Ecological state of the water objects in Perm Krai and prevalence of parasitic disease among the population

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Abstract. Perm Krai is a region with a high level of parasitic disease, which depends on the presence of natural focal points of infection, water pollution and social conditions. The article analyses the role of ecological state of water bodies and social conditions on the basis of population survey. It is confirmed that the pollution of water bodies is not a determinant factor of the spread of helminthiasis among the population. Social factors come to the fore.

1. Introduction
Perm Krai holds the top spot in Ural in terms of water and water-power resources. On the territory of Perm Krai there are nearly 29000 rivers with the total length of 90000 km., almost 800 lakes, more than 1000 swamplands with the overall area of 3 mln. hectares including the bog forests, 3 reservoirs and a large amount of ponds. The absolute majority of the rivers in the region are small, less than 100 km. long.

Intense development of the economy is accompanied by the increased involvement of water resources in the economic turnover. This leads to pollution of the water bodies and, as a rule, to the spread of parasitic disease among the population. In the absence of hydrobiological and hydrochemical observations on separate water bodies, the degree of their pollution and consequently their ecological state are estimated on the basis of indirect data, that are primarily based on the amount of sewage disposals.

2. Materials and methods
The article features materials from years of research into the pollution of water bodies in Perm Krai, as well as medical statistics on the prevalence of parasitic diseases among the population. Main research methods include: statistic method, scoring method and grading (used while characterizing the ecological state of various water bodies and the morbidity rate of parasitic pathology) [1], questionnaire survey.

3. Results and discussion
Several coefficients that characterize deviations from average values in the region (in fractions) were determined in the process of studying the anthropogenic impact [2] on water bodies: total waste water amount \( C_{wwa} \); polluted water amount \( C_{pw} \), the content of pollutants in the waters \( C_c \) in the context of administrative regions that border with Kama reservoirs. The largest discharge of waste waters per
1 km² falls on the household objects that are located in the basin of the Inva river and in the western part of the Kama reservoir. Large industrial enterprises are situated on these territories. The smallest discharge occurs on agricultural territories. Depending on the specialty of the area, chemical composition of the wastewater disposals is different. Thus, large proportions of the effluents in typical agricultural areas are taken over by nitrates, total nitrogen, total phosphorous, potassium, organic compounds and so on. However, health hazards of the wastes do not always correlate with their volumes. City wastes are characterized by the highest toxicity level. Heavy metals, petroleum products, formaldehyde and other toxic compounds can be found in the city wastewaters. On the whole, maximum permissible concentrations (MPC) of phosphates, nitrates, petroleum, phenol, copper, zinc, chromium and iron are exceeded in the region. Domestic wastewater makes a significant contribution in the overall pollution of the water bodies. Thus, in the city of Perm the first place among the sources of pollution is taken by the municipal unitary enterprise «Vodokanal». The same situations can be observed in other regions of the Krai. Their danger lies in the presence of pathogens of infectious and parasitic diseases.

The territory is ranked in accordance with the anthropogenic load [1] on the water bodies on a five-point scale: 1 point - coefficients \( C_{\text{wwa}}, C_{\text{pw}}, C_{c} \) range from 0 to 0,5; 2 points – from 0,51 to 0,9; 3 points – from 0,01 to 1,1; 4 points - from 1,11 to 2,0 and 5 points – more than 2,01.

