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Spatial-temporal variability of mercury content in the river perch *Perca fluviatilis* Linnaeus, 1758 (Perciformes: Percidae) of the Rybinsk Reservoir at the turn of the XX–XXI centuries

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Received: 16.08.2018
Accepted: 29.10.2018
Published online: 20.05.2019

DOI: 10.23859/estr-180816
UDC 597.583.1:574.64
URL: http://www.ecosysttrans.com/publikatsii/detail_page.php?ID=113

ISSN 2619-094X Print
ISSN 2619-0931 Online

Translated by S.V. Nikolaeva

The amount of mercury (Hg) in the muscle tissue of the river perch (*Perca fluviatilis* Linnaeus, 1758) from different stretches of the Rybinsk reservoir was measured in a period from 1997 to 2012. Mercury concentrations were higher in muscles of perches from the Sheksna and Volga reaches, and lower in the Glavnyi and Mologa reaches, as well as Hg in bottom sediments from fish habitats. These values are shown to depend on the size of the fish and were found to increase in recent decades. The amount of mercury was determined in various organs and tissues of the perch. A positive correlation was established between the mercury content in all the studied samples and the mercury concentration in the muscle tissue in which it was the highest (up to 0.91 mg/kg wet weight). The bulk of the accumulated mercury present in the fish was found to be in the muscle tissue.

Keywords: reservoirs, accumulation of mercury, bottom sediments, ichthyofauna, abiotic and biotic environmental factors.

Gremyachikh, V.A., Lozhkina, R.A., Komov, V.T., 2019. Spatial-temporal variability of mercury content in the river perch *Perca fluviatilis* Linnaeus, 1758 (Perciformes: Percidae) of the Rybinsk Reservoir at the turn of the XX–XXI centuries. *Ecosystem Transformation* **2** (2), 34–44.

Introduction

Pollutants continue to enter aquatic ecosystems despite the improvement of technological processes and the tendency towards decreasing anthropogenic impact on the environment in recent decades (Hrabik and Watras, 2002; Moiseenko, 2009; Moiseenko and Gashkina, 2016). The problem of mercury (Hg) accumulation in fish remains relevant for many bodies of water in northern Europe (Strandberg et al., 2016). Large reservoirs of Russia, representing not only major waterways, sources of mineral resources, water supply facilities, recreation, but also the resource base of recreational and commercial fishing, affecting the diet of the human population, require particularly close study. One of these basins is the Rybinsk Reservoir, one of the largest reservoirs of the Upper Volga cascade, in which the living conditions for perch in different stretches differ in hydrological and hydrochemical parameters, composition and number of representatives of different trophic groups of biological communities, and their distribution across the water area (Kopylov, 2001; 2010; Litvinov et al., 2012).

For the first time, high levels of mercury accumulation in freshwater bodies of the north-west of the European part of Russia were recorded in muscles of perch inhabiting small (water surface less than 1 km^2) acidic lakes – up to 3.04 mg/kg wet weight (Haines et al., 1992; Stepanova and Komov, 1997). Perch from water bodies with neutral pH values, which include almost all large lakes and reservoirs (S > 30 km^2), have many-fold lower mercury concentrations, but in some cases exceed 0.3 mg/kg (Gremyachikh and Komov, 2015). Such mercury content may pose a risk to the health of warm-blooded animals, in the diet of which fish is an essential element (Scheuhammer et al., 2007; Wiener et al., 2007).

Table 1. Content and proportion of mercury in various organs and tissues of perch relative to its total amount in the body. Mean values of indicators ± standard deviations are above the line; minimum and maximum values are below the line. Statistically significant meanings are highlighted.
* – Coefficients of correlation between the indicators of mercury concentration in an organ relative to its total amount in the muscles.

