SURFACE WATERS POLLUTION BY URANIUM AND RADIUM AS RESULT OF MINER'S ACTIVITIES IN THE MESTA RIVER

Bernardo Lizama Rivas[1], Liuben Yonchev[2]

[1]*National Institute of Meteorology and Hydrology, Sofia, Bulgaria,*
e-mail: bernardo.lizama@meteo.bg
[2]*National Center of Radiobiology and Radiation Protection, Sofia, Bulgaria,*
e-mail: ncrrp@ ncrrp.org

Abstract: The Mesta River is located in the Southern western part of Bulgaria and mouths into the Marmara Sea through territory of Greece. In the Mesta catchment are located miner's objects for exploitation and treatment of uranium ore. In this paper be considered river pollution of uranium and radium as result of miner's activities in the study region. The data used are for three periods – during the completely productive engagement, during the technical liquidation and after end of technical liquidation. The measured data were processed and analyzed. With the help of correlation analysis was searched the relationships between radioactive pollution observable in the water-quality sampling sites and the discharges of the Mesta river. The results were compared with permissible levels.
Keywords: radioactive pollution, surface water, Mesta river,

INTRODUCTION

The river receives water from both runoff in the highlands and spring discharge in the lowlands. Therefore the river runoff is dependent on both the quantity aquifer discharge to the river and the quantity of surface runoff received by the river from the tributaries. The health risk to humans presented by radioactive waste depends upon the radionuclides present, the type of radiation emitted by the radionuclides, their concentrations, and their chemical and physical form.

In the Mesta watershed are located miner's objects for exploitation and treatment of uranium ore. They are situated in the proximity of the village of Eleshnitsa in the Zlataritsa tributary. There are 4 shafts, several small open pit mines, many underground passages, and installations for extracting uranium from solutions in the surroundings. Besides, a plant for treatment of uranium ore with a depot of waste sediments, which has direct hydrological connection with the Mesta River, is constructed in this area. The aim of this paper is to assess the river pollution of uranium and radium as result of miner's activities in the study region.

The Mesta River is located in the Southern western part of Bulgaria and mouths into the Marmara Sea through territory of Greece. The Mesta watershed is situated between Rila Mountain, Pirin Mountain and Rodope Mountain (Fig. 1). The longitude of the river in Bulgarian territory is 126 km with a watershed area of 2767 km^2. The Mesta River has 25 tributaries one of these is Zlataritsa River. The feeding of the Mesta River is mainly rainy and/or rainy-snowy. Because of influence of mountains the runoff regime has two types of hydrographs: four phase hydrograph for the upper stream and two phase for the mean and low stream. According to the streamflow observations at Momina Kula gauging station (Q215), the high flows period occur in April, May and June. The low flows period occur from July to the end of October. The average annual water discharge of the Mesta River near to Momina Kula gauging station is at the rate of 19.52 m^3/sec, that represents an average annual volume of about 616 million cubic meters. The percentage distribution of this volume at gauging station Momina Kula for the above mentioned periods is about 47% for the spring high waters period, about 38% for the autumn-winter increase of the runoff and 15% for the low flows period. The runoff regime of the Zlataritsa tributary is controlled by the discharge gauging station at the village of Eleshnitsa (Q228). The river is characterized by considerably variable and inconstant runoff.