**Table 1.** Average River Water Characteristics.

| River  | Site          | Annual average wastewater characteristics | The amplitude of perennial water level fluctuations,(m) |
|--------|---------------|-------------------------------------------|------------------------------------------------------|
|        |               | Water discharge, \( m^3/s \) | Unit discharge, \( l/s \) on a \( km^2 \) | Streamflow volume, \( km^3 \) |                                      |
| Kama   | Gayny         | 221,0 | 8,06 | 6,98 | 6,3 |
| Kama   | Bondyug       | 400,0 | 8,64 | 12,6 | 7,7 |
| Kama   | Perm          | 1640,0 | 9,70 | 51,8 | 12,6 |
| Veslyana | Zvuleva    | 66,5 | 9,35 | 2,10 | 4,4 |
| Kosa   | Kosa          | 40,8 | 6,44 | 129,0 | 6,7 |
| Vishera | Mitrakova  | 196,0 | 18,7 | 6,19 | 6,6 |
| Vishera | Ryabinino   | 485,0 | 15,7 | 15,3 | 7,8 |
| Yazva  | N. Yazva     | 90,0 | 15,4 | 2,84 | 7,6 |
| Kolva  | Petrezovo    | 37,6 | 13,3 | 1,19 | 4,9 |
| Kolva  | Pokcha       | 164,0 | 12,3 | 5,18 | 6,9 |
| Berezovaya | Buldyrya | 45,0 | 14,8 | 1,42 | 5,6 |
| Visherka | Fadino       | 29,8 | 10,1 | 0,94 | 8,7 |
| Yayva  | Podsludnoye  | 82,0 | 16,2 | 2,59 | 4,5 |
| Inva   | Sludka       | 33,1 | 6,35 | 1,05 | 6,5 |
| Kosva  | Ostanino     | 83,5 | 13,4 | 2,64 | 3,3 |
| Obva   | Rozhdvestvenskoye | 29,8 | 5,38 | 0,94 | 5,6 |
| Chusovaya | Kyn         | 71,0 | 6,83 | 2,24 | 6,8 |
| Usva   | Lyamino      | 218,0 | 9,36 | 6,89 | 6,9 |
| Vilia  | Usva         | 31,2 | 14,4 | 0,99 | 3,0 |
| Sylva  | Uzkiy        | 39,1 | 13,8 | 1,24 | 4,1 |
| Sylva  | Suksun       | 55,5 | 8,64 | 1,75 | 5,3 |
| Barda  | Podkamennaya | 144,0 | 7,31 | 4,55 | 9,2 |
| Iren   | Petilovo     | 21,9 | 11,5 | 0,69 | 3,8 |
| Babka  | Shubino      | 38,0 | 6,27 | 1,20 | 5,8 |
| Tulva  | Balaly       | 13,6 | 6,87 | 0,43 | 4,0 |
| Bystry | Barda        | 14,5 | 7,67 | 0,46 | - |
| Tanyp  | Chernushka   | 5,45 | 8,17 | 0,17 | - |
Surface waters of Perm Krai are represented by a huge amount of rivers. Their consumption is an environmentally significant factor that determines the abilities of the rivers to self-purify and, as a result, to resist anthropogenic impact (table 1).

Annual drainage yield is distributed on the territory of Perm Krai in the following way: The Vishera river is the largest in terms of water content from the Kama tributaries – 15,3 m³, then come the Chusovaya and the Sylva rivers – 11,8 m³, followed by the Yayva (2,8), the Kosva (2,6), the Veslyana (2,1), the Kosa (2,0), the Obva (1,3), the Inva (1,0), and the Tulva (0,9). Increase in the streamflow along the Kama river itself from its headstream: above the Veslyana mouth – 2,8; near Bondyug – 12,6; above the Yayva mouth – 28,0; near Perm – 52,0; near Chaykovsky – 55,0 [3,4].

According to the distribution of the total pollution coefficient in the river basins (table 2), the areas with the highest pollution are (sorted by the decrease in the pollution coefficient):

1). Basins of the rivers Kolva, Kosva and Chusovaya in the midstream with little water content (5 points). Despite the low score of the anthropological load (1-2 points), the ecological situation in this area ranges from satisfactory to critical.

2). The basin of the Berezovaya river in the upstream, the Kama river in the region of Berezniki and Solikamsk, as well as the river Kondas, the Inva, the Obva, the Nyta and the Iren with their tributaries. These areas are marked by low anthropogenic score - 1 point (with the exception of Berezniki and Solikamsk where the score reaches 4 points), however the ecological situation is characterized as satisfactory. It happens so due to low water contents (5 points) and the discharge of household sewage.

| Site                        | MPC Increase Rate | Water Content (in points) |
|-----------------------------|-------------------|----------------------------|
| Ryabinino (Vishera)         | 25 MPC – Mn       | 5                          |
| Ostanino (Kosva)            | 78 MPC – Fe       | 1                          |
| Lyamino (Usva)              | 21 MPC – Cr       | 3                          |
| Podkamennoe (Barda)         | 54 MPC – Cu       | 2                          |
| Petrezovo (Kolva)           | 62 MPC – Ph       | 1                          |

The areas of the least pollution are: 1) the basin of the Vishera river in its midstream and downstream (water content is 5 points), 2) the north-western part of Perm Krai (the Veslyana, the Pilva, the Kosa, the Kama river in the upstream with large water contents (from 4 to 1 points), 3) Kama and Votkinsk reservoirs. These are the areas where the reverse trend occurs - significant anthropological load (3-5 points) and high water content indicators make up a permissible ecological situation.

