

# *Mercury Levels in the Hair Of Indigenous Population of the Coastal Area of the Vologda Region, Russia*

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**Abstract** - Mercury or hydrargyrum (Hg) is an important neurotoxin for living organisms. Small doses of mercury can cause various disorders of the nervous system. The US Environmental Protection Agency (US EPA) has established recommended levels of mercury in hair (<1 mg / kg). The main source of mercury for human body is fish. In the period from 2017 to 2018, 231 residents of the coastal region of North-West Russia were examined for the determination of mercury in their hair. The average mercury content in the hair was 1.139 mg / kg. No difference in the level of mercury between men (mean = 1.222 mg / kg) and women (mean = 1.099 mg / kg) was found. The smallest amount of mercury is noted in the hair of people under 27 years old (0.579 mg / kg). A correlation was established between the amount of mercury in the hair and the amount of fish consumption. The concentration of mercury in the hair of people who consume fish several times a week (2.001 mg / kg) is 2 times higher than in the hair of people who consume fish less than 1 time per month is (1.070 mg / kg).

**Keywords**— mercury in hair, fish consumption, methylmercury

## I. INTRODUCTION

Mercury (Hg) refers to heavy and toxic metals. Mercury contamination can be caused by both natural factors and

industrial effects [12]. Mercury can get into the environment as a result of physicochemical and biochemical processes. In water reservoir, this metal is in an organic form (methylmercury), which is more dangerous for living organisms. Initially, mercury (Hg) enters the aquatic environment as a compound  $Hg^{+2}$ , then it begins to interact with organic substances and with the help of anaerobic organisms it turns into toxic substances of methyl mercury ( $CH_3Hg^+$ ) [1].

Hair is a biomarker of exposure to methylmercury. It is established that blood contains about 250 times lower mercury than hair [18].

Mercury (Hg) is an important neurotoxin for a living organism [13–15]. Even small doses of organic mercury can cause impaired brain function, and neuropsychological disorders in speech, attention and memory, and motor functions [16].

The US Environmental Protection Agency (US EPA) has established recommended levels of mercury in hair (<1 mg / kg) that correspond to a reference dose (RFD) of 0.1  $\mu g$  / kg body weight per day mercury levels [6]. For women of reproductive

age, a recommended reference value of 0.58 mg / kg has been established [7].

One of the main sources of the organic form of mercury for human body is fish [18].

In the waters of the Kirillovsky district, elevated concentrations of mercury were observed in the muscles of fish. Perch weighing more than 300 grams had an excess of maximum permissible concentration (MPC) in the Sheksninsky reservoir in Vozhe Lake [17].

The purpose of this paper is to assess the factors influencing the accumulation of mercury in the hair of residents of the coastal region.

## II. METHODS AND MATERIALS

Between November 2017 and March 2018, 231 people were examined in order to determine mercury in their hair. The samples were collected from the indigenous population of the coastal Kirillovsky district of the Vologda region of North-West Russia. Kirillovsky district is located in the temperate climate zone, its coordinates are 60 ° 07 'N. and 38 ° 37 'E (Fig.1).



Fig.1. The region of research

In this area, the locals catch fish from large lakes (Beloye and Vozhe, Sheksninskoe reservoir), as well as from other water reservoirs.

The study involved 157 women aged from 4 to 80 years and 74 men aged from 1 to 88 years. Hair samples were taken from the roots with the written consent of people to participate in the study. The survey participants were given a questionnaire in which they indicated their place of residence, gender, age, number and frequency of fish consumed from local lakes.

After filling up this form, the hair was placed in an envelope made of paper.

The mercury content in the samples was determined on a mercury analyzer by the atomic absorption method of cold steam without preliminary sample preparation.

In order to diagnose statistically significant differences in this work, the authors used the non-parametric method of the median test - Kruskal - Wallis test with  $p \leq 0.05$ . The Spearman's rank correlation coefficient was used to establish correlations

between the mercury content in the hair and the amount of fish consumed.

