Short communication

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

Total Hg level in hair, its predictors and relationship with health risk of Chelyabinsk residents

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ABSTRACT. We studied the total mercury concentration (T-Hg) in the hair of people living in Chelyabinsk. Hair analysis was combined with a survey evaluating relationships and variations among subgroups and potential metal exposure predictors. We determined the influence of factors such as age, gender, location of residence, smoking, hair color, T-Hg contents in soil, road dust, household dust as well as fish and potato consumption in the diet. The mean value of T-Hg in the hair for the subjects under study (0.402 μg/g) was lower than the value referred from the World Health Organization (WHO) (1–2 μg/g). There was no linear correlation between mercury hair levels and age or gender. We found a significant positive correlation between T-Hg concentration in hair and health cardiometabolic risk as well as the Hg content in road dust and the Hg of potato consumption in the diet. The data from this study can be used to develop prevention strategies for the health of residents.

Keywords: biomonitoring, human hair, total mercury, trends, health risk

1. Introduction

Mercury (Hg) is a volatile metal that is naturally present in the Earth's crust. Mercury has both natural and artificial sources. Natural sources of Hg include volcanic activity, erosion and the largest emissions as a result of degassing of the Earth's crust (Zhang et al., 2022). But in most cases, the main source of Hg is anthropogenic impact (Driscoll et al., 2013). The level of Hg in the environment is increasing due to emissions from the hydroelectric, mining and pulp and paper industries. Combustion of municipal and medical waste and emissions from coal-fired power plants also contribute to high levels of Hg (Sundseth et al., 2017).

It is important to note that there may not be a direct correlation between blood Hg concentration and the severity of its poisoning because Hg can be rapidly removed from the blood, redistributed and sequestered into various tissues (Halbach et al., 2008). Shortly after ingestion, Hg is believed to rapidly become tightly bound in the brain, spinal cord, ganglia, autonomic ganglia, and peripheral motor neurons (Yoshida et al., 1980). However, although the nervous system is the main repository for Hg exposure, transient and residual systemic distribution of Hg can cause symptoms in many organ systems. Hg accumulation in the heart is believed to contribute to the development of cardiomyopathy (Ivanova et al., 2021). The level of Hg in the heart tissue of people who died from idiopathic dilated cardiomyopathy was 22,000 times higher than in human heart of people who died from other forms of heart disease (Nyland et al., 2012).

Human biomonitoring studies assess human exposure to elements through the measurement of chemicals in body fluids and tissues such as blood, plasma, serum, breast milk, urine, saliva, lung fluid, nails, and hair (Astolfi et al., 2020). Hair has some advantages over other biological matrices. Elements can accumulate in hair at higher concentrations and for longer than other biomarker media such as urine and blood. The ability of hair to consistently accumulate chemicals within its internal structure, together with the ability to perform retrospective analyses, means that hair analysis can be used for screening and confirmation purposes in various application contexts such as forensic and clinical. Another advantage of using hair is the painless and non-invasive sampling and no need for experienced staff. Hair samples can be transported and stored at room temperature, and small sample sizes are required for analysis. The results of hair examination are a useful screening tool for assessing exposure, developmental and nutritional studies, and possible pathological processes.

The aim of this study was to investigate the levels of Hg in the hair of people living in Chelyabinsk, an industrial city in Russia. We observed the influence

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Received: June 16, 2022; ***Accepted:*** July 14, 2022;
Available online: July 31, 2022

of some factors on the variability of Hg concentration in hair and determined the relationship of Hg in hair with risk cardiovascular factors.

2. Materials and methods

A questionnaire was prepared to collect data on age, gender, location of residence, smoking, hair coloring, health, and diet. All participants gave free informed written consent in accordance with the World Medical Association Code of Ethics (Helsinki Declaration) to conduct experiments with human participation and to publish the results obtained. Only adults participated in the study. The privacy rights of participants were of paramount importance. The presence of metabolic syndrome was assessed according to Ivanova et al. (2021).

