Short communication

ISSN 2658-3518
LIMNOLOGY FRESHWATER BIOLOGY
www.limnolfwbiol.com

Identification of the dynamics of carbon accumulation in the Verkh-Invenskoe peatland by the method of Loss on Ignition

Mekhonoshina E.A.*, Novikova E.A.

Perm State University, Bukireva Str., 15, Perm, 614990, Russia

ABSTRACT. The Perm Kama region is characterized by numerous promising paleoar chives, and the paleoecological knowledge of the region is uneven. Identification of the dynamics of organic carbon accumulation in peat is included in the complex of studies used to reconstruct the state of the natural environment in the past. We have studied peat deposits of the Verkh-Invenskoe bog in the western part of the region. For this, depth measurements, sampling of a peat column, and laboratory analysis of samples throughout the thickness were performed. As a result, indicators were determined: Bulk Density (further – BD), Organic Matter Bulk Density (further – OMBD), Loss on Ignition (further – LOI), Long term average rate of carbon accumulation (LORCA). For the first time for the western part of the Perm Kama region, numerical data on the dynamics of carbon accumulation over the last 10.9 thousand years have been obtained.

Keywords: carbon, peatland, LORCA, LOI, paleoecology, Perm Kama region

1. Introduction

Paleoecological knowledge of the Perm Kama region is quite uneven. The region of the Upper Kama (from the village of Tyulkino to the village of Gainy) has been studied better than others. Dedyukhinsky Island and the adjacent area of the Chashkinsky Lakes should also be considered a well-studied area. At the present stage, several paleoarchives have been studied in detail in the southern part of the region: the Kungur forest-steppe, the region of mixed coniferous-deciduous forests and the environs of the city of Perm (Mekhonoshina et al., 2022). The western part of the Perm Kama region still remains practically unexplored. A promising paleoarchive for this part of the region should be considered the Verkh-Invenskoe bog.

The bog is located in the Kudymkarsky municipal district, its area is about 110 hectares. The Inva River flows along the eastern border, and its left tributary, the Vezhayka River, flows from the north.

2. Materials and methods

With the help of remote sensing data, vectorization of the swamp contour was carried out. The places for measuring the depth of the peat deposit were determined on a regular grid with a step of 150 m. The thickness of the peat layer was measured with a peat probe, which was immersed in the ground as far as possible - until it stops.

A point was chosen for the selection of a peat column, where the depth of the peat deposit turned out to be the greatest.

Drilling was carried out using a peat (Russian) drill. In total, 11 cores of 50 cm each were selected and described. At the same time, peat lay down to the level of 470 cm. Deeper, a homogeneous mineral layer composed of gray-blue clays was noted.

Further, the content of organic matter was determined by the loss on ignition method (Chambers et al., 2010) along the entire profile of the column. The essence of the method consists in ashing (calcining) peat samples in a muffle furnace at a temperature of 550 °C. A total of 460 peat samples were processed. The following indicators were calculated: BD (g cm^{-3}), OMBD (g OM cm^{-3}), LOI (g), LOI (%), organic carbon (%). Long term average rate of carbon accumulation was calculated using average values of carbon content differentiated by peat types (Loisel et al., 2014).

To date, the age of the peat sample from a depth of 462-464 cm has been determined by the AMS method. The analysis was carried out in the Poznan Radiocarbon Laboratory. The result of radiocarbon analysis of sample Poz-146486 is 9550 + 50 ^{14}C BP. This corresponds to the age of 10,9 kyr cal. BP. Calibration was performed using the Calib 8.2 online service

*Corresponding author.
E-mail address: elizamkh@psu.ru (E.A. Mekhonoshina)

Received: July 01, 2022; ***Accepted:*** July 28, 2022;
Available online: September 02, 2022

(Stuiver et al., 2021) using the IntCal20 calibration curve (Reimer et al., 2020). Based on the available sample date from the base of the column, the LORCA score is calculated.

In addition, a hypothesis was put forward about the possible flooding of the swamp area by a nearby stream during floods. For this, a profile of the Inva river valley was constructed, passing through the sampling point of the core. According to the hydrological post in the city of Kudymkar, the level of high waters (HWL) was determined.

3. Results

On the graph of the content of organic carbon relative to the depth of the column, 9 zones are distinguished (Fig.).

The average organic content (LOI) for the entire column is 89.28%. The minimum and maximum values for the column are 11.90% (469-470 cm) and99.30% (355-356 cm), respectively.

The average content of organic carbon is 43.65%. The minimum value is 5.95% (469-470 cm), the maximum is 50.39% (244-245 cm). Areas of increase and decrease in the percentage of organic carbon correlate with areas of increase and decrease in the percentage of organic matter throughout almost the entire depth of the column.

469 cm. The minimum value of the content of organic matter and carbon is noted – 5.95%.

467-447 cm. From a depth of 467 cm there is a sharp increase in values from 22.64% to 35%, continuing to a depth of 460 cm. Then there is an abrupt decrease in carbon (up to 29.2%) up to a depth of 455 cm, with a subsequent increase in values up to 49.1% at a depth of 447 cm. The average carbon concentration throughout the entire area is 32.8%.

447-423 cm. There is a decrease in values to 44.1% at a depth of 423 cm. The average value of the indicator is 46.8%.

423-393 cm. The zone is characterized by sharp jumps in the carbon content throughout its length with a maximum amplitude of up to 15%. The average carbon content is 43.2%.

