The “Mercury breathing” of the Baikal rift zone according to the study of tree annual rings (on the example of Tunkinskaya depression)

E E Lyapina¹, E M Tursunalieva², L P Rikhvanov² and D V Yusupov²,³
¹Institute of Monitoring of Climatic and Ecological System SB RAS, Russia, Tomsk
²National Research Tomsk Polytechnic University, Russia, Tomsk
³AmurState University, Russia, Blagoveshchensk

E-mail: eeldv@mail.ru, tursunalieva.em@gmail.com, rikhvanov@tpu.ru, yusupovd@mail.ru

Abstract. The work evaluates the general distribution of mercury in the rings of trees of the Tunkinskaya depression (the Republic of Buryatia, the national park "Tunkinsky"). The used methods of dendrochronology and dendrogeochemistry allow us to estimate the contribution of different factors affecting the quality of the environment and ascertain the history of natural components pollution. In this research, the phenomenon of natural degassing of mercury in the Baikal Rift Zone (BRZ) according to the study of annual tree rings is considered. The BRZ covers 13 large parallel lobes separated from each other by high mountain ridges and bridges. Geodynamic activity of the zone is shown by contrast relief transformation and high seismicity. High tectonic and seismic activity causes the "output" of mercury to the surface. The dynamics of Hg concentration changes in the Tunkinskaya lobe for more than a half a century was observed. The average mercury content in the sample was 7 ng/g, the max – 35ng/g. The max concentration is detected in areas of the territory associated with free tectonic faults. The connection between the peaks of high mercury concentration in wood and periods of major earthquakes was detected.

1. Introduction

One of the most important problems in the list of global ecological issues is an environmental pollution with different matters. Mercury is one of the pollutants, which negatively influence both environment and human health [1].

Mercury accumulation in the living matters depends on different agents: type of studied subject, morphology features, level of mercury concentration in such conjugate environments, as soil, atmospheric air and others [2]. To a high degree, Hg comes into plants from the air; it is accumulated by bark and leaves [2]. Branches and roots of woody plants accumulate mercury less than leaves.

Dendrogeochemical method provides an opportunity to estimate dynamics of mercury concentration affected by both anthropogenic [3] and natural sources.

The objective of the research is to trace the change dynamics of mercury concentration in year rings of populusuaveolens on the territory of Tunkinskaya depression in the southwestern part of the Baikal Rift Zone.
The Baikal Rift Zone (BRZ) is a deep fault of Earth's crust in the continental part of Eurasia. In the centre of BRZ, there is a tectonic lake – Lake Baikal. The Zone has several depressions, one of which is the Tunkinskaya depression. It is a system of intermountain depressions of tectonic origin in the East Sayan Mountains (Buryatia) and the Irkutsk region, limited with the Khamar-Daban Range from the southeast.

The BRZ is one of the most earthquake-prone places in Russia. Annually, more than 2000 earthquakes with the magnitude of less than 5 occur throughout the BRZ territory. This fact makes the BRZ a unique subject for biogeochemical studies of “mercury breathing” in active tectonic faults [4].

2. Methods and research objects
This study aims to evaluate the general allocation of mercury in the trees of the Tunkinskaya depression (Republic of Buryatia, Tunkinskiy National Park). The Tunka depression is a continuation to the west of the Baikal rift zone. Its length from east to west is 190 km. From the south it is bounded by the Khamar-Daban Mountains and the spurs of the Khangarul ridge, from the north by the Tunkinskiygoletz, from the west by the southeastern chain of the Great Sayan. In the basin there are six separate basins, separated by narrowings of the bed of the Irkut-Bystrinskaya, Torskaya, Tunkinskaya, Turanskaya, Khoytogolskaya and Mondina.

Wood core samples were taken in July 2018 along and across the strike of the depression near settlements [5]. The wood core was sampled using an incremental borer in dry clear weather at the height of 1-2 meters from the surface of the Earth according to methodological recommendations [6]. The extracted samples were placed in paper boxes with the date, cardinal point of sampling, coordinates, and point number. Preparation of samples for analysis included: drying at room temperature in paper cases in a well-ventilated room, cleaning and sandpapering, marking of rings, dividing the core into annual rings and grinding them.