No.	Organ	Mercury content, mg/kg wet weight	Proportion of the weight of the body of the total weight of organs, %	The content of mercury in the body relative to its total amount in the organs, %	r_s, p < 0,05*
1	muscles	0.26 ± 0.06 / 0.10–0.68	49.2 ± 1.8 / 37.1–56.8	76.0 ± 1.3 / 67.8–82.4	1
2	heart	0.18 ± 0.1 / 0.001–0.91	0.15 ± 0.01 / 0.09–0.24	0.12 ± 0.04 / 0.001–0.37	0.67
3	axial skeleton	0.14 ± 0.03 / 0.05–0.46	7.81 ± 0.29 / 6.43–9.62	8.17 ± 1.02 / 2.01–13.02	0.52
4	liver	0.12 ± 0.05 / 0.03–0.80	2.42 ± 0.17 / 1.60–4.00	1.49 ± 0.18 / 0.66–3.03	**0.73**
5	scull bones	0.09 ± 0.05 / 0.02–0.59	10.6 ± 0.5 / 8.5–14.3	4.91 ± 1.27 / 0.24–14.15	0.55
6	kidneys	0.09 ± 0.02 / 0.03–0.25	0.24 ± 0.03 / 0.08–0.49	0.11 ± 0.02 / 0.06–0.22	**0.88**
7	stomach	0.08 ± 0.02 / 0.02–0.25	0.92 ± 0.08 / 0.51–1.52	0.54 ± 0.07 / 0.10–0.96	**0.72**
8	spleen	0.08 ± 0.02 / 0.02–0.19	0.15 ± 0.02 / 0.08–0.41	0.06 ± 0.01 / 0.03–0.09	**0.86**
9	gut	0.07 ± 0.02 / 0.001–0.27	1.00 ± 0.07 / 0.73–1.47	0.47 ± 0.11 / 0.02–1.54	**0.66**
10	gonads	0.05 ± 0.03 / 0–0.35	7.7 ± 2.3 / 0.49–26.08	1.80 ± 1.00 / 0–12.19	**0.68**
11	skin	0.06 ± 0.01 / 0–0.18	7.12 ± 0.25 / 5.51–8.79	3.51 ± 0.62 / 0–6.80	0.39
12	gills	0.05 ± 0.02 / 0.001–0.19	3.45 ± 0.21 / 2.32–4.57	1.30 ± 0.27 / 0.03–3.25	**0.70**
13	eyes	0.05 ± 0.01 / 0.001–0.15	1.56 ± 0.23 / 0.48–2.86	0.55 ± 0.15 / 0.01–1.52	**0.75**
14	brain	0.04 ± 0.01 / 0–0.10	0.36 ± 0.08 / 0.06–0.84	0.07 ± 0.02 / 0–0.21	**0.94**
15	pectoral fins	0.04 ± 0.01 / 0.03–0.14	2.86 ± 0.11 / 1.86–3.65	0.71 ± 0,20 / 0.12–2.51	**0.85**
16	scales	0.03 ± 0.01 / 0–0.10	4.52 ± 0.52 / 2.45–10.43	1.13 ± 0.36 / 0–3.98	0.22

For many years, river perch has been used as a model representative of ichthyofauna when studying patterns of mercury accumulation by fish from water bodies and watercourses of different typologies (Komov et al., 2004). At the same time, the perception of the main mercury depositing organs or tissues in perch has not yet been formed. In addition, no universal dependence of metal accumulation by fish from large lakes and reservoirs on hydrochemical and hydrobiological conditions has been derived.

Taking this into account, the following tasks were set: (1) analysis of the spatio-temporal dynamics of mercury concentrations in the muscles of the perch of the Rybinsk Reservoir and its reaches in recent decades; (2) the study of the distribution of mercury in the organs and tissues of the perch to determine the parts of the body of major and minor importance for mercury accumulation.

Material and methods

For the subsequent analysis of the mercury content, at the stations of the Volga, Glavnyi, Mologa and Sheksna stretches of the Rybinsk reservoir in 1997–2012 samples of bottom sediments (BS) were taken, perch were caught with nets and seine nets (104 females, 40 males and 5 juveniles).

BS samples were collected by a bottom grab sampler and dried at 39 °C for 3 days (Komov et al., 2017). Fishing, sampling and storage were carried out according to standard methods (Komov et al, 2004).

