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A fast and reliable method for radiocarbon measurements in air and vegetation

Acronym: CARBONMAV

Stage 3/09.10.2020:

Monthly variation of ^{14}C activity in the air and the wild vegetation at ICSI Rm. Valcea for 12 months period

STAGE 3 REPORT

Stage 3 Objectives: Monthly variation of ^{14}C activity in the air and the wild vegetation at ICSI Rm. Valcea for 12 months period

Activity 3.1: Correlations between ^{14}C activity in the air and the wild vegetation;

Activity 3.2: Management activities and dissemination.

To achieve the project objectives, the specific activity of C-14 in vegetation (*Thuja occidentalis* L.) and the air were determined. The sampling location was the National Research-Development Institute for Cryogenic and Isotopic Technologies - ICSI Rm. Valcea is located 10 km south of Ramnicu Valcea in the Govora industrial area. This location has some particularities. A first particularity to take into account is the fact that the institute is located in an important industrial area. The institute operates a nuclear installation, namely "Experimental Pilot for Separation of Tritium and Deuterium", a semi-industrial installation designed for the detritiation of heavy water moderator of CANDU reactors. Until now, PESTD normal operation was with heavy water and tritiated water below the exemption level approved by Romanian legislation. Foreseen experiments will be done with tritiated heavy water moderator from Cernavoda NPP (CANDU reactor technology). It is well known that heavy water reactors (IAEA 2004) emit significant amounts of tritiated water and ^{14}C . The ^{14}C is a by-product resulting primarily from neutron activation of ^{17}O from heavy water molecules. The ^{14}C enters the natural environment as CO_2 and is found in water, air, soil, and sediments.

It should be noted that in the Govora industrial area operates a 315MW coal-fired thermoelectric power plant. Due to the Suess effect, a relative decrease of the ^{14}C activity on a local scale is expected as a result of the dilution of the carbon isotopic mixture by fossil carbon.

Vegetation samples were taken monthly starting with April 2019. As the device for active absorption of atmospheric CO_2 with Raschig tube was not finished until the end of 2019, the monthly sampling of atmospheric CO_2 was done using an experimental set-up which involves bubbling air through 3M NaOH solution. To maximize the absorption efficiency for bubbling, 2 gas washer flasks with a frit filter with a total volume of 1L were used. Starting with January 2020, the bi-monthly sampling of atmospheric CO_2 was started using a CO_2 absorption device that uses a Raschig tube and 4M NaOH solution. After two weeks of sampling, it was found that the sodium hydroxide solution is too concentrated and during sampling it becomes carbonated. Due to this fact, the CO_2 absorption is difficult and because the sodium hydroxide solution is sufficiently concentrated for sampling for two weeks it was decided to use a lower concentration of 3M NaOH. After reducing the concentration of the sodium hydroxide solution, its carbonation was no longer observed. Once these problems were

overcome, the bi-monthly atmospheric CO₂ sampling was successfully started starting with February 2020.

The determination of the C-14 concentration activity was done by the direct absorption method followed by liquid scintillation counting. This method consists of measuring the activity of the C-14 concentration contained in a known amount of carbon dioxide with the help of the Quantulus 1220 an ultra-low-level liquid scintillation spectrometer. In parallel with the air sampling, the CO₂ concentration was monitored using a gas analyzer type LICOR LI-850, the following figure showing the evolution of the CO₂ concentration in the atmosphere between December 2019 - October 2020:

