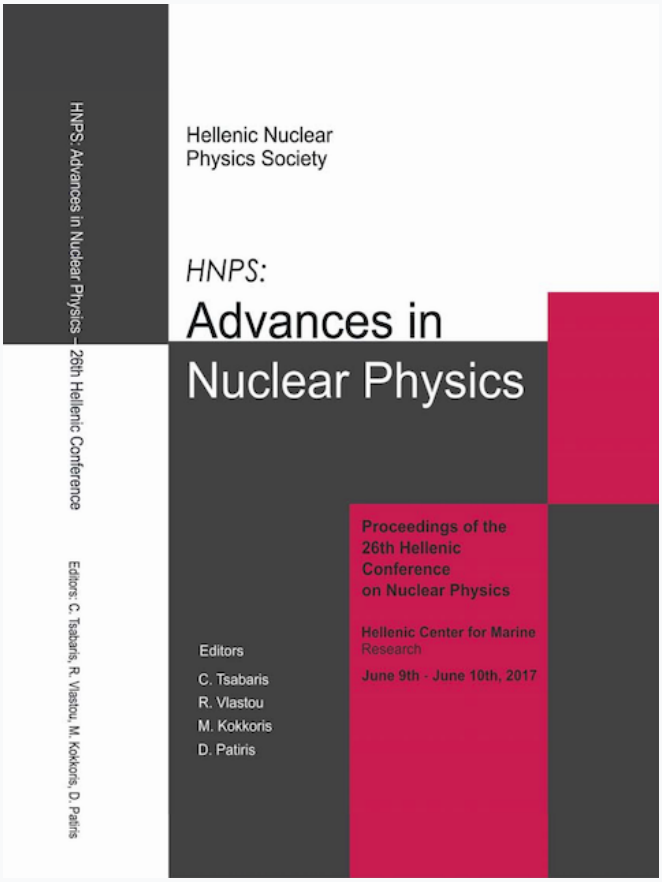
HNPS Advances in Nuclear Physics

Vol 25 (2017)

HNPS2017



A study of tritium concentrations in air humidity following a rainfall

K. C. Stamoulis, K. G. Ioannides, C. A. Papachristodoulou, S. Alexandropoulou

doi: 10.12681/hnps.1991

A study of tritium concentrations in air humidity following a rainfall

K.C. Stamoulis[1,2], K.G.Ioannides[1,2], C. Papachristodoulou[1], S. Alexandropoulou[1,*]

[1] *Department of Physics, University of Ioannina, 45110-Ioannina, Greece*
[2]*Archaeometry Center, University of Ioannina, 45110-Ioannina, Greece*

Abstract Tritium (^{3}H), an isotope of hydrogen, is produced in the upper level of the atmosphere. It enters the water cycle after its oxidation and through the precipitation. The measurement of tritium concentration in rainwater is of great importance because it can be used for hydrology investigations.
Tritium concentrations in the atmospheric precipitation vary from 0.5-2 BqL^{-1}. The Tritium Laboratory of the Archaeometry Center of the University of Ioannina is among the few laboratories in Greece, which can perform tritium measurements in water samples. In the present study, atmospheric humidity condensed to water and rain water was measured for tritium concentration. The study was conducted in the summer of 2016, following a single thunderstorm near the University of Ioannina and the aim was to explore the possibility of measuring tritium in the atmosphere in water samples other than precipitation and water from lakes, rivers and springs.

Keywords Tritium, LSC, humidity, rain water.