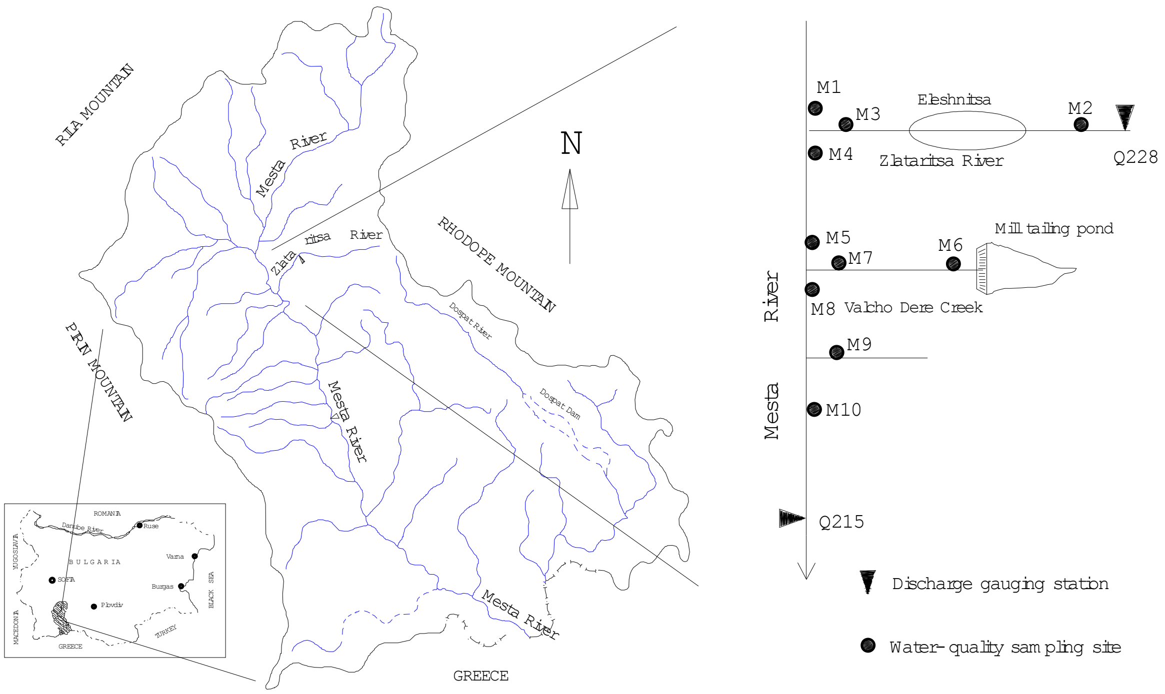

Fig. 1. The Mesta Catchment and the schematic figure showing the location of the water-quality sampling sites and the discharges gauge stations in the Mesta River

MATERIALS AND METHODS

The investigations have been performed on the basis of observation data (1983–2000) for Uranium and Radium concentrations in the waters and river discharge. The data used were collected for three periods – during the completely productive engagement, during the technical liquidation and after end of technical liquidation.

The region of the uranium mine, the Zlataritsa River and the creeks debouchment into the Mesta River are shown in Fig. 1. Here is given the pollution sources (ore water from the underground passages), the water-quality samplings sites (from M1 to M10) and the discharge-gauging stations at the Zlataritsa river (Q228) and at the Mesta river (Q215). To the Mesta River mouth three streams which drain waste water from the region of ore activity and from the treatment plant of uranium ore. The water-quality sampling sites in the Mesta River are located before and after each wastewater debouchment.

The water samples for uranium and ^{226}Ra are taken once per every three months, but they are incomplete for the first and the second period. The data of observed discharge are averaged per every month. There are not data for the concrete technological processes of the activities in the uranium ore-mine during the days when the water samples were taken. These uncertainties influence to a certain extend on the analysis of the final outcomes, but the trend of the pollution levels of the river waters is clear enough.

RESULTS AND DISCUSSION

According to the Bulgarian legislation, the permissible concentrations of radioactive elements in waters for drinking are different from those of the debouchment of the polluted waters into water bodies. Concerning the debouchment of the polluted waters the permissible concentration is 2.0 mg/dm^3 and 0.7 Bq/dm^3 of uranium and ^{226}Ra respectively [3]. The permissible concentrations for debouchment of industrial waste waters are referred to the polluted-water debouchment site into a receiver (sewage or water body). On this supposition, at a certain distance from the debouchment, these concentrations will decrease as a result of the dilution with greater and clearer water volume.

The Figures 2a and 2b show plots of the uranium and ^{226}Ra concentrations in water samples, taken at the sampling sites M1, M3, M7, M9 and M10 (Fig. 1) at the Mesta River watershed. Significant difference in the values of concentrations, even of two consecutive periods of water sampling is evident in both figures. The situation observed in the last studied period: 1999-2000 is different. Here the compactness of the data for the two radionuclides in the water sampling sites is in evidence. The influence of the uranium ore mine is distinct in these figures.

