

## RADIOECOLOGY OF VARDAR RIVER BASIN

T. Anovski,<sup>1</sup> L. Cvetanovska-Nastevska,<sup>2</sup> N. Jovanovski<sup>2</sup>  
and  
Z. Bozinovski<sup>2</sup>

<sup>1</sup> Faculty of Technology & Metallurgy, Univ. "Sv. Kiril & Metodij"  
91000, Skopje, Macedonia

<sup>2</sup> Center for Application of Radioisotopes in Science and Industry  
91000, Skopje, Macedonia

### ABSTRACT

Beside the determination of the distribution coefficients for individual elements of interest, radiological measurement including total alpha, total beta as well as the specific activity for both artificial (H-3, Cs-134, Cs-137) and natural (Uranium and Actinium series: Pb-212, Pb-214, Tl-208, Bi-214, Ac-228, Rn-222 and K-40) radioisotopes presents in different environmental (water, soil, food and atmosphere) samples along the Vardar river, were performed.

Taking into consideration the results obtained so far and by application of adequate radioecological model, a global view on radioactivity of the investigated area, its origin, pathway of transport and places of accumulation as well as their influence on the total irradiation of the population have been evaluated and partly presented in this paper.

### INTRODUCTION

Various assignment of the surface and underground water flows of the Vardar river (water supply, irrigation etc.) to which gravitate cca 2/3 of the total population of the Republic of Macedonia /see Fig. 1/, are subject of particular interest regarding their protection and rational usage.

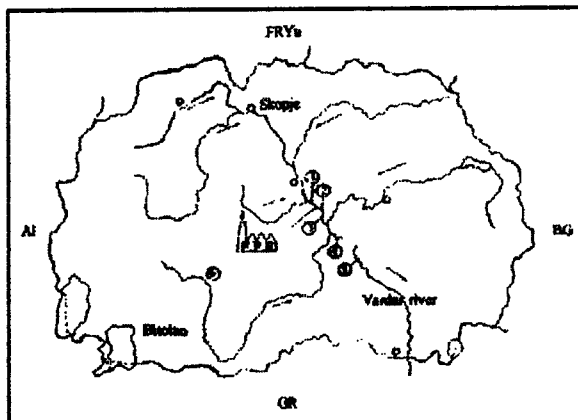


Fig. 1 Location of sampling points along the Vardar river basin  
1-T. Veles, 2-Zgropolci, 3-Nogaevci, 4-Ulanci, 5-Krivopalak,  
Pelagonija, PPF-factory for phosph. fertilizers

Parallel to the other investigations related with the determination of the bio-chemical pollution of the Vardar river basin (1), radioecological investigations took a significant attention, too. In this sense, several profiles along the Vardar river had been selected and collection of various samples on a regular base were performed.

In the very beginning, starting with the determination of the distribution coefficients for individual elements in various components of the Vardar River Basin(2), showing the place of their accumulation, radiological measurements /determination of the total -  $\alpha$  and total-  $\beta$  as well as the specific activity of individual natural (Pb-212, Pb-214, Tl-208, Bi-214, Ac-228, Rn-222 and K-40) and artificial (Cs-137, Cs-134 and H-3 ) radioisotopes/ in different environmental (water, soil, food, and atmosphere) samples along the Vardar river , were also introduced, identifying on such way the samples and locations with the increased level of radioactivity. Different the total -  $\alpha$  and total -  $\beta$  measurements which were done on Canberra - 2200 , anticoincident gas proportional counting system, specific activity for individual radioisotopes were performed on Tricarb , M 3320, Packard instrument,  $\beta$  Liquid Scintillation Counter or Canberra  $\gamma$  - spectrometer supplied with MCA - 40 and high resolution semiconducting detector.(3).

These investigations gained in their importance specially after the Chernobyl accident. This was a period when an increased environmental radioactive contamination has been registered particularly in the regions which are known to have received the highest amounts of precipitations during the period following the Chernobyl release(4).

By application of an adequate mathematically supported radioecological model (5-7) and taking into the consideration all relevant parameters (human habits, food chain etc.) , the annual effective equivalent dose received ( through ingestion , the most important pathway) by the local population, was calculated.

## RESULTS AND DISCUSSION

While the values of the total- $\alpha$  activity in the investigated water samples from the Vardar river, for the last 10 years, were in the range between 0.02 and 0.4 Bq/L, the other samples showed values increased up to 63,7 Bq/kg in case of cultivated soil, with a maximum value following the period of Chernobyl release /26th of April, 1996/, common for the other radiological measurements, too.