INTRODUCTION

Tritium (^{3}H) is an isotope of hydrogen, produced in the upper level of the atmosphere. The major reaction involved is that of thermal neutrons with nitrogen ^{14}N (n,^{3}H) ^{12}C. Tritium is oxidized and enters the water cycle through the precipitation. Tritium is also produced in Nuclear Power Plant facilities and periodically is released into the environment, lakes or rivers. During the nuclear tests era, the thermonuclear explosions lasted from early 1950s to early 1960s, released into the atmosphere great amounts of ^{3}H, and the global atmospheric concentrations, mainly in the northern hemisphere, have been raised up to ~700 BqL^{-1} or 6000 TU during 1963 (1Tritium Unit= 0.119 BqL^{-1}) [1]. Afterwards, tritium concentrations in the atmosphere began to decrease showing a remarkable yearly cycle of maximum during the spring and summer months followed by a minimum during the winter, 3-5 times lower than the maximum values (Fig. 1). These variations were observed at most of the northern hemisphere stations while the concentrations at the southern hemisphere were lower up to 10-100 times compared to the northern hemisphere ones. This was due to the predominant northern location of weapon testing sites and the slow inter-hemispheric transport of tracers [1].

Nowadays, tritium concentrations in the atmospheric precipitation have fallen to natural levels and vary from 0.5-2 BqL^{-1}or 5-20 TU. The measurement of tritium concentration in

rainwater is of great importance because it can be used for hydrology investigations, such as the recharge mode or the vulnerability of aquifers [2,3,4]. The Tritium Laboratory of the Archaeometry Center of the University of Ioannina is among the few laboratories in Greece, which can perform tritium measurements in water samples [2,3,4,5]. A series of tritium concentration measurements in precipitation samples from the area of Ioannina, Northwestern Greece, measured at the Tritium Laboratory, is presented in Fig. 2. In this figure a 3-5 times ratio of maximum to minimum values is observed and the yearly cycle is also noticeable. In the present study, atmospheric humidity was condensed to water using a commercial condenser. The study was conducted in the summer of 2016, following a single thunderstorm near the University of Ioannina and the aim was to explore the possibility of measuring tritium in the atmosphere in water samples other than precipitation and water from lakes, rivers and springs.

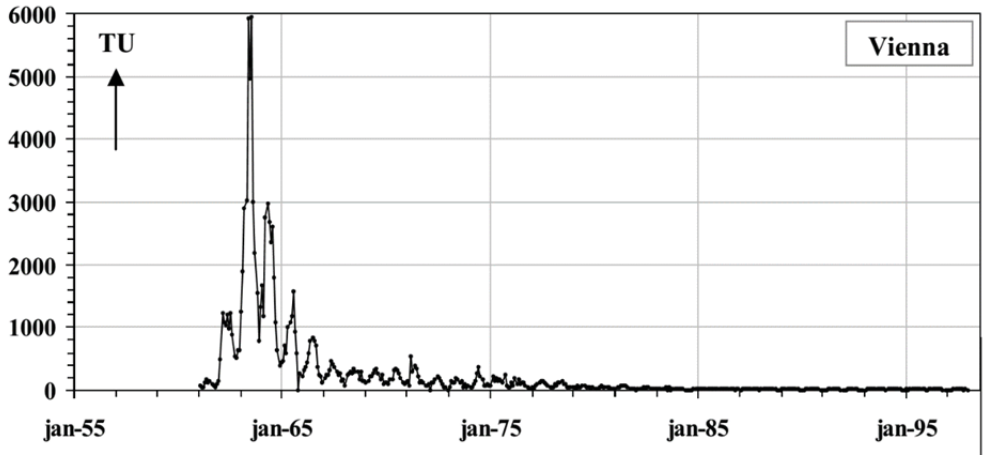


Fig. 1. Tritium concentration in precipitation during 1955-1985, at Vienna (1TU=0.119 BqL^{-1}).

