

# Influence of environmental and social factors on mercury accumulation in the hair of residents of the Northwest Russia

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**ABSTRACT.** Mercury is a global pollutant. The main source of mercury in the human body is seafood and freshwater fish. More than 90% of methylmercury from total mercury is found in fish muscles. The main aim of this study was to investigate the mercury levels in the hair of the population of the Vologda Oblast, Northwest Russia, where the heterogeneous distribution of rivers and lakes is the resource base of fishing. The mean mercury concentration in the hair of residents of the Vologda Oblast was  $0.445 \pm 0.018$  mg/kg. 10.7% of the samples studied had mercury concentrations exceeding 1 mg/kg. The minimum mercury concentrations were detected in residents of Cherepovets and the eastern districts of the Vologda Oblast. Residents of western districts, where local reservoirs are the main sources of commercial fish, had the maximum concentrations. There were no differences in the amount of this metal between men and women. At the same time, mercury concentrations in men and women from the western districts of the Vologda Oblast had a higher percentage of exceeding the recommended standards.

**Keywords:** mercury, human hair, recommended levels of mercury, consumption of wild fish

## 1. Introduction

Mercury is a neurotoxin for a living organism. Even low doses of mercury compounds can cause brain dysfunction (WHO, 2015). Fish is the most important source of mercury in Russia for the population. More than 90% of methylmercury (MeHg) from total mercury (T-Hg) is found in fish muscles (US EPA, 2010). The methylmercury contained in the muscles of fish during digestion is absorbed in the human intestinal tract by 95%. The determination of mercury in hair is widely used in assessing the level of metal intake into the human body (UNEP, 2008). The concentration of methylmercury in hair usually reaches 90% of the total amount of THg.

In different countries, the rationing of the mercury concentrations in the hair differs. According to the World Health Organization (WHO, 2015), the recommended mercury concentration in hair is 2 mg/kg. The US Environmental Protection Agency (US EPA, 2010) established recommended levels of mercury in hair < 1 mg/kg (NRC, 2000). At the same time, a recommended value of 0.58 mg/kg was established for women of reproductive age (Bellanger et al., 2013).

The mercury accumulation in the biotic and abiotic components of biosystems has been studied in

the Vologda Oblast over the past 25 years (Komov et al., 2016; Ivanova et al., 2020). Few studies have been conducted on the analysis of mercury concentration in human hair (Rumiantseva et al., 2018).

**The aim** of this study was to investigate mercury levels in the hair of the population of the Vologda Oblast, Northwest Russia, where the heterogeneous distribution of rivers and lakes are the resource base of fishing. There is traditionally a high level of consumption of wild fish by residents. Rather often, there are high concentrations of mercury in the muscles of fish in local water bodies, whereas the issue of mercury entering the bodies of the residents has not been sufficiently investigated.

## 2. Materials and methods

This study involved 1,643 residents of the Vologda Oblast for the period from 2016 to 2020. Samples of human hair in the form of a strand from the occipital part of the head, several mm thick, were sampled according to the recommendations of the World Health Organization. The mercury concentration was determined in the hair from the root with a length of about 2 cm (UNEP, 2008) using a RA-915M mercury analyzer (Lumex LLC, St. Petersburg, Russia).

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Each person signed an agreement to participate in the study. This study was carried out in accordance with the Helsinki Declaration of the World Medical Association (WMA) – Ethical Principles of Medical Research involving People (WMA, 2008). The program of this study was discussed and approved by the Bioethics Commission of Cherepovets State University and the Territorial Department of Health of the Vologda Oblast (No. 2-1/55).

Based on the results of the normality test, nonparametric methods were used, with a significance level (p) of less than 0.05.

### 3. Results and discussion

The mean mercury concentration in the hair of Vologda Oblast residents was 0.445 mg/kg. The main part of the sample had mercury levels in the hair less than 1 mg/kg. In 10.7% of the studied material, mercury concentrations exceeding 1 mg/kg were detected.

In different localities of the Vologda Oblast, there were different mean concentrations of mercury in the hair. Residents living in the western part of the Volga Oblast had significantly high mean concentrations: Kirillovsky District –  $1.226 \pm 0.235$  mg/kg, Vytegorsky District –  $0.954 \pm 0.125$  mg/kg and Babaevsky District –  $0.916 \pm 0.141$  mg/kg. Also, high values were detected in residents of the Belozersky District ( $0.739 \pm 0.182$  mg/kg) and Sokolsky District ( $0.679 \pm 0.138$  mg/kg). The mercury concentrations in the hair of people from the western districts of the Vologda Oblast were comparable with those in the hair of residents from areas where gold mining is developed (1.21 mg/kg and 1.61 mg/kg) (Harada et al., 2001).

The minimum mean concentrations of mercury were detected in residents of the Sheksninsky District ( $0.184 \pm 0.029$  mg/kg) and Cherepovets ( $0.327 \pm 0.017$  mg/kg), and also in residents of the Verkhovazhsky District ( $0.063 \pm 0.023$  mg/kg). Residents of the following eastern districts had intermediate values of mercury concentrations in their hair: Babushkinsky –  $0.398 \pm 0.053$  mg/kg, Kich-Gorodetsky –  $0.513 \pm 0.144$  mg/kg and Tarnogsky –  $0.540 \pm 0.083$  mg/kg.