Samples were different in fish size and weight, so in some cases, a comparative analysis did not take into account fish weighing more than 100 g.

To determine the mercury content in different tissues, 12 perches from the Volga Reach weighing from 7 to 947 g were prepared to extract liver, kidneys, muscles, heart, stomach, spleen, intestines, gonads, brain, gills, eyes, bones of the head and axial skeleton, scales, skin and pectoral fins. The extracted organs and tissues were weighed (to determine the proportion of the mass of the organ in relation to the mass of the whole organism), and the concentration of mercury was determined in them. Based on the data obtained, the relative (%) Hg content in the organ of its total amount in the body of fish was calculated.

The mercury content was determined in 2–3 replicates by the atomic absorption method of cold steam on a Lumex RA-915+ mercury analyzer equipped with a PYRO attachment without preliminary sample preparation. The accuracy of analytical measurement methods was controlled using certified DORM-2 and DOLM-2 biological reference material (supplied by National Research Council of Canada).

The results were processed statistically using the univariate and multiple dispersion analysis (ANOVA) method and the LSD test procedure at a level of significance $p < 0.05$ (Sokal and Rohlf, 1995). All data were expressed as a mean ± *SEM* ($x \pm SE$). To identify correlations between the studied parameters, whose values

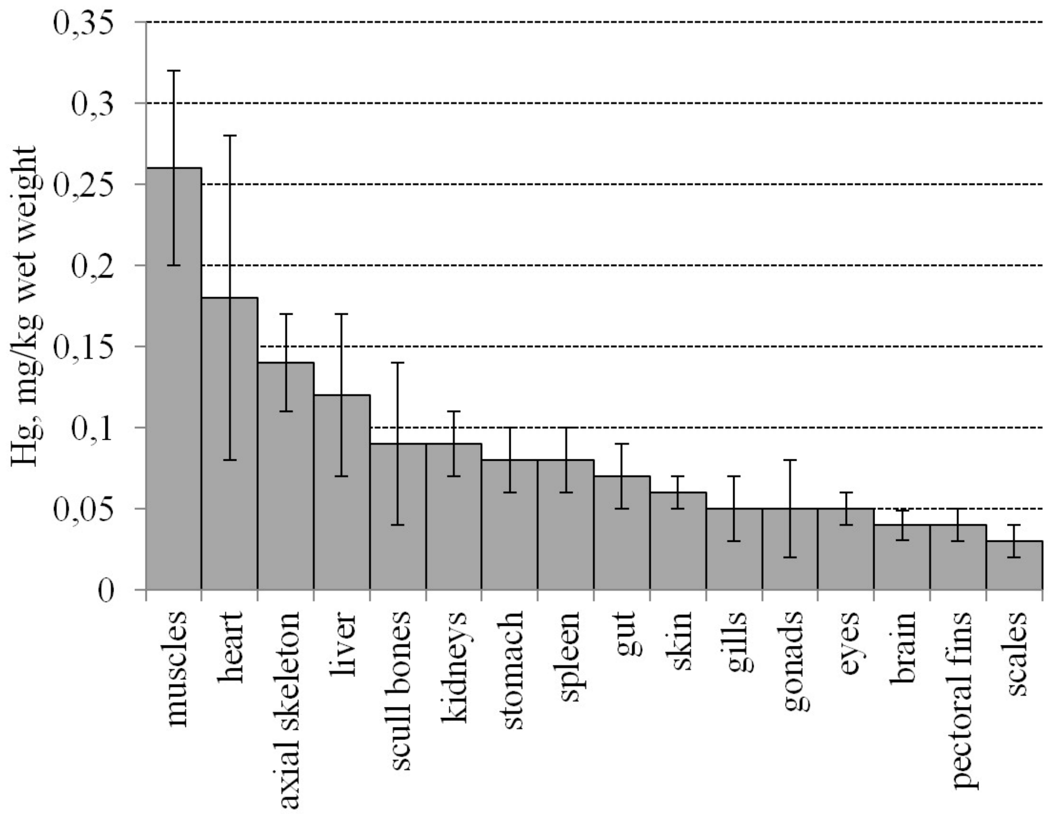

Fig. 1. Mean content of mercury in various organs and tissues of the river perch from the Rybinsk Reservoir.

in the samples do not have a normal distribution (Shapiro – Wilk test of normality), the non-parametric Spearman coefficient (r_s, $p < 0.05$) was used.