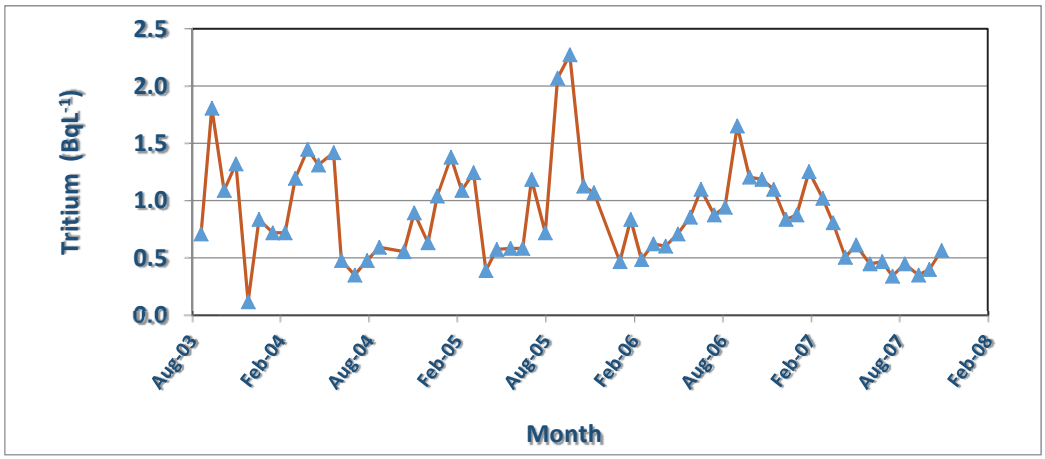


Fig. 2. Tritium concentration in precipitation during 2003-2008, at Ioannina.

MATERIALS AND METHODS

Seven condensed humidity samples and two rain samples were collected in consecutive days during August of 2016 and were sent for tritium measurements to the Tritium

Laboratory at the Archaeometry Center of the University of Ioannina. The Center is equipped with a super low-level background, liquid scintillation analyzer Tri-Carb 3170TR/SL (PerkinElmer, Inc), which is capable to measure very low concentrations of tritium for applications in radiation protection and underground water measurements. Without any further processing, 8 mL of each sample were added in a low potassium glass vial of 20 mL capacity and mixed with 12 mL of Ultima Gold LLT scintillation cocktail, suitable for low level tritium measurements. Each sample was measured for 1400 min with a mean of 2-3 % relative error (1sd). The background was also recorded during the same batch of measurements and the net count rate was obtained with a relative error of 20-30%. The increasing of the relative error occurred due to the fact that measurements of the samples showed count rate values close to the background count rates.

RESULTS AND DISCUSSION

Tritium concentrations in rain water varied from 1.76-2.52 BqL^{-1} showing an average value of 2.2 ± 0.5 BqL^{-1}, while concentrations in humidity samples varied from 1.9-3.2 BqL^{-1} with an average of 2.4 ± 0.4 BqL^{-1}. Individual tritium concentration values with the associated uncertainties (± 1sd) in seven humidity samples and two rain samples collected during August 2016 are presented in Fig. 3 and Table 1. Tap water and laboratory condensed humidity are also presented for comparison. The results show that the activity concentration of tritium in the condensed humidity water samples was similar to the activity of tritium in the initial rainfall sample. In Fig. 4, measurements of tritium concentration in rain during the whole year of 2016 are also presented, for comparison purposes. Results are given from pooled samples during consecutive months including the beginning or end of a month. Tritium content in rain, shows an increase during the summer months, while during the cold months of the year the concentrations tend to decrease. This seasonal variation in tritium concentrations is also observed in Fig. 2, where data from a 5-years period are presented. The present study results can lead to a new method of monitoring environmental tritium in the case of a tritium release accident, or in the interior of Nuclear Power Plant facilities.