Hair strands from each participant were collected according to Grandjean et al. (1994) and then placed in plastic bags. We collected soil, road dust, and household dust in all locations and households. The main source of mercury and its compounds in the human body is fish (Bradley et al., 2017). We asked the frequency of eating fish per week. However, as the residents of the Chelyabinsk region eat little sea fish (rarely more than twice a week), they buy it in supermarkets, where it was tested for safety, we chose potatoes as a food product. We collected samples of potatoes; the source of Hg in them may be pesticides.

Soil and dust samples were taken and dried in an oven at 60 °C for 3 days and then crushed and sieved through a 1 mm polyethylene sieve to remove stones. After that, the dusts were sieved through a 63 μm sieve. Potato samples were washed in freshwater. A freeze dryer was used for drying potato samples.

The total Hg concentration (T-Hg) was determined by the atomic absorption pyrolysis method without preliminary **sample preparation** on a RA-915M mercury analyzer with PYRO (for hair and potato samples) and URP (for soils and dusts) attachments**.**

We used certified biological material (DOLT-5) to control the accuracy. Data analysis was carried out using the IBM SSPS Statistics 27. Correlations were assessed using the nonparametric Spearman coefficient.

3. Results

Table 1 gives some statistical parameters for the T-Hg concentrations in hair for all subjects in the study.

The correlation coefficients of several predictors with the measured T-Hg concentrations in hair were considered useful for understanding to what extent these factors influence the accumulation of mercury in the hair of the subjects. The data are presented in Table 2.

Table 1. T-Hg concentrations in hair.

Parameter (*n* = 71)	Hg value (μg/g)
Mean	0.402
Minimum value	0.092
Maximum value	0.931
Standard deviation	0.210

Table 2. Correlation coefficients of T-Hg concentrations in hair with other factors

Correlation type (*n* = 61)	*R* value
Hg concentration in hair	
Health cardiometabolic risk	**0.29***
Gender	-0.039
Age	-0.026
Place of resident	-0.113
Frequency of eating fish in a week	0.160
Smoking	0.105
Hair color	-0.104
Road dust	**0.291***
Soil	0.159
Household dust	-0.086
Potato	**0.338****

Note: * Correlation is significant at 0.05 (two-tailed)
** Correlation is significant at 0.01 (two-tailed)

4. Discussion

The overall mean value of the mercury concentrations in the hair samples (0.402 μg/g) was within the range (1–2 μg/g) that WHO considers normal for populations that do not consume fish with high methylmercury concentrations.

There was no linear correlation between mercury hair levels and age or gender. This could be explained by the relatively short biological half-life of Hg. We detected the positive significant correlations between T-Hg hair levels and road dust and potato. Our research revealed that mercury concentration in hair was significantly correlated with health. Mercury is currently considered a pollutant with a high human health risk and it has high toxicity and mobility in ecosystems. According to the literature, there are more than 250 symptoms associated with Hg exposure, which can make an accurate diagnosis difficult (Paduraru et al., 2022). The values of cardiometabolic risk factors of health (systolic blood pressure, diastolic blood pressure, cholesterol, and glucose) indicated a statistically significant dependency on T-Hg in hair.

5. Conclusions

The mean value of mercury in hair for the combined population is well within the range that WHO classifies as normal. The positive results of potato consumption in the diet proves its importance in the mercury content in the body and hair. More reliable conclusions require a greater number of cases to be sampled.

Acknowledgments

The study of Hg concentrations in the environment was funded by the Russian Science Foundation (RSF), project number 22-17-20006 (https://rscf.ru/en/project/22-17-20006/) and the Chelyabinsk Region. The relationship of T-Hg in hair with cardiometabolic risk factors was supported by the Ministry of Science and Higher Education of the Russian Federation (government order FENU-2020-0022).

Conflict of interest

The authors declare no conflict of interest.

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