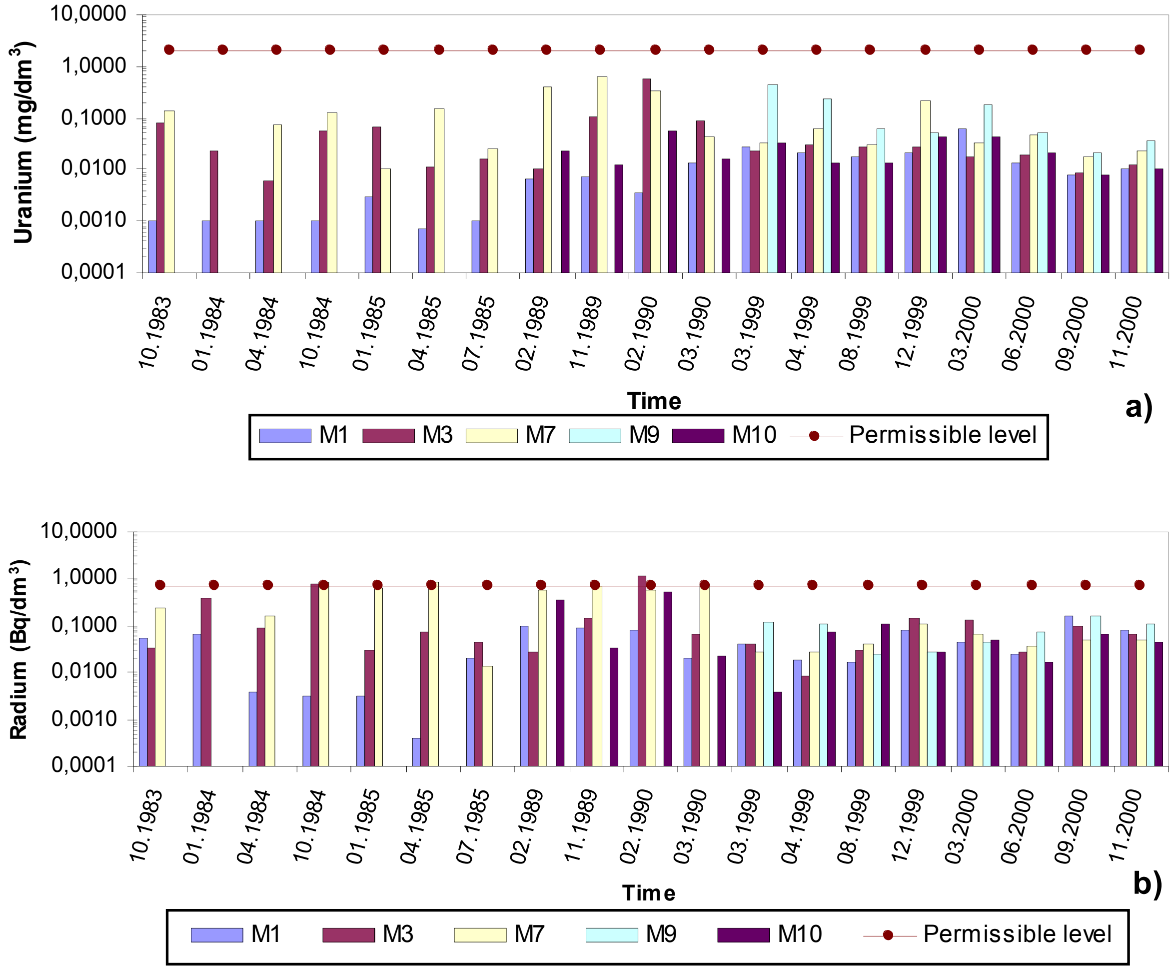

Fig. 2. Observed pattern of Uranium and ^{226}Ra concentrations in the Mesta catchment

The Fig. 3a shows that the values of uranium concentrations are lower than the permissible level. In respect of radium pollution (Fig. 3b) the situation is similar. Except in the measurements carried out during February 1989 and 1990. These high values are the consequence of high pollutant waters from the mill tailing pond which debouch to the Valcho Dere Creek which is tributary of the Mesta River.

