ACTIVITIES OF HYDROMETEOROLOGIC INSTITUTE OF SERBIA - BELGRADE, DURING THE CASE OF RADIOACTIVE POLLUTION OF ENVIRONMENT CAUSED BY THE ACCIDENT OF NUCLEAR POWER PLANT "CHERNOBYL" IN 1986.

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ABSTRACT

The programme of "Systematic testing of water quality" performed by Hydrometeorologic Institute of Serbia - Belgrade includes the measurement of total beta radioactivity on 33 sampling points. The measurement of total beta radioactivity is performed with instrument "Lola - 4" produced by "Institute for Nuclear Science - Vinča". During the accident of Nuclear Power Plant "Chernobyl" in 1986 arose the need to investigate the influence of this case on the environment of Belgrade and Serbia. In that respect a series of measurement of total beta radioactivity of rain water, surface waters, tap water and air were performed. Those measurements showed an increase of radioactivity of river waters. River Sava had radioactivity of 3,4 Bq/l (0,08 Bq/l in 19850 and river Danube 3-5 Bq/l (0,09 Bq/l in 1985). High values of radioactivity were measured in the waters of highland accumulation lakes over 30 Bq/l. Rain water showed it's maximum of 52 Bq/l on 1st and 2nd May l986 and it drooped to 0,13 Bq/l until 5th of June. Tap water showed it' maximum of 35,2 Bq/l on 12th May and it was reduced to 1,0 Bq/l on 2nd of June. Radioactivity of air showed it's maximum of 2,64 Bq/m^3 in the period 1-3 May and in the period 5-8 May, 1.1 - 1,57 Bq/m^3. Measurement of river water radioactivity on 33 regular sampling points at the end of the year 1986 showed that was no increase in comparison with the same measurements in 1985. All mentioned results of the radioactivity of river waters and the waters of highland accumulations used to fall into ranges predicted by the model of the radioactive pollution distribution developed on the Imperial College - London.
Key words: nuclear accident, pollutants, transport, measurements

INTRODUCTION

The results of measurement are given in Bequerels per litters for water samples (Bq/l), and in Bequerels per cubic meter for air samples (Bq/m^3).

Permitted value of total beta radioactivity is 1,0 Bq/l.

METEOROLOGIC CONDITION IN THE PERIOD FROM APRIL 26 TO MAY 12, 1986

Total quantity of rainfall in the area of Belgrade and it's near surroundings, in the named period, was 25 to 40 l/m^2. There was a rainfall nearly every day, and the rain was mainly of the shower type. The ground was constantly wet.
The system of clouds, which delivered mentioned rainfall, used to come with the north east stream of air, from the region of Karpatian Mountains and further from Ukraine. This situation was formed by cyclone activity in the region of Black Sea and southern parts of Balkan Peninsula. This activity was held on about ten days.
The clouds were of vertical development on the attitude of 10 to 12 km above the ground. Those clouds gave shower type rainfalls which were different from place to place. It must be mentioned here that the clouds , in because of their dynamics in the space where they were formed. have "collected" all the particles up to the attitude of 10-12 km from the ground. Radioactivity, high or low, was dependant on the quantity of rainfall which used to fall on the ground, and which was in relation with this cloud system.

2. RESULTS

2.1. Rain water

Date	Sampling point	Bq/l	Rainfall l/m^2
1/2.05.1986	Meteorologic station Belgrade (Vračar)	52,1	9,8
09.05.	Meteorologic station Belgrade (Košutnjak)	11,7	0,1
16.05.	" " "	10,9	
24/25.0.5.	" " "	0,5	
30.05/01.06.	" " "	0,53	
05.06.	" " "	0,13	

2.2 Surface waters

Date	**River (or Lake)**	**Sampling point**	**Bq/l**	**Average for 1985. Bq/l**
0.5.05.	Sava	Belgrade-Makiš	3,4	0,08
05.05.	Danube	Belgrade -Vinča	3,1	0,09
0.5.05.	Danube	Belgrade-Vinča	4,95*	
06.05.	Gruzha (river)	Selo Bare	2,1	
06.05.	Celije (acc. lake)	On dame	2,0	1,1 (inflow river Rasina)
06.05.	Vrutci (acc. lake)	On dame	29,6	0,19 (inflow river Djetina)

measured by Institute for Nuclear Science - "Vinča", Belgrade
Flow of water in river Sava was 2400 m^3/s, and in river Danube 7500 m^3/s.

2.3 Measurement of other institutions. Highland accumulation lake "Bukulja" near the town of Arandjelovac

Date	Bq/l	Institution
Before accident	0,034	Hydrometeorologic Institute Belgrade
02.05.1986	2,9 (depth 12 m)	Institute for Nuclear Science - Vincha
04.05.	11,9	Cabinet for biophysics PMF – Univ. Kragujevac
04.05.	34,2 (surface)	" " "
05.05	7,35 (depth 12 m)	Institute "Dr D. Karajović" - Belgrade
12.05.	5,3	Cabinet for biophysics PMF – Univ. Kragujevac

2.4 Tap water

Date	Bq/l
05.06.1986	1,85
06.05.	3,7
12.05.	35,2
16.05.	5,0
19.05.	1,8
02.06.	1,0

3. AIR

Hydeometeorologic Institute daily measure the content of smoke particles in air. Method of measurement comprises of the pumping of air through a paper filter for 24 hours. Content of particles on filter is determined by reflectometric method. Intake tube for air is placed 1,5 m high above ground. Paper filters are changed every day in 07.00 hours. Place of measurement is inside the area of Hydrometeorologic Institute on the hill of Vrachar near the centre of Belgrade. The total beta activity of the 5 cm^2 paper surface, where the solid particles were deposited, was measured.

