Short communication

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

Macro-charcoal particles in lake sediments of North-Minusinsk Basin (South Siberia, Russia) as indicator of natural and human-induced paleo-fires

Burdin L.A.[1], Bolobanshchikova G.N.[2], Rogozin D.Y.[1,2] *

[1] Siberian Federal University (SibFU), 79 Svobodny ave., Krasnoyarsk, 660041, Russia
[2] Institute of Biophysics SB RAS, 50/50 Akademgorodok str., Krasnoyarsk, 660036, Russia

ABSTRACT. Microscopic analysis of the core from the bottom sediments of Lake Shira (southern Siberia, Khakassia, Russia), have shown that for the last 100 years the sedimentation flux of charcoal particles sharply increased. This increase is consistent with the results for many lakes in the world and is presumably due to the current increase in anthropogenic impact, both in the form of accidental and deliberate arson, and in the form of burning wood and coal for heating residential buildings and recreation in the area adjacent to the lake. A flux of charcoal particles >100 μm into Lake Shira was estimated base on sedimentation traps in 2012-2019. It was shown that the particle flux increasing from October to May, which can be explained by two factors: the burning of fuel from surrounding villages at cold time and fires of steppe in April-May. During the warm season, this flow are significantly decreased, therefore, a impact of campfires is likely minor compare to village sources. Our data show a significant contribution of anthropogenic factors to the flow of coal particles from burning fuel and spring fires.

Keywords: charcoal, fires, lake sediments, sedimentation traps, Lake Shira

1. Introduction

The forecast of fire regimes under various climatic scenarios is an extremely urgent for Siberia, where fires pose a serious threat to natural ecosystems and a people. For an adequate forecast, information is needed on the frequency and intensity of fires in the past. In addition, a comparative assessment of the contribution of anthropogenic factors to the modern fire situation can only be made on the basis of a comparison of the modern fire situation with that reconstructed from natural archives. Lake sediments is one of the best archives of the past fire intensity (Marlon, 2020).

2. Materials and methods

Lake Shira (54°30' N, 90°11' E) is located in Republic of Khakassia (Russia), 15 km from the regional settlement the Shira. The lake is oval in shape, 5.3 × 9.3 km in size, 35.9 sq. km in area, maximum depth 25.4 m (2021). A core 110 cm long was sampled using a UWITEC gravity sampler (Austria). The age of bottom sediments was previously determined for another core based on radioisotope analyzes (Kalugin et al., 2013). Cores were compared by stratigraphic correlation of visually distinguishable layers. The analysis of charcoal particles was carried out in core sampling with a step of 1 cm based on the methods described in the works (Unkelbach et al., 2018; Anderson and Wahl, 2016). Sedimentation traps were installed seasonally from 2012 to 2019 at a depth of 20 m in the central deep part of the lake (N 54°30.350, E 90°11.350). Sedimentation traps were polypropylene cylinders, open at the upper end, 580 mm long and 103 mm in diameter. Sedimentary material from each trap, stored as a suspension in sealed plastic bottles, was thoroughly mixed and 100 ml was poured for analysis of charcoal. Samples of wet bottom sediments were kept in a deflocculating solution (6% sodium hexametaphosphate). After at least three hours, the samples were wet sieved through a tissue with a mesh size of 100 μm. The resulting residue was kept for 1 hour in 6% sodium hypochlorite for bleaching and again sifted through the same tissue. The residue was placed in a Bogorov chamber and viewed under a stereomicroscope in reflected light at 25x magnification. The sedimentary material of the traps was treated in a similar way, but without keeping in the deflocculating solution. Statistical analysis and plotting

*Corresponding author.
E-mail address: rogozin@ibp.ru (D.Y. Rogozin)

Received: May 27, 2022; ***Accepted:*** June 15, 2022;
Available online: September 02, 2022

