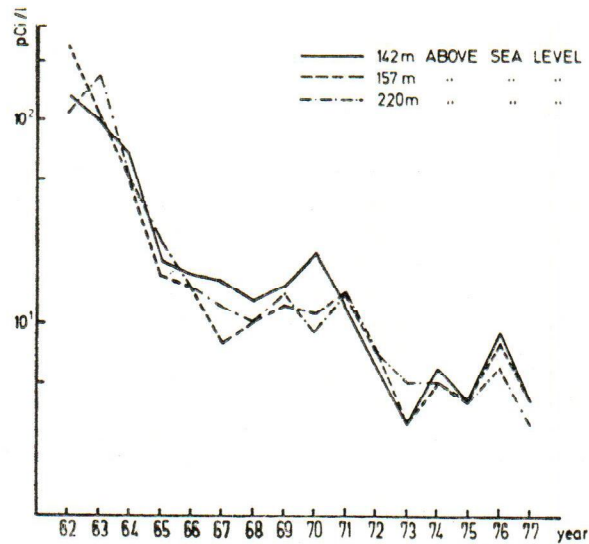


Fig. 1. Beta radioactivity in cistern waters in Northern Dalmatia

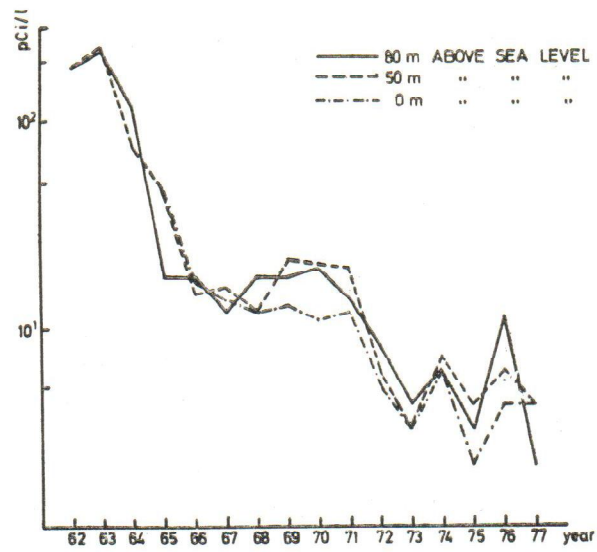


Fig. 2. Beta radioactivity in cistern water in Mid — Dalmatia

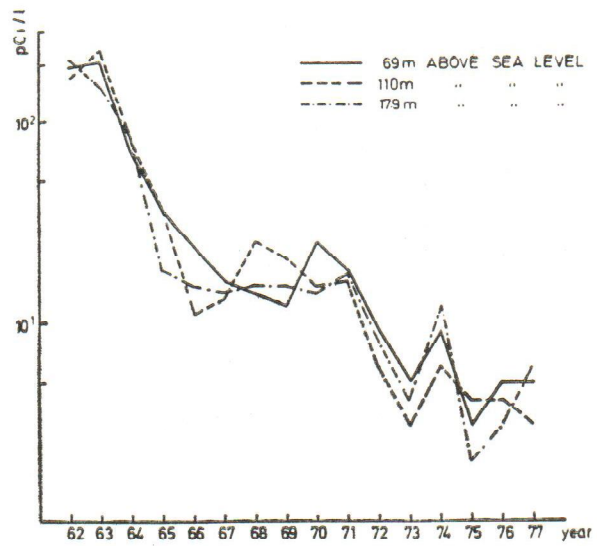


Fig. 3. Beta radioactivity in cistern waters in Southern Dalmatia

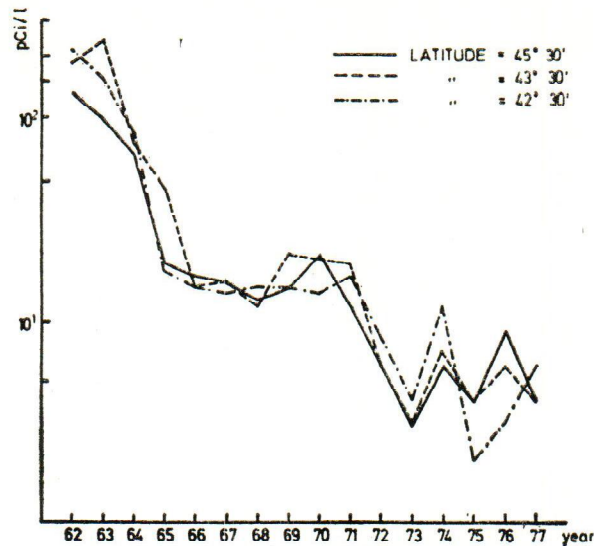


Fig. 4. Beta radioactivity in cistern waters along the Yugoslav Adriatic Coast of Dalmatia

