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TRITIUM CONTENT IN PRECIPITATION AND ATMOSPHERIC WATER VAPOUR OF THE REACTOR HALL IN THE VINČA INSTITUTE OF NUCLEAR SCIENCES

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Abstract

Tritium activity was determined in precipitation samples collected at two locations in Belgrade over the period 1998-2007: meteorological station Belgrade (Zeleno Brdo 44º47' N, 20º32' E, altitude 243.2m asl) and the station at the Vinča Institute of Nuclear Sciences. Tritium concentrations in precipitation ranged from 0.4 to 4.41 Bq l^{-1} (samples collected at Zeleno Brdo) and from 2.31 to 41.30 Bq l^{-1} (samples collected at VINS). Tritium content in atmospheric water vapour of the indoor reactor hall and inside of the reactor during the regular inspection of the fuel channels in the Vinča Institute of Nuclear Sciences in March and May 2006 was measured. The obtained results showed that the tritium content in HTO form varied from 1.56×10^2 Bq m^{-3} to 4.05×10^2 Bq m^{-3}.

Introduction

Tritium released from man-made source to the environment could be in the form of tritiated hydrogen gas (HT) and gaseous compounds, tritiated water (HTO) and aerosols of solid compounds. Transfer of tritiated water from the atmosphere to the surface of the earth occurs mainly by precipitation, but also by vapor exchange. Precipitation samples are of special interest because their tritium concentration govern the tritium activity fed into the soil and, consequently, have an impact on all the other media [1].

The research reactor RA in the Vinča Institute of Nuclear Sciences worked from 1959 to 1986 at a nominal power level of 6.5 MW. Heavy water (D_2O) of the reactor moderator and coolant, with a concentration of some TBq l^{-1} of tritium produced by neutron reaction during reactor operation, was drained and placed in a storage tank in October 1987 [2]. The RA reactor was placed in the "long term shutdown" condition in April 1986 in order to reconstruct and improve practically all the vital reactor systems. Since then, during the regular inspection of the fuel channels, tritium in HTO form can be released to the environment. From that reason, tritium content in precipitation in VINS and in Belgrade (meteorological station Zeleno Brdo) has to be measured.

Experimental

Composite monthly precipitation samples were collected at two locations: meteorological station Belgrade (Zeleno Brdo 44º47' N, 20º32' E, altitude 243.2 m asl) and the Vinča Institute of Nuclear Sciences (95 m asl).

Sampling of atmospheric water vapour was performed using the differential moisture sampler HT/HTO, produced by the Institute for Isotopes, Hungarian

Academy of Sciences. Sampling is based on the absorption technique [3]. Atmospheric water vapour in reactor hall was collected during 24 h over the period 30/03 – 03/04/2006, and inside of the reactor during 17/05 (1.1 h), 18/05 (0.41 h) and 19/5/2006 (0.66 h). In this period regular inspection of the fuel channels was performed.

Tritium activity measurements were carried out by a liquid scintillation spectrometer LKB-Wallac 1219 RackBeta, and expressed in Bq l^{-1} or Bq m^{-3}. The activity of tritium in precipitation samples was measured after electrolytic enrichment, while tritium activity in atmospheric water vapour was measured without electrolytic enrichment.

Results and Discussion

The obtained yearly mean tritium concentrations in precipitation samples collected at Zeleno Brdo (ZB) and Vinča Institute of Nuclear Sciences (VINS) are presented at Fig. 1. The activity concentration of tritium for samples at ZB ranged from the limit of detection (0.4 Bq l^{-1}) to 4.41 Bq l^{-1} and for samples collected at VINS ranged from 2.31 Bq l^{-1} to 41.30 Bq l^{-1}. Generally, tritium activity in precipitation increase in spring and summer months and decrease in the other part of a year. This pattern corresponds to tritium stratospheric origin. The obtained values for precipitation samples from VINS are higher then samples from ZB, which is attributed to the influence of local contamination by heavy water nuclear reactor.

Previous measurements showed that the tritium concentration in precipitation collected at Zeleno Brdo ranged from 1.1 to 18.3 Bq l^{-1} for period 1976-1990 [4]. Concentration of tritium observed at this location show the tendency of current global levels found at the other towns (Vienna, Budapest, Zagreb) [5]. For period 1988-1997, tritium concentration in precipitation ranged from 0.9 to 11.5 Bq l^{-1} (precipitation collected at ZB) and from 4.2 to 74.6 Bq l^{-1} (precipitation collected at VINS) [2].

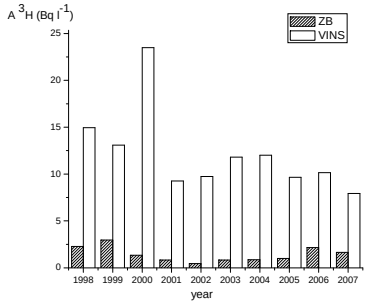

Fig. 1. Tritium concentration in the precipitation at ZB and VINS

Content of tritium in atmospheric water vapour is presented in Table 1. Activity of tritium measured in the reactor hall during the working days 30/03/2006 - 31/03/2006, was 3.37×10^2 Bq m^{-3}, while during the weekend 31/03/2006 - 03/04/2006, activity of tritium was 4.05×10^2 Bq m^{-3}. The obtained value of tritium content for weekend is higher because for weekend ventilation does not work,

which means that tritium in HTO form released to the environment during the working days. Tritium content measured in atmospheric water vapour inside of the reactor is the same order of magnitude as water vapour in the hall. All obtained values for tritium activity in atmospheric water vapour are below 80×10^4 Bq m^{-3}, which is acceptable for working environment [6].

Table 1. Tritium concentration in atmospheric water vapour

date	RA HTO $\times10^2$ (Bq m^{-3})
30.03.	3.37
31.03.	
01.04.	
02.04.	4.05
03.04.	
17.05.	3.87
18.05.	1.56
19.05.	

The obtained values for tritium activity in atmospheric water vapour in reactor hall (reactor RA) in this paper are in agreement with the results obtained in 1996 (0.40×10^3 Bq m^{-3} to 112×10^3 Bq m^{-3}) [7]. These values are one order of magnitude higher than values obtained in 2006, which is a consequence of tritium half-life.

Conclusion

Tritium content of samples collected at VINS appears to be one order of magnitude higher than that of samples from Zeleno Brdo, that is attributed to the influence of local contamination by heavy water nuclear reactor. The obtained values for tritium activity in atmospheric water vapour of the indoor reactor hall and inside of the reactor RA are below 80×10^4 Bq m^{-3}, which is acceptable for working environment.

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