Mercury concentrations were higher in the western part of the region due to natural and climatic conditions. Mercury methylation occurs in water bodies

with the formation of a compound toxic to organisms (methylmercury) that accumulates in the tissues and organs of aquatic animals and is transmitted along the food chain. Thus, we can assume that people living in the western districts are more exposed to mercury because lakes have favorable conditions for the conversion of mercury into organic form. The dimension value for the entire region is 1.98%, but for the western districts it exceeds 4%, and in the eastern districts it is a fraction of a percent.

There were no differences in the amount of mercury between men and women. Notably, mercury concentrations in the hair of men living in the eastern part of the region and in Cherepovets were less than 1 mg/kg, i.e. in 92% and 91% of cases, respectively. 33% of men living in the western regions of the region had metal concentrations exceeding 1 mg/kg (Fig. 1).

Mercury concentrations in the hair of women living in the eastern part of the region and in Cherepovets were also less than 0.58 mg/kg (the threshold, at which there is a risk of disruption of the nervous system in the fetus), i.e. in 87% and 89% of cases, respectively. At the same time, the concentrations exceeding 1 mg/kg (the threshold, above which mental retardation may occur in children in the future) were detected in 13 and 11% of women from these areas. At the same time, 35% of women living in the western districts of the Vologda Oblast were at risk (Fig. 2).

### 4. Conclusions

The mean mercury concentration in the hair of residents from the Vologda Oblast was  $0.445 \pm 0.018$  mg/kg, ranging from less than 0.002 to 7.64 mg/kg. 10.7% of the samples studied had mercury concentration more than 1 mg/kg. The minimum concentrations of mercury were detected in residents of Cherepovets and the eastern districts of the Vologda Oblast, and the maximum concentrations were observed in residents of western districts where local reservoirs are the main sources of commercial fish. There were no differences in the amount of this metal between men and women. At the same time, mercury concentrations in the hair of men and women from the western districts of the Vologda Oblast had a higher percentage of exceeding the recommended standards.

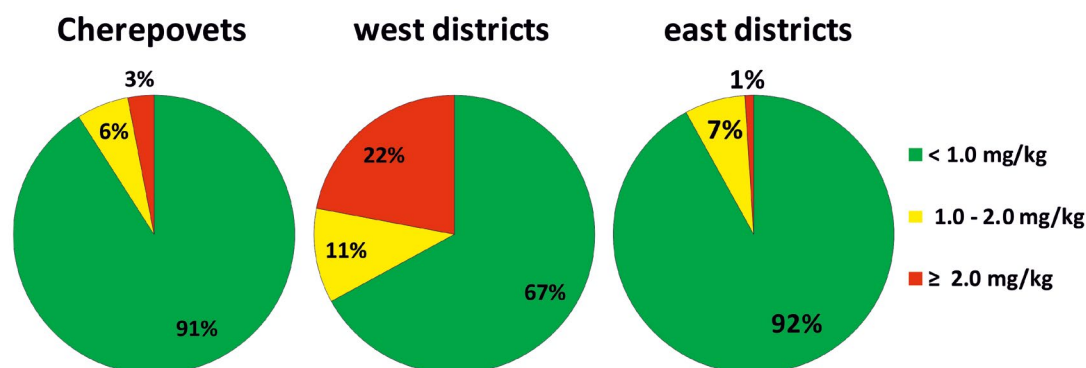


Fig.1. Percentage of mercury concentrations in the hair of men from different districts.

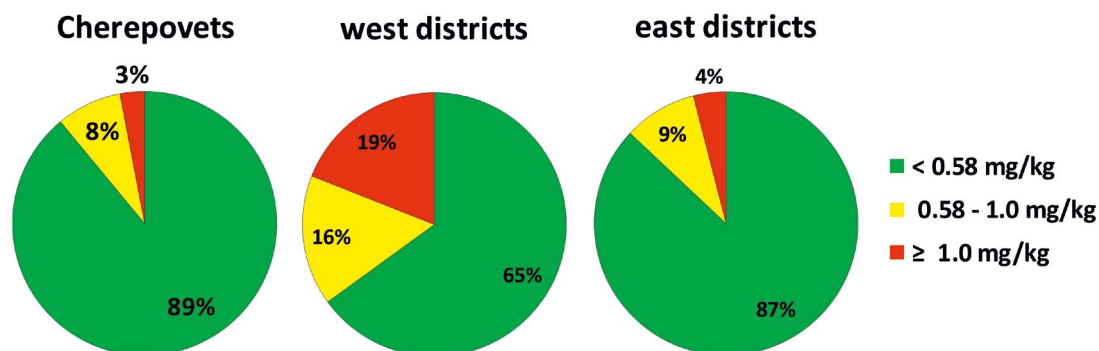


Fig.2. Percentage of mercury concentrations in the hair of women of childbearing age from different districts.

## Conflict of interest

Authors declare no conflict of interest.

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