Tables 1. and 2. show the ^{90}Sr contamination of cistern waters in the periods 1963—1968 and 1969—1973 when aftereffects of the extensive nuclear weapon tests could still be easily detected and the amount of ^{90}Sr present could be significant.

Table 3. presents the ^{90}Sr values during the period 1974—1978 when the aftereffects of nuclear weapon tests were rapidly declining, but some new radioactivity from Chinese tests was added.

In Table 4. data are given for total alpha activity to check for possible plutonium contamination from SNAP and fall-out.

Total beta activity levels in cistern waters from the countryside north-west from Zagreb for the 1977—1978 period are presented in Table 5.

DISCUSSION

In Tables 1—3 a certain pattern of ^{90}Sr activity emerges for the same period of time. The first period dates from the beginning of systematic investigations in 1962 when high radioactivity levels were detected originating from the last nuclear weapon test before the moratorium in 1963. Total beta activity levels are closely followed by those of ^{90}Sr so that this same year 1583.97 mBq/L of ^{90}Sr was detected in a cistern on the northern Adriatic coast. A still high result was obtained at the same

Table 1
⁹⁰Sr activity/(mBq/L) in cistern waters for the period 1963—1968

Location	Altitude/m a)	Year					
		1963	1964	1965	1966	1967	1968
Northern Dalmatia (as far as Maslenica bridge)	142	II III	263 ± 16	446 ± 21			293 ± 17
	157	II	228 ± 15		286 ± 17		
		III					
	80	II	1584 ± 40	1085 ± 33	399 ± 20		
		III					
	220	II III			304 ± 68		124 ± 11
50	II III					177 ± 13	38 ± 6
Middle Dalmatia (as far as Ploče)	180	II III	691 ± 26				
	Sea level	II				85 ± 9	
		III			93 ± 10		
	69	II				418 ± 20	320 ± 15
		III				366 ± 19	
	152	II III			424 ± 21		
Southern Dalmatia	190	II III		710 ± 27	406 ± 20		
	110	II					303 ± 17
		III					
179	II III					164 ± 13	

a) 2nd trimester
 3rd trimester

Table 2
⁹⁰Sr activity/(mBq/L) in cistern waters for the period 1969-1973

Location	Altitude/m a)	Year				
		1969	1970	1971	1972	1973
Northern Dalmatia (as far as Maslenica bridge)	142		162 ± 13	184 ± 14	43 ± 7	
		II				
		III				
	157					
		II				
		III				
Middle Dalmatia (as far as Ploče)	80		90 ± 9		98 ± 10	57 ± 8
		II			73 ± 9	82 ± 9
		III				
	220					
		II				
		III				
Southern Dalmatia	50		57 ± 7	63 ± 8		
		II				
		III				
	180		under the detection limit			
		II				
		III				
Middle Dalmatia (as far as Ploče)	Sea level		under the detection limit			
		II				
		III				
	69		229 ± 15	117 ± 11	93 ± 10	30 ± 5
		II		144 ± 12		53 ± 7
		III				
Southern Dalmatia	152		under the detection limit			
		II				
		III				
	190		under the detection limit			
		II				
		III				
Southern Dalmatia	110		62 ± 8	79 ± 9		
		II				
		III				
	179		160 ± 13			
		II				
		III				

a) 2nd trimester
 3rd trimester

Table 3.
⁹⁰Sr activity/(mBq/L) in cistern waters for the period 1974-1978.

