

EGU2020-8265

<https://doi.org/10.5194/egusphere-egu2020-8265>

EGU General Assembly 2020

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Investigation of carbon isotope ratio variations caused by natural and anthropogenic processes in lacustrine ecosystems

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The difference of radiocarbon (¹⁴C) concentration between terrestrial and aquatic samples is called the freshwater reservoir effect (FRE). The FRE is a potential issue for archaeologists dating fish bones, shells, human bones, or food crusts on pottery from sites near rivers or lakes. Studies on the FRE showed its variability in space and time, significant variations within one river or lake, different aquatic plants, and animals, or even single fish species of the lake [1, 2 and the references therein]. Therefore, dating the artifacts, it is very important to understand the nature of the FRE by studying processes that determine the redistribution of carbon isotopes in water ecosystems. It is important to obtain new knowledge on temporal variation of the FRE of a water system as due to climate change and anthropogenic activities it could be completely different at ancient times since such periods as Mesolithic, Neolithic and Early Bronze Age when aquatic resources were an important contribution to human nutrition are relatively poorly studied. The objective of the research was to examine how known anthropogenic factors affected carbon cycling in the lake systems, including how these changes are reflected in carbon isotope variations as well as the FRA of lake sediments and different species of fish.

Two completely different lake systems of eastern Lithuania were studied. Lake Tapeliai belongs to the huge drainage system and is permanently affected by hydrological changes. When Lake Drūkšiai served as a cooling pond for the Ignalina Nuclear Power Plant, its average temperature increased by 3-4 °C. Results revealed that over the last century the estimated radiocarbon freshwater reservoir age (FRA) in sediments of Lake Tapeliai varied from 1136±112 y to 5733±122 y. These changes were caused by old organic carbon import to the lake from a neighboring peat bog. The FRA in samples of different fish species differed by up to 500 y, whereas the variations in the FRA measured in samples of the same species reached up to 300 y. Radiocarbon activity measurements in the samples of fish caught in Lake Drūkšiai during the operation of the nuclear power plant were performed. During 1984-1999 years measurements showed that ¹⁴C activity in fish slightly exceeded (up to 5 pMC) atmospheric activity. However, during 2000-2009 it exceeded by 40 pMC. Unfortunately, no information about increased activity levels of aquatic effluents or different chemical agents used could be found in INPP reports. Data of the fish scales ¹⁴C activity

measurements are in good agreement with the data of the humic acid fraction of lake bottom sediments.

This data clearly indicates that there was an event in the year 2000 when substances from NPP with elevated ^{14}C content were introduced into the lake, although not exceeding the permissible levels.

This research was funded by a grant (No. S-MIP-19-16) from the Research Council of Lithuania

References

[1] Heritage Science (2013) 1(1), 1–622.

[2] Quaternary Science Reviews (2012) 48: 67–79.