Date	Smoke particles $\mu g/m^3$	Radioactivity of air Bq/m^3
28/27.04.1986	22	0,0
29/30.04	17	0,0
30.04./01.05	14	0,01
01/02.05.	20	2,36
02/03.05.	22	2,64
03/04.05.	24	0,32
04/05.05.	30	0,43
05/06.05.	15	1,57*start of south east wind which comes from Ukraine
06/07.05.	21	1,36
07/08.05.	6	1,1
08/09.05.	19	0,56
09/10.05.	19	0,04
10/11/12.05	21	0,0
12/13.05.	20	0,0

4. COMPARISON OF THE TOTAL BETA RADIOACTIVITY MEASUREMENT PERFORMED IN THE YEARS 1985 AND 1986.

During the year 1985 the total beta radioactivity was measured as the part of the program of "systematic testing of water quality" on 33 sampling points in three series in the months May, June and August, while in the year 1986 the radioactivity was measured in two series in months October and December. The average values are given in table below

No.	Sampling point	River	Bq/l in 1985	Bq/l in 1986
1	Belgrade (Zemun)	Danube	0.1	0,1
2	Smederevo	Danube	0,05	0,35
3	Radujevac	Danube	0,4	0,3
4	Šabac	Sava	0,13	0,05
5	Provo	Sava	0,16	0,15
6	Osružnica	Sava	0,08	0,1
7	Crna Bara	Drina	0,2	0,15
8	Prijepolje	Lim	0,08	0,05
9	Draževac	Kolubara	0,5	0,15
10	Rakovica	Topciderska reka	0,4	0,3
11	Varvarin	Velika Morava	0,24	0,25
12	Bagrdan	Velika Morava	0,08	0,3
13	Ljubičevski Most	Velika Morava	0,4	0,05
14	Mladenovac	Veliki Lug	8,0	0,05
15	Gugaljski Most	Z. Morava	0,04	0,15
16	Kratovska Stena	Z. Morava	0,08	0,05
17	Kraljevo	Z, Morava	0,05	0,05
18	Trstenik	Z. Morava	0,22	0,8
19	Jasika	Z. Morava	0,13	0,2
20	Raška	Ibar	0,46	0,4
21	Kraljevo	Ibar	0,22	0,1
22	Grdelica	J. Morava	0,1	0,2
23	Aleksinac	J. Morava	0,1	0,1
24	Doljevac	Toplica	0,11	0,45
25	Kuršumlija	Banjska	0,17	0,2
26	Dimitrovgrad	Nishava	0,24	0,2
27	Niš	Nishava	0,03	0,1
28	Petačnica	Jerma	0,08	0,1
29	Petačnica	Jablanica	0,05	0,1
30	Kusići	Pek	0,13	0,15
31	Čokonjar	Veliki Timok	5,25	0,85
32	Brusnik	Veliki Timok	0,85	0,7
33	Rgotina	Borska Reka	2,7	2,8

5. DISCUSSION

Rainfall had maximal radioactivity immediately after the accident of nuclear power plant Chernobyl 1st and 2nd May 1986. This radioactivity used to diminish and it vanished at the end of month May.

In river waters and waters of accumulation lakes in plains the radioactivity was in the scope of 2,0 to 5,0 Bq/l, and in the highland accumulations Vrutci, on mountain Zlatibor 200 km south of Belgrade, and in the accumulation lake Bukulja, 100 km south of Belgrade, measured radioactivity was 30 Bq/l and over. Explanation for such disposal of radioactivity was given in the lecture given by Dr Helen Apsimon from Imperial College London Group of European Association for Science of Air Pollution, on the Faculty for Physical-Chemistry of University of Belgrade on 04.09.1990. She said that immediately after the accident the model of the spreading of radioactive pollution over Europe was made. According to the expectations of this model the surface waters in the plains of Serbia should have radioactivity in the range 1 - 10 Bq/l, and the waters in highlands over 20 Bql/ inbecause of steaming of air up from plains to highlands, which takes with the rainfall. Measured values of radioactivity, given above, are in the range of those foreseen by the model.

Tap water had increased radioactivity during May l986 with maximum on May 12. Those 12 days radioactivity was penetrating the layers of soil between river Sava and reni wells for water supply and has penetratet through all the stages of purification process. All measured values were greater than allowed value of 1 Bq/l. Radioactivity reached normal value in beginning of June.

Comparison of the average values of radioactivity between the years 1985 and 1986 shoved that there was no radioactivity in the surface waters at the end of the year 1986. In both years on some sampling points radioactivity was greater than 1 Bq/l. This is the consequence of mining activity registered on those places in earlier years.