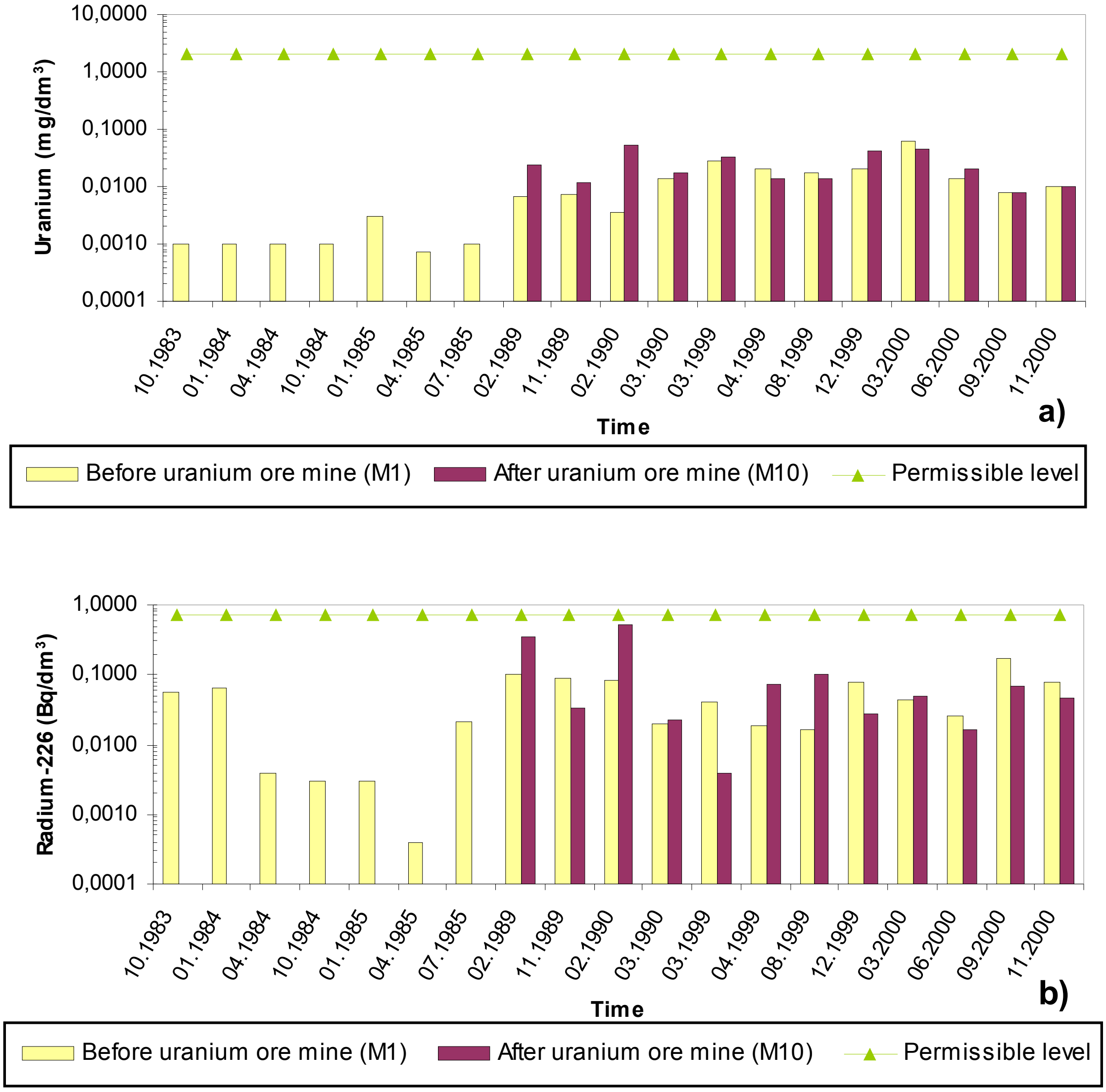

Fig. 3. Uranium and Radium-226 concentrations before and after ore mine compared to permissible level for debouchment of wastewater into the water bodies.

In Table 1 are given the mean values of uranium and radium content in Mesta River waters, before and after uranium ore mine. It can be seen that the mean values for both radionuclides before uranium ore mine are small compared with the one after uranium ore mine. Except in the radium data for the period 1989 - 1990. These high values are due to above-mentioned causes. It is obviously after the cessation of uranium ore exploitation, the pollution due to mining activities is not observed. In most cases the increase or decrease of one radionuclide contents responds to the other.