Ring marking was completed using a LINTAB device equipped with a binocular microscope. The mercury was measured on a RA-915M mercury analyzer with the PIRO-915 + attachment in the microelement analysis laboratory of the Uranium Geology International Research and Education Center at Tomsk Polytechnic University. Calibration was preliminarily carried out using the standard sample “birch leaf” (GSO 89232007, СО КООМЕТ 0067-2008-RU). Mercury concentrations are given per 1 g of dry matter. The lower detection limit of Hg is 5 ng/g. In total, 435 samples of annual poplar rings were analyzed.

3. Results and discussion
The average Hg content in the total sample is 7 ng/g, and the maximum content is 35 ng/g. According to the measurements, the largest range of Hg contents was detected in the annual poplar rings near the villages of Kyren, Galbai and Zun-Murino (figure 1). It should be noted, that the highest average mercury content among all studied trees is detected in poplar cores near the above mentioned villages, the highest Hg content among these locations is in the poplar core near the village Zun-Murino. The distribution of mercury content in the cores of these sampling points is characterized by the periods of from 13 years to 44 years and differs by a factor of 2.6 to 7 times.

So, near the village Kyren we distinguished two segments with an average Hg content of 22 ng/g from 1957 to 1973, and 5 ng/g from 1974 to 2018. A similar character is also detected in poplar core near the village Zun-Murino: increased mercury content from 1957 to 1981 (16 ng/g), then from 1982 to 2006 a decrease of CHg to 5 ng/g, and after 2007 again increased to 13 ng/g. Dynamics of mercury in the poplar core near the village Zun-Murino is characterized by the peak of increased mercury content - 14 ng/g in the period between 1978 and 2001, before 1977 and after 2001. The average content is detected in the region in the level of 2-4 ng/g.

The average Hg content in pine wood cores in the Tunkinskaya depression in the total sample is 22 ng/g, the maximum is 1842 ng/g, and the minimum is ≤5 ng/g. According to the measurements, the largest range of Hg content is detected in pine annual rings near the villages Tunka, Kyren and Talaya (figure 1). It should be noted, that the highest average mercury content among all studied trees is...
typical for pine cores near the mentioned villages, the highest among them is indicated in the poplar core near the village Tunka. The distribution of mercury content in the cores of these sampling points is characterized by periods of from 17 years to 23 years and differs from 3.7 to 79.5 times. So, near the village Talaya, there are two segments with an average Hg content of 26 ng/g during the period from 1972 to 1987, and 7 ng/g from 1988 to 2018. A similar character is detected in the pine core near the village Tunka: increased mercury level between 1993 and 1998 (318 ng/g), but between 1979 and 1991 and after 1998 the averaged content is 5 ng/g. Dynamics of mercury in the pine core near the village Kyren is distinguished by the presence of two significant picot with a mercury concentration of 56 and 26 ng/g, respectively, the average content from 1940 to 2018 is 5 ng/g.

**Figure 1.** Mercury distribution in annual rings of poplar and pine on the territory of the Tunkinskaya depression.
4. Conclusion
As a result of the study, the total content of mercury in various types of both natural and anthropogenically disturbed soils was determined. The average content of the element № 80 increases in the direction from west to east from the Tunkinskaya depression to the Bystrinskaya (from 6 to 8.6 ng/g).

The multiple correlation analysis showed a relationship between the study points of mercury in poplar cores over the past 20 years (1998-2018). However, it should be noted both the positive and the negative character of this connection.

The dynamics analysis of changes in the Hg content over the past 62 years at the sampling points of poplar core, allowed us to find the relationship between small and large earthquakes in 2008, 1999, 1959 and peaks of mercury content in the annual rings of poplar corresponding to this time period.

The mercury content in annual tree rings can serve as paleoindicators of deformations of the Earth's crust, recording both certain event processes of a short-term discharge of tectonic stresses, earthquakes themselves, and long-term dynamic loads on definite blocks of the Earth's crust.

The reaction to the rock deformations makes Hg a very sensitive strain tester, and its accumulation levels can be a source of important information in the study of dynamic processes in the Earth's crust.

The obtained data can serve as a basis for the spatiotemporal patterns analysis of mercury distribution in tectonically and seismically active areas, where environmental samples can be affected mainly by the natural sources of mercury emissions.

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