The data are presented as mean, median, minimum and maximum, standard deviation, standard error  $Q_{25}$ ,  $Q_{75}$ .

## III. RESULTS AND DISCUSSION

The average content of mercury in the hair of residents of the Kirillovsky district was 1.139 mg / kg and ranged from 0.001 mg / kg to 17.080 mg / kg (Table 1)

TABLE 1. DESCRIPTIVE STATISTICS OF MERCURY CONCENTRATIONS IN HAIR OF RESIDENTS OF KIRILLOVSKY DISTRICT, MG / KG

N	Mea n	Med	SD	SE	Min	Max	Q <sub>25</sub>	Q <sub>75</sub>
23	1.139	0.59	1.74	0.11	0.00	17.0	0.23	1.27
1		5	2	5	1	8	2	5

It is noted that the average level of mercury in the hair of residents of the Kirillovsky district is higher than the average values of this metal in the hair of residents of the countries of Germany and China, but lower than that of Brazilians [2–4] (Table 2).

TABLE 2.COMPARATIVE TABLE OF DATA ON THE CONTENT OF MERCURY IN HAIR DEPENDING ON THE LOCATION

Hg in hair (Germany) [2]	Hg in hair (Kirillovsky district)	Hg in hair (China) [3]	Hg in hair (Brazil) [4]
0.109 mg/kg	1.139 mg/kg	0.830 mg/kg	16.400 mg/kg

The concentration of mercury in the hair of Germans was determined in areas that are remote from water objects. A study in China and Brazil was carried out in coastal areas. Accordingly, our data are comparable to coastal areas of other countries.

The concentration of mercury in the hair between women and men is not significantly different (Fig. 2, Table 3). The average mercury value for men in the Kirillovsky district was 1.222 mg / kg, for women - 1.099 mg / kg.

The difference in mercury content among residents of coastal cities of China (men-0.94 mg / kg, women-0.72 mg / kg) and residents of Russia in the city of Cherepovets (men-0.174 mg / kg, women-0.201 mg / kg) by gender was also not detected [3, 5]. Moreover, gender differences were not established in the study on the territory of Upper Maroni, French Guiana (men -9.4 mg / kg, women - 9.9 mg / kg) [11]. At the same time, the differences in the level of mercury in the hair are noted by gender in the adult population of the Karakuwacho, Japan [9].

It is noted that the average value of mercury in the hair of women in the Kirillovsky district is significantly higher than the concentration of 0.58 mg / kg, which is the limit, exceeding which the risk of negative effects on the developing fetus

increases [7]. At the same time, the average value of mercury concentration in the hair of men in the Kirillovsky district does not exceed the recommendations (USEPA) of 1.0 mg / kg [6]. It is worth noting that an excess of 0.58 mg / kg of mercury in the hair of women was observed in 53.5% of all those examined. Excess of 1 mg / kg was observed in 32.4% of men in the region.

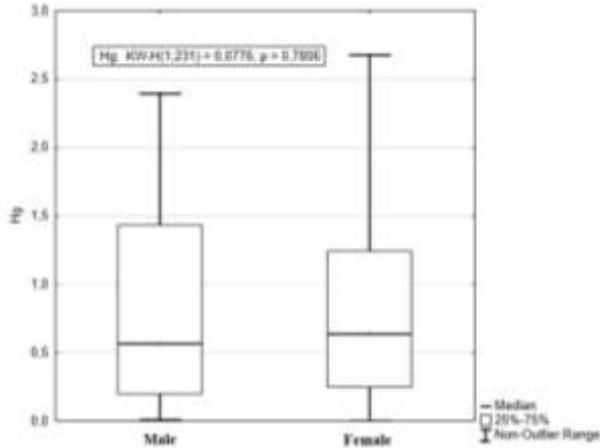


Fig 2. - Concentrations of mercury in the hair of men and women

TABLE 3. INDICATORS OF MERCURY CONTENT IN HAIR OF MEN AND WOMEN OF KYRILLOVSKY AREA, MG / KG

Gender	Mean	Med	SD	SE	Min	Max	Q <sub>25</sub>	Q <sub>75</sub>
Female(n=157)	1.099	0.637	1.482	0.118	0.001	8.764	0.245	1.242
Male(n=74)	1.222	0.564	2.204	0.256	0.007	17.080	0.199	1.430