Results

The mercury content in the studied organs and tissues of 12 river perch specimens varied from values lying below the threshold for analytical determination of the instrument to 0.91 mg/kg. The mean Hg concentration was the highest (0.26 ± 0.06 mg/kg) in muscle tissue, and was lower in the axial skeleton, bones of the head and internal organs (0.03–0.18 mg/kg). Minimum concentrations were recorded in the brain, pectoral fins and scales (< 0.05 mg/kg wet weight) (Table 1, Fig. 1). Muscles accounted for the maximum proportion in the total mass of organs

Table 2. Average mercury content in the muscles of perch from the Rybinsk Reservoir (1997–2012). The mean values ± standard deviation are above the line; minimum and maximum values are below the line. n – number of fishes studied; L_2 – fork length of the fish (the distance from the tip of the snout to the end of the middle rays of the caudal fin).

Year	n	$L_{2,}$ cm	Weight, g	Mercury content, mg/kg wet weight
1997	8	13.3 ± 0.7 / 11.6–18.2	27.1 ± 4.8 / 16.2–58.0	0.08 ± 0.03 / 0.01–0.25
1998	18	17.3 ± 0.7 / 13.5–26.5	77.6 ± 14.1 / 29.9–297.6	0.20 ± 0.04 / 0.01–0.58
1999	6	30.0 ± 1.1 / 27.0–34.0	461.7 ± 61.6 / 308–672.0	0.37 ± 0.03 / 0.3–0.46
2000	9	12.8 ± 1.2 / 5.2–19.5	35.5 ± 7.8 / 16.5–95.4	0.04 ± 0.003 / 0.03–0.06
2001	4	39.3 ± 2.1 / 35.0–45.0	1006.3 ± 78.9 / 850.0–1200.0	0.44 ± 0.03 / 0.38–0.51
2002	13	30.5 ± 0.8 / 27.5–37.0	569.5 ± 68.8 / 400.0–1240.0	0.35 ± 0.03 / 0.25–0.57
2003	2	42.3 / 42–42.5	1226.0	0.56 / 0.4 and 0.72
2004	16	30.2 ± 1.0 / 25.6–37.0	493.5 ± 56.5 / 240.3–910.0	0.28 ± 0.05 / 0.11–0.82
2005	4	18.5 ± 2.2 / 15.0–24.2	92.4 ± 32.0 / 43.3–178.8	0.14 ± 0.04 / 0.08–0.25
2006	10	17.6 ± 0.9 / 13.2–22.7	81.3 ± 12.6 / 31.5–150.9	0.21 ± 0.02 / 0.09–0.29
2008	14	18.8 ± 2.0 / 3.5–33.3	90.4 ± 18.4 / 3.0–209.7	0.17 ± 0.03 / 0.03–0.39
2009	15	23.4 ± 1.7 / 16.3–33.2	278.5 ± 53.6 / 81.4–695.0	0.25 ± 0.04 / 0.06–0.58
2010	13	40.4 ± 17.8 / 13.5–244.6	254.1 ± 68.0 / 26.8–969.0	0.26 ± 0.02 / 0.13–0.41
2012	16	28.0 ± 1.7 / 17.5–42.5	351.1 ± 91.5 / 74.2–1543.0	0.41 ± 0.04 / 0.18–0.68
For all years	148	24.8–1.7 / 3.5–244.6	284.0 ± 25.4 / 3.0–1543.0	0.25 ± 0.01 / 0.01–0.82

(49.2 ± 1.8%) and in the total amount of accumulated metal (76.0 ± 1.3%) (Table 1). The concentration of mercury in the muscles was reliably correlated with the metal content in all the organs and tissues studied, in most cases the correlation was statistically significant (Table 2).