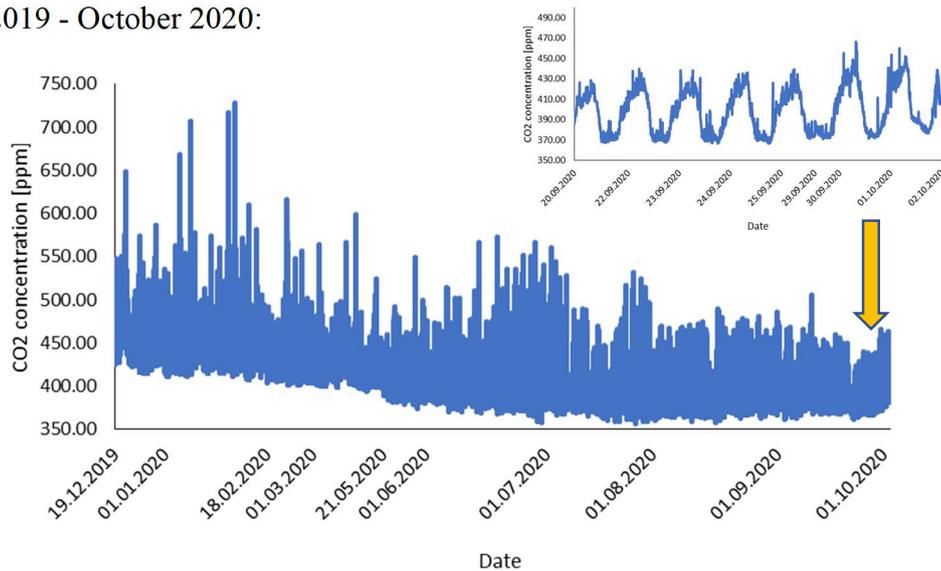


Fig. 1. Variation of CO₂ concentration in the atmosphere during December 2019 - October at ICSI Rm. Valcea

The following figure graphically represents the variation of the specific activity of C-14 in samples of: Thuja occidentalis, air taken by bubbling and air taken with Raschig tube during December 2019 - October at ICSI Rm. Valcea.

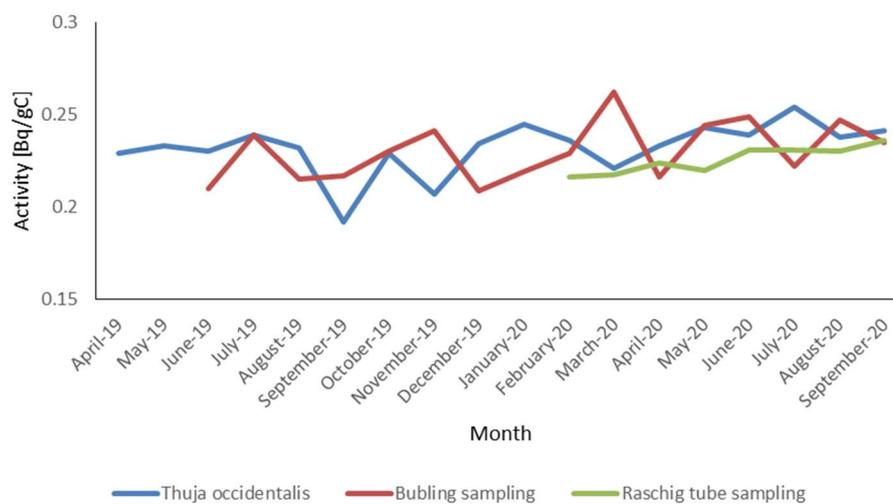


Fig. 2. Variation of the specific activity of C-14 in samples of: Thuja occidentalis, air taken by bubbling and air taken with Raschig tube during December 2019 - October at ICSI Rm. Valcea

It can be observed that the specific activity of C-14 was similar for all three types of samples investigated. The variations encountered generally within the limit of uncertainty associated with the activity of the C-14 concentration. The average specific activity of C-14 for the three types of samples recorded has the following values: 0.231 ± 0.08 Bq/ C for Thuja occidentalis, 0.262 ± 0.009 Bq/gC for the air samples taken by bubbling, and 0.236 ± 0.008 Bq/gC for Raschig tube samples. From the analysis of this evolution, it can also be concluded that the minimums and maximums of C-14 activity encountered in the air are found also in the vegetation with a delay of several months, the time necessary for the transfer of radiocarbon from the air to the plant.

For management and dissemination activities in this stage of the project, the following aspects were considered:

- Planning, monitoring, management, and project coordination. Actions were taken to acquire the equipment and materials needed to conduct the experiments from this stage of the project;

- Literature study for the correct interpretation of the data to achieve the objectives of this stage;

- In the period 08-14.09.2019 I attended the 5th International Conference on Environmental Radioactivity ENVIRA2019, where was presented the paper „Comparison of two air sampling methods for determination of the radiocarbon level in the atmosphere”, authors: Ionut Faurescu, Octavian Dului, Carmen Varlam, Denisa Faurescu, Irina Vagner, Diana Costinel. The event, which was attended by over 100 specialists from all over the continent, took place in Prague, Czech Republic, and was organized by the Nuclear Physics Institute of the Czech Academy of Sciences and Czech Technical University in Prague, in cooperation with Comenius University in Bratislava, European Academy of Sciences and Art, International Union of Radioecology and Journal of Environmental Radioactivity;

- Was published the paper entitled "RADIOCARBON LEVEL IN THE ATMOSPHERE OF RAMNICU VALCEA, ROMANIA", authors Ionut Faurescu, Carmen Varlam, Irina Vagner, Denisa Faurescu, Diana Bogdan, Diana Costinel in the RADIOCARBON Journal (IF2018 - 1.531), Vol 61, Nr 6, 2019, p 1625–1632.