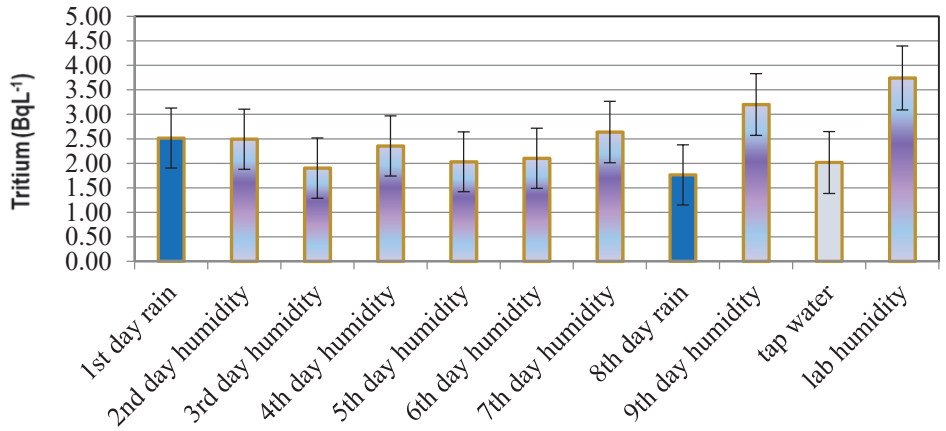


Fig. 3. Tritium concentration in rain and humidity during August 2016, at the University of Ioannina.

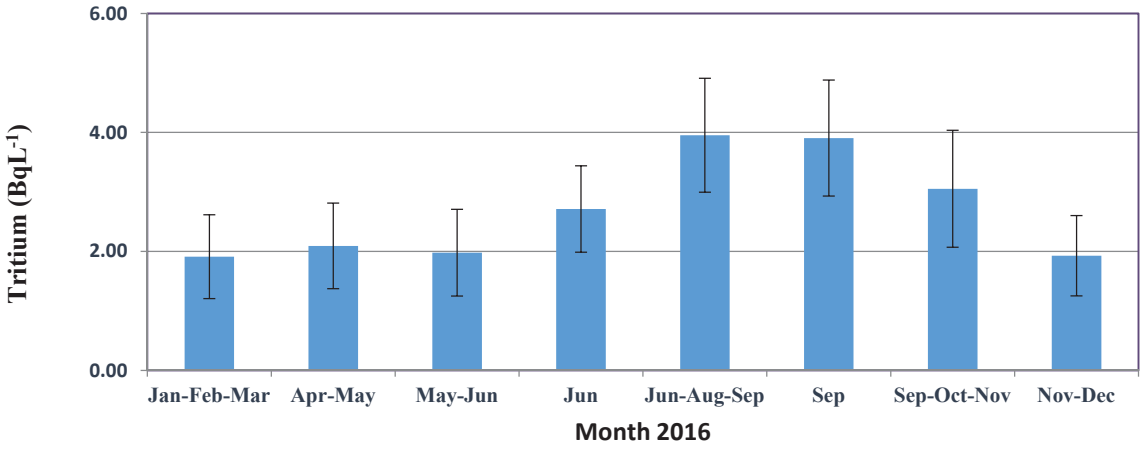


Fig. 4. Tritium concentration in precipitation during 2016, at Ioannina. Results are from pooled samples from consecutive months including the beginning or end of a month.

SAMPLES	*BqL^{-1} ± 1SD*
1st day rain	2.52 ± 0.61
2nd day humidity	2.49 ± 0.61
3rd day humidity	1.9 ± 0.61
4th day humidity	2.35 ± 0.61
5th day humidity	2.03 ± 0.61
6th day humidity	2.1 ± 0.61
7th day humidity	2.64 ± 0.63
8th day rain	1.76 ± 0.61
9th day humidity	3.2 ± 0.63
tap water	2.02 ± 0.63
lab humidity	3.74 ± 0.65

Table 1 Tritium concentration in humidity and rain samples, collected during August 2016.

References

[1] IAEA Tritium in the Atmosphere, in the "Environmental Isotopes in the Hydrological Cycle: Principles and Applications" Vol. 2.
[2] K.C. Stamoulis, D. Karamanis, K.G. Ioannides, Fusion Engineering and Design 86 (2), 206-213 (2011).
[3] K.C. Stamoulis, K.G. Ioannides, Proceedings of CEST2009, B-901-907, (2009)
[4] K.C. Stamoulis, K. Ioannides, P. Kassomenos, A. Vlachogianni, Fusion science and technology 48 (1), 512-515 (2005).
[5] https://sites.google.com/site/archaeometrycenter/tritium-laboratory