The concentration of Hg in the perch muscles of the Rybinsk Reservoir for the entire time of the study varied from 0.01 to 0.82 mg/kg wet weight (Table 2). The fish samples over the years were statistically significantly different in length, mass, and mercury content in the muscles, which positively correlated with the perch mass (r_s = 0.96, $p < 0.05$). In fish from different reservoir stretches, no statistically significant differences in the indicator values were found either when analyzing data for all samples or when limiting the weight of individuals to 100 g (Table 3), but concentrations were higher in the Sheksna and Volga stretches and lower – in the Glavnyi and Mologa stretches (Table 4).

The mean mercury concentration in the perch muscles of the Rybinsk Reservoir has increased over the years of research: when analyzing data for the entire sample (r_s = 0.29, $p < 0.05$) and when limiting the mass of the analyzed fish to 100 g (r_s = 0.37, $p < 0.05$). The same trend was also recorded in samples from the Volga, Glavnyi and Mologa stretches, while for the perch from Sheksna stretch, a significant decrease was observed in the indicator for the entire sample of fish (r_s = −0.88, $p < 0.05$) and for the perch weighing up to 100 g (r_s = −0.95, $p < 0.05$).

Table 3. Average mercury content in perch muscles from different stretches of the Rybinsk Reservoir in 1997–2012. Mean values ± standard deviation are above the line; minimum and maximum values are below the line. n – number of fish studied; L_2 – fork length of the fish (the distance from the tip of the snout to the end of the middle rays of the caudal fin).

Reach	n	L_2, cm	Weight, g	Mercury content, mg/kg wet weight	Year
Volga	12	16.50.6 13.5–20.5	62.9 ± 7.7 30–123	0.16 ± 0.02 0.04–0.27	1998
	4	13.0 ± 0.4 12.0–13.5	31.6 ± 3.6 24–38	0.03 ± 0.003 0.03–0.04	2000
	5	38.8 ± 1.7 35.0–45.0	985.4 ± 64.6 850–1200	0.45 ± 0.03 0.38–0.52	2001
	12	29.9 ± 0.5 27.5–34.0	541.8 ± 68.4 400–1240	0.33 ± 0.03 0.25–0.57	2002
	11	28.8 ± 1.2 25.6–37.0	422.8 ± 69.4 240–910	0.29 ± 0.06 0.11–0.82	2004
	8	23.6 ± 1.5 20.0–33.3	137.5 ± 17.3 58–210	0.26 ± 0.03 0.09–0.39	2008
	15	23.4 ± 1.7 16.3–33.2	278.5 ± 53.6 81–695	0.25 ± 0.04 0.06–0.58	2009
	5	27.1 ± 2.3 24.5–36.5	386.6 ± 146.2 226–969	0.31 ± 0.03 0.26–0.41	2010
	5	26.1 ± 0.8 24.0–29.0	233.6 ± 28.3 185–340	0.48 ± 0.08 0.21–0.68	2012
Glavnyi	3	21.0 ± 2.9 16.5–26.5	150.9 ± 74.2 57–298	0.05 ± 0.05 0.01–0.13	1998
	6	30.0 ± 1.1 27–34	461.7 ± 61.6 308–672	0.37 ± 0.03 0.3–0.46	1999
	1	19.5	95.4	0.03	2000
	2	19.1	104.3	0.18	2010