Values for the Total -  $\beta$  activity for Vardar river water and other samples are registered to be below 2.76 Bq/L and 5210 Bq/kg, respectively, with K-40 as a dominating radionuclide. For an example, on Fig. 2, the values for Total -  $\beta$  activity in water samples from the Vardar river /profile - Krivolak, which

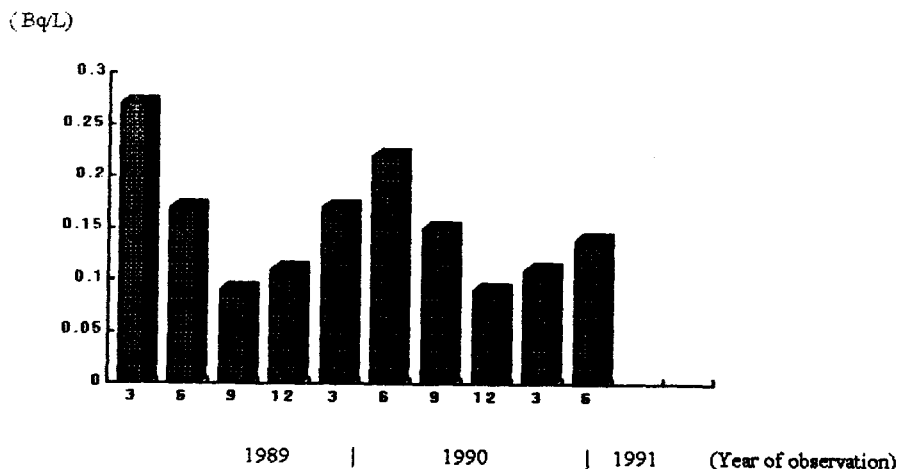


Figure 2. Total -  $\beta$  activity in water samples from the Vardar river /profile - Krivolak/

together with the previous up stream profile -Nogaevci, showed an increased activity/ with time is presented. It is evident that the changing of the total -  $\beta$  activity is following the shape of sinusoidal oscillation. Although this function is periodical, some characteristics of damped oscillations due to the decreasing of the amplitude with time, are evident. This can be explained by washing out of the contaminated soil during the melting period of snow /March - June/.

Different the tritium concentration in Vardar river water samples showing values between 5 and 15 T.U.<sup>1</sup> falling down to the level of the period before 1952 (starting period of thermonuclear explosions), the values for Pb - 214 and Ac- 228 are increased specially at Nogaevci and Krivolak profiles. In particular the concentration of Pb-214 in the sediment samples during the 1989-1991 period is reaching the value 125 Bq/kg which is several times higher in comparison with the previous observations. The reason for such an increasing of the mentioned activities has to be looked and related with the activities of the factory for phosphatic fertilizers, located upstream of these profiles.

Analysing the results obtained by the determination of the Cs-isotopes, it has been found out that the concentration of Cs-134 in comparison with this of Cs-137 during the period of increased contamination i.e. after the Chernobyl release, was twice less and disappeared earlier due to its shorter half life time. The concentration of Cs-137 in water samples from Vardar river for longer period of observation ('86-'95) showed a tendency of faster activity decreasing compared with the natural decay, the most probably, due to the presence of other comparative processes of dissolving, extraction, diffusion etc, approaching the level of early eighties (5).

Different the specific activity of the observed radionuclides (Cs-137, Pb-212, Pb-214, Tl-208, Bi-214 and Ac-228) in cultivated and uncultivated soils which showed values between 10 and 70 Bq/kg, various food samples had values below 25 Bq/kg or L, see Figure 3.

(Bq/kg or L)

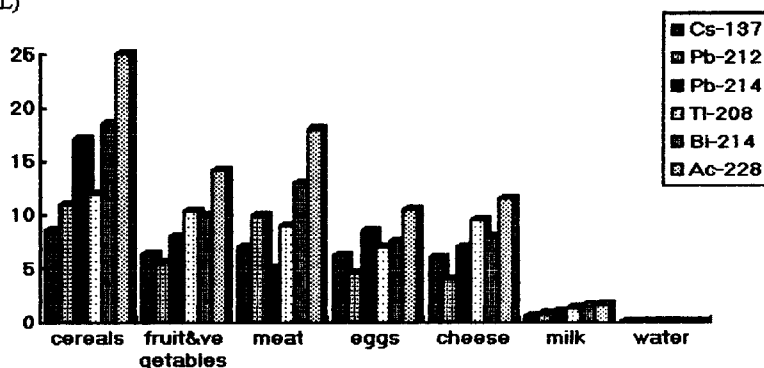


Figure 3. Average specific activity for the observed radionuclides in various food samples for the period '89 - '91

It is worth to mention the milk samples whose values were not higher than 4 Bq/L. This is of particular interest for the radiation burdening of children, dominantly consuming this product.

On the basis of the above mentioned results and by application of an adequate mathematically supported radioecological model (6-8), taking into the account all relevant parameters (human habits, food chain etc.), the annual effective equivalent dose received through ingestion (the most important pathway of the human irradiation) was calculated for the period '89-'91 and the value of 1.5 mSv/y was obtained, while the Cs-137 contribution significantly decreases in comparison with the early period following the Chernobyl accident (5), and was not higher than 60  $\mu$ Sv/y.

<sup>1</sup> One tritium unit, 1 T.U. =  $H^3$  - atom /  $10^{18} H^1$  - atoms