Radiocarbon distribution in sediments of the cooling pond of the RBMK type nuclear power plant

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The radiocarbon, together with several isotopes of noble gasses such as $^{41}$Ar, $^{85m}$Kr, $^{87}$Kr, $^{88}$Kr, $^{133}$Xe, $^{135}$Xe, $^{135m}$Xe, is one of the main radionuclides discharged to the environment by nuclear industry. Different materials of neutron moderator, composition of reactor fuel and constructions, and the concentration of target nuclei for activation in these constructions leads to variations in amounts of discharged $^{14}$C. The RBMK (Russian Acronym for “Channelized Large Power Reactor”) is a graphite-moderated boiling water channel-type reactor with the principle of electricity generation the same as for boiling water reactors (BWRs). $^{14}$C produced in this type of reactor is released mostly in a gaseous carbon dioxide form and in much smaller quantities as liquid effluents [1].

The Ignalina Nuclear Power Plant (INPP) in north-eastern Lithuania, operated two RBMK-1500 Units (design electric power 1500 MWₐₚ): Unit 1 came online in December 1983 and was shut-down on December 31, 2004 whereas Unit 2 started operation in August 1987 and was shut-down on December 31, 2009.

The INPP used Lake Drūkšiai as a cooling pond by the closed cooling loop and for technological water supply, as well as for controlled industrial drainage discharges from the plant.

In this study radiocarbon activity measurements were performed in two organic fractions of the lake sediment core layers: alkali- soluble and alkali insoluble. During the period of 1945-1999, the radiocarbon activity in both fractions exhibited the parallel course. During first 14 years of operation, excess of $^{14}$C activity in both fractions reached $0.34\pm0.41\times10^9$ Bq. The period from 1999 to 2013 is distinctive by considerable increase of $^{14}$C activity in alkali soluble fraction (by $2.4\times10^8$ Bq) but in alkali insoluble fraction this increase did not exceeded $0.21\times10^9$ Bq. However, this radiocarbon distribution in both fractions during this period could be related with additional releases of $^{14}$C incorporated alkali soluble organic compounds used in technological process of NPP operation and/or maintenance. However, no information about increased activity levels of aquatic effluents or different chemical agents used could be found in INPP reports.

[1] IAEA, Management of waste containing tritium and carbon-14, Technical Report Series No. 421,