393-218 cm. The values of this zone are rather homogeneous. The average percentage of carbon in this segment is 46.4%, which is higher than the average value for the entire column.

218-207 cm. At the site, the carbon concentration is uniform, but significantly lower than the previous and subsequent layers of peat with an average content of 39.9%.

207-40 cm. The average concentration of carbon again rises to 44.8%, the values of the indicator in this zone are characterized as homogeneous.

40-10 cm. On the site, fluctuations in the values of the indicator are observed from the minimum – 39.7% to the maximum – 46.9%.

10-0 cm. 10-0 cm. The values of the indicator are not available, since there was not enough material for analysis in this area of the peat column.

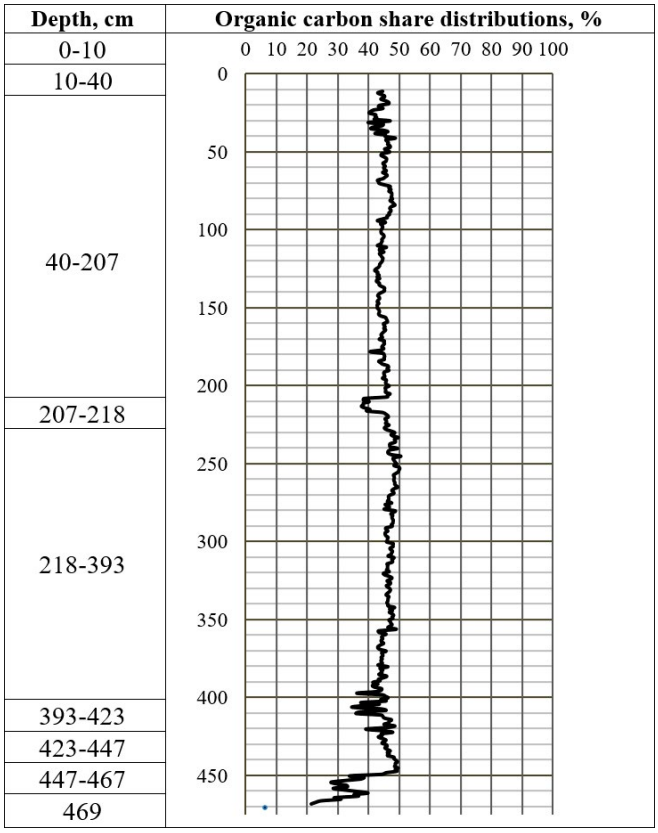

Fig. Distribution of organic carbon content

The curve of the content of organic carbon in the peat of the Verkh-Invenskoe bog remains at the same level over most of the core or fluctuates slightly. Several areas where sharp fluctuations were found are at the base of the column and its upper part.

Long term average rate of carbon accumulation (LORCA) was 26.43 g/m^2/year, with a total carbon mass (over the entire column) of 28.83 g.

4. Discussion and conclusions

The age of the base of the peat bog indicates that the formation of the bog began at the end of the preboreal period.

A significant difference in the content of organic carbon at depths of 469 cm and 467 cm is explained by the transition of sapropel deposits to peat, which was shown by a preliminary microscopic analysis of peat. In the area of 467-423 cm, fluctuations in the carbon concentration fall on the process of bog formation.

Subsequent fluctuations of the indicator, noted in the interval of 423-393 cm, are apparently associated with the introduction of minerals due to periodic flooding of the site during floods. The constructed profile of the valley of the river Inva indicates that the maximum level of high waters of the river could reach a depth of 320 cm of peat bog.

The homogeneity of the distribution of the values of the indicator in the interval 393-40 cm indicates a long-term development of the bog according to the transitional type, since there is no obvious decrease or increase in the content of mineral substances.

The fluctuations noted at a depth of 40-10 cm appear to be related to the accidental introduction of foreign clay in the sampler tube.

The study of the Verkh-Invenskoe bog peat column made it possible for the first time, for the western part of the Perm Kama region, to obtain numerical data on the dynamics of carbon accumulation over the last 10.9 kyr.

Acknowledgments

The authors are grateful to P.Yu. Sannikov, L.S. Shumilovskikh, I.F. Abdulmanova, E.A. Igosheva, D.E. Sivkov for help with the study.

Conflict of interest

The authors declare no conflict of interest.

References

Chambers F.M., Beilman D.W., Yu Z. 2010. Methods for determining peat humification and for quantifying peat bulk density, organic matter and carbon content for palaeostudies of climate and peatland carbon dynamics. Mires and Peat 7(7): 1-10.

Loisel J., Yu Z., Beilman D.W. et al. 2014. A database and synthesis of northern peatland soil properties and Holocene carbon and nitrogen accumulation. The Holocene 24(9): 1028-1042. DOI: 10.1177/0959683614538073

Mekhonoshina E., Kopytov S., Sannikov P. et al. 2022. The database of Late Pleistocene and Holocene paleoarchives in the Perm Kama region – PaleoPerm. Antropogennaya Transformatsiya Prirodnoy Sredy [Anthropogenic Transformation of Nature] 8(1): 58-77. DOI: 10.17072/2410-8553-2022-1-58-77 (in Russian)

Reimer P., Austin W., Bard E. et al. 2020. The IntCal20 Northern hemisphere radiocarbon age calibration curve (0–55 cal kBP). Radiocarbon 62(4): 725-757. DOI: 10.1017/RDC.2020.41

Stuiver M., Reimer P., Reimer R. 2021. CALIB 8.2. URL: http://calib.org