The obtained results indicate that the definitive cessation of the exploitation activities and the liquidation events brought to significant natural decrease of the radionuclide concentration in the surface waters of the Mesta catchment.

Table 1. Mean values for three characteristic periods, referring to the activities of the Uranium ore-mine

Mesta River before uranium ore-mine

	1983-1985	1989-1990	1999-2000
U mg/dm^3	0.0015	0.008	0.023
Ra Bq/dm^3	0.026	0.075	0.058
Mesta River after uranium ore-mine			
	1983-1985	1989-1990	1999-2000
U mg/dm^3	-	0.027	0.065
Ra Bq/dm^3	-	0.240	0.048
Permissible levels			
U mg/dm^3	2,0 [3]		
Ra Bq/dm^3	0,7 [3]		

In order to investigate the relationships between water discharges and the uranium and radium concentrations in the region of the village Eleshnitza a correlation analysis was used. For this purpose a correlation matrix was calculated, which includes the water-quality sampling sites and discharge gauging stations at Eleshnitsa (Q228) and Momina Kula (Q215). The significance of the correlation coefficient was verified with help of the Fisher criterion [2]. The analysis of the correlation matrix indicates that the relationships between the radionuclides in sampling sites, located in the Mesta catchment and the discharges measured in the gauging station Q215 are significant enough. The correlation coefficients for ^{226}Ra in the Mesta River are between -0.33 and -0.77. The highest correlation coefficient (-0,77) is observed with the sampling site M4, which is situated after the debouchment of Zlataritsa River to the Mesta River. In respect of uranium concentrations, the relationships, concerning the Mesta River, are between 0.42 and 0.76, which indicates good correlation dependence. The more significant relationships occur with the sampling site M4, which is situated after the debouchment of Zlataritsa River and with the sampling site M8, which is located immediately after Valcho Dere Creek. In respect of radium, the peculiarity of the obtained results is that the correlation coefficients are negative. This indicates that the increase of water volume causes the decrease of the radium concentration. For uranium concentrations can be emphasized that the relationships are positive. This can be explicated with the mining activities.

CONCLUSION

The radioactivity measurements in the surroundings of the uranium mine at Eleshnitsa showed that uranium and radium concentrations in the waters of the Mesta River during the three selected periods do not exceed the permissible concentrations in the wastewater discharged into the water bodies. As a whole, the obtained results demonstrate that radionuclide concentrations do not affect the waters of the Mesta.

REFERENCES

1. Archives of DIAL, Buhovo. (in bulgarian)
2. Himmelblau, D. M., Process Analysis by Statistical Methods, John Wiley, New York, 1970.
3. Ministry of Environment and Waters, Ministry of Territorial Development and Reconstruction, Ministry of National Health, Ministry of Economy (2000). Regulation No 6 concerning emissions norms for permissible content of harmful and dangerous substances in the wastewaters discharged into the water bodies. State Newspaper No 30. (in bulgarian)
4. Jakubick Al. – Training in International Standards and Methods for the Reclamation of Uranium Mines, PHARE – Project B 9107-01-15-(4).
5. Decommissioning of Facilities for milling of Radioactive Ore and Closeu of Residues, Technical reports Series N 362 IAEA, Vienna 1994.
6. Perez Esteves C., M. Sanchez Delgado – Decommisioning Plan for Andujar Uranium Mill Facilities, Technical Co-operation Project on Environmental Restoration in Central and Eastern Europe, IAEA TECDOC 865, vol. 1, Budapest, Hungary, 4-8 October 1993, February 1996.

7. Juhasz L., Zs. Loudvai, M. Csovari – The Restoration Work on the Hungarian Uranium Mining Area, Contribution to 3rd Workshop on Environmental for Central and Eastern Europe, Rez, Czech Republic 12-16 December 1994, IAEA TECDOC 865, vol. 3, IAEA, May 1996.
8. Fekete I., N. Bardan, C. A. Redulisen – Planing Environmental Restoration in Romania: Progress Report – RER/9/022, Regional Workshop in environmental and Restoration, Sofia, Bulgaria, 9-13 October 1995.