Reach	n	L_{2}, cm	Weight, g	Mercury content, mg/kg wet weight	Year
Mologa	8	13.3 ± 0.7 11.6–18.2	27.1 ± 4.8 16–58	0.08 ± 0.03 0.01–0.25	1997
	4	10.9 ± 1.9 5.2–13.2	24.5 ± 3.0 17–31	0.04 ± 0.01 0.03–0.06	2000
	2	21.9 ± 2.4 19.5–24.2	140.2 ± 39.6 101–180	0.18 ± 0.08 0.1–0.25	2005
	10	17.6 ± 0.9 13.2–22.7	81.3 ± 12.3 32–151	0.21 ± 0.02 0.09–0.29	2006
	4	9.4 ± 2.1 3.5–12.5	17.0 ± 5.8 3–28	0.06 ± 0.02 0.02–0.1	2008
	6	22.0 ± 2.5 17.0–32.5	195.4 ± 66.2 66–483	0.25 ± 0.04 0.13–0.36	2010
	11	28.9 ± 2.4 17.5–42.5	404.5 ± 131.2 75–1543	0.38 ± 0.04 0.18–0.61	2012
Sheksna	3	16.7 ± 0.6 15.6–17.7	63.1 ± 9.0 54–81	0.51 ± 0.07 0.36–0.58	1998
	2	42.3	1226	0.56	2003
	5	33.5 ± 0.8 31.3–36.0	488.8 ± 55.5 488–830	0.26 ± 0.06 0.18–0.49	2004
	2	15.1	44.6	0.11	2005
	2	18	49.2	0.05	2008

The mercury content in the bottom sediments of the reaches of the Rybinsk reservoir varied: in 2000, within 0.02–0.07, in 2016 – 0.01–0.3 mg/kg of dry weight (Table 5). Mercury content was higher in BS of the Sheksna and Volga reaches, lower in BS of the Glavnyi and Mologa reaches. Mercury content in the perch from different reaches was shown to correlate with the values of this indicator in BS (r = 0.95, p < 0.047), concentrations of nitrogen (N_{total}), chlorophyll (Chl_{total}) and the number of cladocerans (Lazarev et al., 2012) (r = 0.91–0.95, p < 0.1).

Discussion

The study showed that the lowest metal content is in the brain and gonads, while the highest is in the muscles. The gonads in fish are formed each year, so they should be considered as organs with the highest degree of self-renewal (Nemova, 2005; Svobodova et al., 1999). Muscles make up about half of the body weight of the fish, and this tissue contains about 80% of all the mercury that has entered the body. In other organs, the metal content is significantly lower due to their lower mass. High correlations between mercury levels in organs and tissues make it possible to roughly estimate the concentration of mercury in muscles in the presence of data on pectoral fins, gills, bones of the head and axial skeleton. This can be useful when working with collection material or when collecting incomplete fish remains in the field.

The results of this study agree with the findings of previous studies, where non-lethal approaches to assessing mercury pollution of the aquatic environment using fish as indicators were considered, and various methods of biopsy were used to obtain data (Ackerson et al., 2014; Schmitt and Brumbaugh, 2007). Thus, prediction of metal concentrations in the muscles of fish was carried out according to the values of the indicator in the fins (fin fragments) (Cervenka et al., 2011; Cerveny et al., 2016; Gremillion et al., 2005; Piraino and Taylor, 2013; Ryba et al., 2008). The statistically significant correlation between the metal content of muscles and fins creates additional opportunities to determine levels of mercury load on water bodies using perch as an indicator species. Its presence allows changes over time in the process of metal accumulation by fish to be tracked and simplifies the sampling procedure.

Maximum concentrations of mercury, according to literary data, are found in the liver, kidneys, muscles, skeleton and cardiac tissue (Cizdziel et al., 2003;

Gazina, 2005; Moiseenko, 2003; Popov et al., 2002). Depending on the type of fish and the amount of work carried out, the studied organs and tissues are arranged by the authors in different ways: liver > kidneys (Popov et al., 2002); liver > kidney > skeleton (Moiseenko, 2003); liver > muscles > gonads > blood (Cizdziel et al., 2003); heart > gills > muscles > liver (Gazina, 2005).