All the people who took part in the study were divided into 4 age groups: the first - up to 27 years old, the second - from 28 to 45 years old, the third - from 46 to 59 years old, the fourth - from 60 years old and older. The mercury content in the hair of the people under 27 years old is significantly lower (0.579 mg / kg) than in hair of the people from 28 to 45 (1.557 mg / kg), the mercury content in the hair of people from 46 to 59 (1.172 mg / kg) and from 60 years and older (1.241 mg / kg) (fig. 3, table 4)

In previous studies of the coastal cities of China and in Cherepovets, Russia there was also an increase in the concentration of mercury in the hair with age [3.5]. The studies on the territory of Canada also found an association of increasing mercury in hair with age of women (n = 1870) and men (n = 1675) [8].

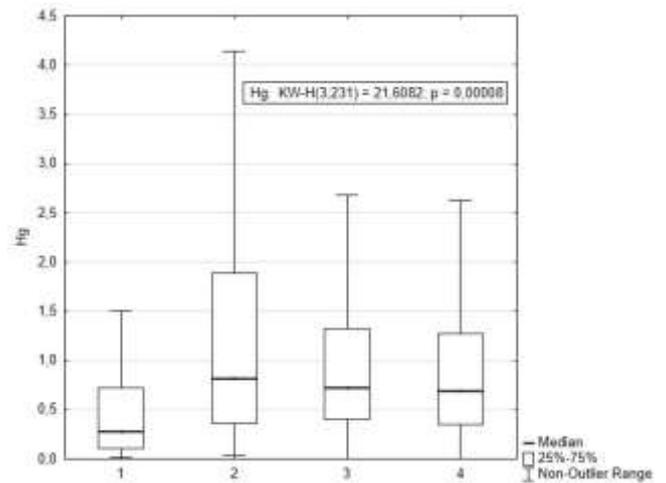


Fig 3. - The concentration of mercury in the hair in different age groups (1 – under 27 years old; 2 – 28-45 years old ; 3- 46-59 years old; 4 – older than 60 years old).

TABLE 4. THE INDICATORS OF MERCURY CONTENT IN HUMAN HAIR OF DIFFERENT AGE GROUPS, MG / KG

Age. groups	Mean	Med	SD	SE	Min	Max	Q <sub>25</sub>	Q <sub>75</sub>
1-27 y (n=58)	0.579	0.275	0.924	0.121	0.007	5.806	0.106	0.718
28-45 y (n=59)	1.557	0.821	2.474	0.322	17.080	0.356	1.885	2.474
46-59 y (n=57)	1.172	0.721	1.285	0.170	0.001	7.223	0.405	1.328
≥ 60 y (n=57)	1.241	0.686	1.755	0.232	0.001	8.764	0.350	1.275

The concentration of mercury in the hair depends on the consumption of fish by the residents of the Kirillovsky district once a month and several times a week are significantly different (Fig. 4, Table 5). The maximum concentrations of mercury were observed in the hair of people consuming fish several times a week (2.001 mg / kg). The average content of mercury in the hair of people who consume fish less than 1 time per month is (1.070 mg / kg).

In Japan, in the area of the Karakuwacho, where fish is the main source of food, the differences are also noted depending on the frequency of fish consumption among the adult population (n = 73) and children (n = 55) [9].

In studies on the territory of Canada, the differences were established depending on the frequency of fish consumption (fish consumption less than 1 serving per month - 0.44 mg / kg, fish consumption more often than one serving per month - 2.01 mg / kg) [8].