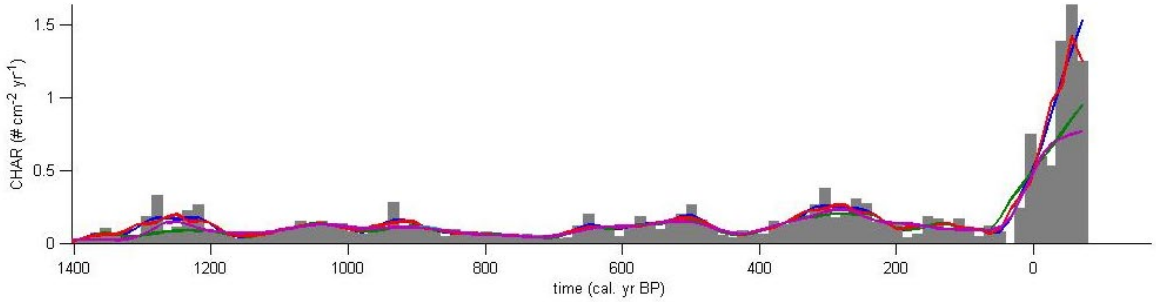

Fig. Dynamics of the flow of charcoal particles >100 micron into the bottom sediments of Lake Shira for the past 1400 years (0 means 1950 CE).

were performed using the CharAnalysis program (http://CharAnalysis.googlepages.com, Higuera et al., 2009).

3. Results and discussion

Charcoal particles >100 μm in bottom sediments are indicators of fires that occurred in a territory several kilometers adjacent to the lake (Unkelbach et al., 2018). Our results indicate that charcoal sedimentation flux sharply increased for the past ca. 100 yr (Fig.). This increase is consistent with the results for many lakes in the World and is presumably due to the current increase in anthropogenic impact, both as accidental and deliberate arson, and as burning wood and coal for heating buildings and summer camping fires in the area adjacent to the lake.

In all traps, charcoal particles of various shapes were found. These particles can be interpreted as the result of fires in the 10 km vicinity of the lake (Anderson and Wahl, 2016). The dynamics of flows showed a clearly pronounced seasonal dynamics with maxima in the period from October to May, and minima in summer and autumn. Obviously, in winter, the supply of charcoal from the burned fuel (coal, firewood) for heating dwellings in the surrounding villages increases significantly. However, in early spring, after the snow melts, the largest number of steppe fires is observed here, due to the presence of last year's dry grass. Thus, coals from two different sources - winter fuel combustion and spring fires - fall into the same October-May traps, so we cannot assess the contribution of each of the sources separately.

However, predominance of "particle" type charcoal indicates that the main contribution comes from fuel combustion. When burning steppe vegetation, one would expect the predominance of coals of the "grass" and "leaves" type, which is not observed in our case.

4. Conclusions

Our data show a significant contribution of anthropogenic factors to the sedimentation flow of charcoal particles in the Late Holocene, both as traces from burning fuel and traces from spring fires.

Acknowledgements

This work was funded by Russian Science Foundation, grant No. 22-27-00398 https://rscf.ru/en/project/22-27-00398/.

Conflict of interest

The authors declare no conflict of interest.

References

Marlon J.R. 2020. What the past can say about the present and future of fire. Quaternary Research 96: 66-87. DOI: 10.1017/qua.2020.48

Unkelbach J., Dulamsuren C., Punsalpaamuu G. et al. 2018. Late-Holocene vegetation, climate, human and fire history of the forest-steppe-ecosystem inferred from core G2-A in the 'Altai Tavan Bogd' conservation area in Mongolia. Vegetation History and Archaeobotany 27: 665-677. DOI: 10.1007/s00334-017-0664-5

Anderson S., Wahl D. 2016. Two Holocene paleofire records from Peten, Guatemala: implications for natural fire regime and prehispanic Maya land use. Global and Planetary Change 138: 82-92. DOI: 10.1016/j.gloplacha.2015.09.012

Kalugin I., Darin A., Rogozin D. et al. 2013. Seasonal and centennial cycles of carbonate mineralisation during the past 2500 years from varved sediment in Lake Shira, South Siberia. Quaternary International 290-291: 245-252. DOI: 10.1016/j.quaint.2012.09.016

Higuera P., Brubaker L., Anderson P. et al. 2009. Vegetation mediated the impacts of postglacial climate change on fire regimes in the south-central Brooks Range, Alaska. Ecological Monographs 79: 201-219. DOI: 10.1890/07-2019.1