The correlation of the mercury content with the weight (size, age) of the perch established in this study is consistent with data from other studies (Chen and Folt, 2005; Dang and Wang, 2012; Hanna et al., 2015). Kannan et al. (1998) considered that body size plays a particularly important role because the accumulation of mercury, unlike other trace elements, in the body positively correlates with the length and weight of the fish. According to the other authors mentioned, the intensity of the metal bioconcentration depends on the size (weight) of the fish. It is shown that the mercury content of the food of young fish is low, and the rapid growth rates of young fish reduce the concentration of metal in their muscle tissue as a result of “growth dilution”. This effect is less pronounced in large fish specimens (the growth rate is lower), and the mercury content of the prey is higher (due to an increase in its size).

A complex multicomponent ecosystem of the Rybinsk reservoir, the interaction of a large number of abiotic and biotic factors, which remain poorly documented or even neglected, did not make it possible to put forward a simple explanation for the increased concentration of mercury in perch muscles in recent decades, especially since metal accumulation processes proceeded differently even in some parts of the reservoir (reaches).

For similar reasons, monitoring of mercury content in the muscles of two indicator species (bream, chub) from freshwater and estuary water bodies of five European countries (England, Germany, Netherlands, France and Sweden) in 2007–2013 did not permit an unambiguous conclusion about trends in the mercury bioconcentration process. Nevertheless, the results of these studies served as a basis for the following conclusions: the EU environmental quality standard (EQS) of 20 μg/kg of wet weight was exceeded at all sites and for all years except for one lake in Germany in 2012 (Commission Regulation ..., 2008); Further efforts are needed to reduce mercury emissions both to the atmosphere and directly to water (Nguetseng et al., 2015).

The established positive correlation of the Hg content in perch muscle tissue and the indicator parameter in the BS reaches of the reservoir suggests further work in this direction and a more in-depth analysis of the problem, since it is unclear whether the mercury concentration in the reservoir BS reflects

Table 4. Mean mercury content in muscles of perch from different reaches of the Rybinsk Reservoir over the entire study period. Mean values ± standard deviation are above the line; minimum and maximum values are below the line. n – number of fish studied; L_2 – fork length of the fish (the distance from the tip of the snout to the end of the middle rays of the caudal fin).

	Reach	n	L_2, cm	Weight, g	Mercury content, mg/kg wet weight
For all fish	Volga	77	24.9 ± 0.8 / 12.0–45.0	328.9 ± 33.8 / 23.9–1240.0	0.28 ± 0.02 / 0.03–0.82
	Glavnyi	12	25.1 ± 1.8 / 13.5–34.0	293.9 ± 61.6 / 26.8–672.0	0.23 ± 0.05 / 0.01–0.46
	Mologa	45	19.1 ± 1.3 / 3.5–42.5	157.7 ± 39.4 / 3.0–1543.0	0.21 ± 0.02 / 0.01–0.61
	Sheksna	14	26.3 ± 2.8 / 15.0–42.5	433.8 ± 118.6 / 22.1–1226.0	0.30 ± 0.06 / 0.03–0.72
For fish less than 100g	Volga	18	16.5 ± 1.1 / 12.0–33.3	55.5 ± 5.5 / 23.9=100.1	0.13 ± 0.02 / 0.03–0.39
	Glavnyi	4	17.4 ± 1.5 / 13.5–20.1	69.4 ± 17.0 / 26.8–97.9	0.06 ± 0.04 / 0.01–0.17
	Mologa	30	17.4 ± 1.5 / 13.5–20.1	47.2 ± 5.6 / 3.0–100.6	0.12 ± 0.01 / 0.01–0.27
	Sheksna	7	16.6 ± 0.5 / 15.0–18.0	53.8 ± 7.6 / 22.1–81.	0.26 ± 0.1 / 0.03–0.58

Table 5. Average mercury content (mg/kg dry weight) in BS of different reaches. Mean values ± standard deviation are above the line; minimum and maximum values are below the line. The number of studied fish specimens is below the line in parentheses.

Year	Reach			
	Mologa	Glavnyi	Volga	Sheksna
2000	0.05 ± 0.001	0.02 ± 0.001	0.29 ± 0.07	0.08 ± 0.005
	0.050–0.052 (4)	0.022–0.024 (3)	0.10–0.67 (4)	0.07–0.10 (6)
2016	0.06 ± 0.01	0.04 ± 0.01	0.16	0.19 ± 0.02
	0.01–0.14 (20)	0.02–0.07 (6)	0.15–0.16 (2)	0.14–0.28 (6)

the levels of metal accumulation in its fish.