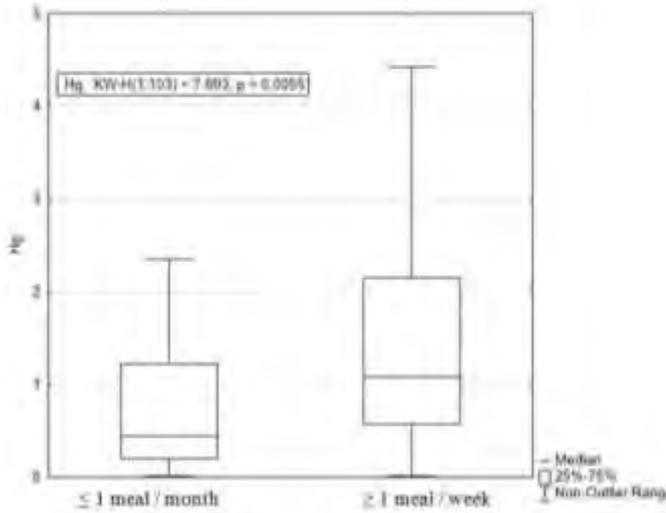


Fig 4. - The concentration of mercury in the hair of residents of the Kirillovsky district, depending on the frequency of consumed fish

TABLE 5. THE INDICATORS OF MERCURY CONTENT IN HUMAN HAIR DEPENDING ON THE FREQUENCY OF FISH CONSUMPTION, MG / KG

Fish consumption n	Mean	Med	SD	SE	Min	Max	Q <sub>25</sub>	Q <sub>75</sub>
≥ 1 meal /week (n=37)	2.001	1.078	2.875	0.473	0.011	17.080	0.581	2.156
≤ 1 meal /month (n=66)	1.070	0.443	1.521	0.187	0.007	7.223	0.206	1.226

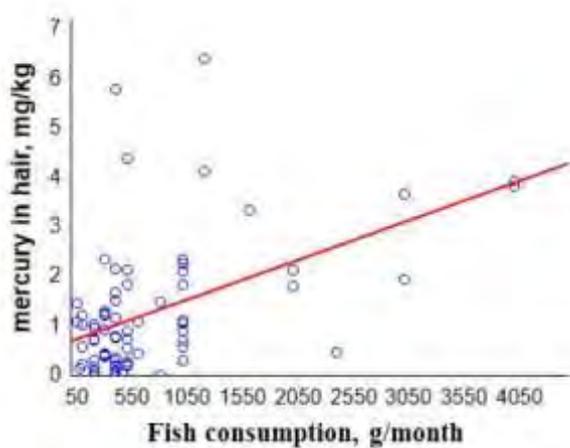


Fig 5. - Correlation between mercury in hair and fish consumption

In this work, the correlation is established between the level of mercury in the hair and the monthly consumption of fish ( $r_s = 0.415$ ,  $p = 0.000$ ) (fig.5). A positive correlation between the amount of fish consumed and the level of mercury in the hair was also established in the territory of Upper Maroni, French Guiana [11]. In the South China study, it was noted that the

more fish the population consume, the higher the risk from eating local fish to health [10].

#### IV. CONCLUSION

During the course of this study, the authors noted that the average mercury content in the hair of residents of the Kirillovsky district is significantly different from the levels of mercury in the hair of the European population. There are no statistical significant differences by gender, as well as in other studies. At the same time, in a part of the population, the excess levels of mercury in the hair in comparison with regulatory standards are noted. Significantly high concentrations of mercury are noted in the hair of residents of the Kirillovsky district over 30 years old. Depending on the frequency of fish consumption, it was found that reliably maximum concentrations of mercury were observed in the hair of people eating fish several times a week. This fact supports the established correlation between the level of mercury in the hair and the monthly consumption of fish (g / month).

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