Location	Altitude/m a)	Year				
		1978	1974	1975	1976	1977
Northern Dalmatia (as far as Mastenica bridge)	142					
		II				
		III				
	158	II		84 ± 9	29 ± 5	66 ± 8
		III		184 ± 14		
	80	II	56 ± 7			53 ± 7
	III					
	220	II	28 ± 5			
		III				
	50	II			33 ± 6	40 ± 6
	III		53 ± 7			
			39 ± 6			
Middle Dalmatia (as far as Ploče)	180	II	under the detection limit			
		III				
	Sea Level	II	under the detection limit			
		III				
	69	II	52 ± 7			
		III				
	152	II	under the detection limit			
		III				
	190	II	under the detection limit			
	III					
Southern Dalmatia	110	II		39 ± 6	24.05 ± 5	
		III		19 ± 4		
	179	II	44 ± 7	59 ± 8		53 ± 7
	III		40 ± 6		36 ± 6	

a) 2nd trimester
 3rd trimester

Table 4.

Total alpha activity (mBq/L) in cistern waters in the vicinity of Zagreb

Slani Dol	Tepec	Smerovišće	Bistra
ϕ	ϕ	ϕ	ϕ
6.3 ± 2.5	6.3 ± 2.5	6.3 ± 2.5	ϕ
ϕ	3.7 ± 1.9	ϕ	3.7 ± 1.9

ϕ = LLD < 0.06

Table 5.

Total beta activity (mBq/L) in cistern waters in the vicinity of Zagreb

Slani Dol	Tepec	Smerovišće	Bistra
15.2 ± 3.9	41.1 ± 6.4	57.7 ± 7.6	17.8 ± 4.2
89.9 ± 9.5	69.6 ± 8.3	87.0 ± 9.3	11.1 ± 3.3
79.9 ± 8.9	41.1 ± 6.4	37.4 ± 6.1	12.6 ± 3.5

location one year later but the level of activity declined during the year from 1085.58 mBq/L (in the second trimester) to 896.14 mBq/L (in the third trimester). At the same time the total beta activity in the same region fell conspicuously. In 1965 ^{90}Sr activity was already diminishing. A slow rise in radioactive contamination was detected during the period 1968—1970 when the remains of atmospheric contamination were washed down as fall-out and Chinese nuclear weapon tests began. Seventeen Chinese nuclear explosions have been registered since 1968. The last test in 1977 and 1978 made a significant contribution to the total beta activity and ^{90}Sr level in cistern waters. This can be attributed to the fact that the radioactivity in cistern waters in 1973 and 1975 fell to an all-time low, so that the contributions from Chinese experiments became significant.

The alpha radioactivity of cistern waters is very low, mostly under the detection limit. The alpha and beta activity measurements in cistern waters in the vicinity of Zagreb do not indicate any specific nuclide. However, they provide an index to the radioactive contamination of the sample. Total beta activity is in general lower than along the Adriatic coast.

CONCLUSION

The knowledge of radioactivity trends in cistern waters in the areas along the Adriatic coast and inland, north-west from Zagreb, has a significant value in defining the present level of radioactivity. Cistern water

on the Adriatic coast is often the only source of drinking water for large segments of population. Cistern waters in the vicinity of Zagreb, in the case of pollution of the drinking water originating from the river Sava during a nuclear accident, would be the only source of uncontaminated drinking water and also an indicator of air pollution. An addition of calcium to such waters could, in critical situations, considerably diminish serious contamination of the human organism with ^{90}Sr . Cistern waters as a significant source of drinking water must be held under constant surveillance to detect the smallest increase in radioactivity since too many people and animals depend on it.

Literature

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Sažetak

RADIOAKTIVNOST U CISTERNSKIM VODAMA U HRVATSKOJ

Nivo radioaktivnosti u cisternskim vodama duž Jadrana ispituje se od 1962. godinc. Prati se stalno ukupna beta-aktivnost i ^{90}Sr . Nakon prestanka velikih pokusa s nuklearnim oružjem, radioaktivnost je naglo pala i ostala niska do sada. Poslije 1968. godine došlo je do malog povišenja nivoa radioaktivnosti uslijed kineskih nuklearnih eksperimenata, međutim, značajnog povišenja nije bilo. Tokom dvije godine praćena je i alfa i beta aktivnost cisternskih voda u blizini Zagreba kao nulta točka prije rada nuklearne elektrane Krško. Istraživanja se nastavljaju.

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