A study of BS and the biota of estuaries of South Florida (Kannan et al., 1998) showed a positive correlation between total and methyl mercury concentrations in muscles of several species of marine fish and shellfish with total mercury concentrations in BS.

Analysis of the distribution of mercury in abiotic (water, soil) and biotic (zooplankton, zoobenthos, fish, birds, mammals) components of drainless neutral and acidic lakes of various typologies on the territory of Darwin State Reserve showed a negative correlation of mercury concentrations in fish muscles on its content in BS. At the same time, the highest concentrations of metal in BS were characteristic of neutral lakes, and in fish muscle, for acidic lakes (Stepanova and Komov, 2004). The discrepancy between the obtained results may be due to the fact that research was conducted in aquatic ecosystems of different types.

The correlation of mercury content in perch muscles and its concentration in water (N_{total}, Chl_{total}) and the abundance of cladocerans can be considered as a tendency. Published data on the effect of the above abiotic and biotic factors on the content of Hg in fish are inconsistent. According to Finley et al. (2016), the mercury content in muscles of brook trout (*Salvelinus fontinalis* Mitchell, 1814) negatively correlated with the pH values of the water and slightly positively with the trophic level of the reservoir, and with the content of total of P_{total}).

In an experimental study by Essington and Hauser (2003), the introduction of nutrients into reservoirs (an increase in the trophicity of lakes) promoted the growth of yellow perch (*Perca flavescens* Mitchell, 1814) and a decrease in mercury content in its muscles. According to the authors, this may be for 30–40% associated with growth dilution and, to a greater extent, with a change in diet – the transfer of food from benthic invertebrates to plankton.

In the present work, a positive correlation was established between the concentration of metal in fish muscle and the abundance of planktonic Cladocera. In studies conducted on the Volga reservoirs (including Rybinsk) in the last years of the twentieth century, it has already been shown that the mercury content in the muscles of perch is higher in sites with the maximum values of zooplankton biomass and the minimum values of phytoplankton (Stepanova and Komov, 2004). According to Chen and Folt (2005), the mercury content in phytoplankton and various-sized zooplankton decreased with an increase in their abundance, which was estimated from the concentration of Cl (mg/l) and the number of hydrobionts (specimen/l). The increase in phyto- and zooplankton abundance was negatively correlated with the Hg concentration in the muscle tissue of non-predatory and predatory fish.

The content of mercury in muscles of perch from the Rybinsk Reservoir over the study period tended to increase. The average values of the index for fish from the reaches were not statistically significantly different, but, just as in BS, they were higher in the Sheksna and Volga reaches, and lower in the Glavnyi and Mologa reaches. The absence of any significant patterns in the process of mercury accumulation in fish from hydrochemical and hydrobiological indicators of their habitats is probably due to the fact that these indicators themselves are variable and depend on the season and place of sampling.

A slight change in the Hg content in the perch muscles from the Rybinsk reservoir indicates the stability of the indicator and the possibility of its use for assessing the degree of mercury contamination of aquatic ecosystems. A necessary condition for obtaining a reliable result in a comparative analysis of samples of fish from different biotopes with different biocenoses will be a limited variation in the size and weight indicators of the specimens examined, since the concentrations of Hg in the muscles increase with the growth of the fish.

The results indicate that over the past decades the Rybinsk reservoir ecosystem is in a relatively stable state and is not subject to significant impact from changes in the external environment. At the beginning of the XXI century, the level of mercury contamination does not pose a serious danger to the reservoir ecosystem or to people who eat fish from it.

Acknowledgments

This work was performed within the framework of the state grant of the Ministry of Science and Higher

Education of the Russian Federation "Physiological, biochemical and immunological reactions of aquatic organisms under the influence of biotic and abiotic environmental factors" (No. AAAAA1818182690123-4).

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