Despite the pollution of the water bodies by industrial and household waste waters, they are being used for fishing purposes (during the last five years only, the commercial fish catch in the Kama reservoir region has increased almost 4 times, 2,4 times in Votkinsk reservoir and 3,3 times in the Upper Kama basin [5]), which should contribute to the spread of waterway-transmitted parasitic diseases among the population [5-7]. In order to confirm this, we have compared the environmental assessment of surface waters and the prevalence of parasitic diseases in the area.

Perm Krai belongs to regions with high levels of parasitic morbidity: its long-term average annual is more than 2,5 times higher than the average in Russia, children’s rate is almost 5 times higher than that of the adults. More than 65% of the overall parasitic disease cases are registered in 13 territories of the Krai. The most disadvantaged territories are Krasnovishersky, Chaikovsky, Dobryansky and Usolsky districts as well as the territory of Komi-Permyak Okrug. In the structure of infectious pathology, parasitic diseases come third after ARVI and tick bites [8-10].

The most common and significant types of invasions transmitted by water are diphyllobothriasis, opisthorchiasis and giardiasis, the long-term average annual levels of which are 17,8; 7,2 and 123 accordingly per 100,000 people. In the structure of parasitic diseases, helminthiasis and protozoa contributed to 88.7%. The most unfavorable territories in terms of diphyllobothriasis prevalence are 6 territories. Okhansky, Chastinsky, Osinsky, Usolsky, Kosinsky, Ilyinsky, and Sivinsky which are
among the said territories are located in the basin of the Votkinsk and Kama reservoirs. The prevalence rate in them exceeds the average regional indicators by 2.9 - 6.8 times.

In order to assess the prevalence of parasitic diseases [1], coefficients which characterize deviations from the average values of the Krai (in fractions) were determined, similarly to the calculation of anthropogenic load: the rate of diphyllobothriasis prevalence (Cd), opisthorchiasis (Co) and giardiasis (Cg) in the administrative regions adjacent to the Kama reservoirs. The same ranking of the territory was carried out on a five-point scale as for the anthropogenic load on water bodies.

The comparison of the ecological situation of surface waters and the prevalence of parasitic diseases is provided in Table 3. With the help of it we can conclude that the prevalence of parasitic diseases does not have a direct connection with the pollution of water bodies. Apparently, other factors play a significant role in this as well, for instance, social factors. Thus, the results of the population survey of the Osa, Okhansky, Nytvensky, and other districts (more than 1,500 people) showed that river fish during the period of mass fishing make up a significant part in the diet of the local population. The reason for invasions is the eating of undercooked, non-salted fish and caviar. Salting and drying technologies (widely used in the field of fish conservation), guaranteeing the disinfection of fish, are not known by any of the surveyed. Only about 3% of respondents from the local population of the region have some ideas about helminth invasions, while the incidence rate of such fish as pike, burbot, perch and ruff in water bodies varies from 8.1 to 80%

**Table 3.** Characteristics of the administrative regions on the territory of Perm Krai located in the river basins, on the basis of the ecological state of the surface waters and the spread of parasitic diseases.

| Territory           | Ecological evaluation of the state of the surface waters | Evaluation of the parasitic disease prevalence |
|---------------------|----------------------------------------------------------|-----------------------------------------------|
| Krasnobishersky     | Strenuous                                                | Permissible                                   |
| Cherdynsky          | Permissible                                              | Satisfactory                                  |
| Solikamsky          | Strenuous                                                | Strenuous                                     |
| Berezniki           | Critical                                                 | Permissible                                   |
| Usolsky             | Satisfactory                                             | Satisfactory                                  |
| Yusvinsky           | Permissible                                              | Strenuous                                     |
| Ilyinsky            | Permissible                                              | Critical                                      |
| Dobryansky          | Satisfactory                                             | Satisfactory                                  |
| Perm                | Critical                                                 | Satisfactory                                  |
| Permsky             | Strenuous                                                | Permissible                                   |
| Krasnokamsky        | Critical                                                 | Strenuous                                     |
| Okhansky            | Permissible                                              | Strenuous                                     |
| Osinsky             | Permissible                                              | Strenuous                                     |
| Nytvensky           | Permissible                                              | Permissible                                   |
| Chastinsky          | Permissible                                              | Satisfactory                                  |
| Elovsky             | Permissible                                              | Satisfactory                                  |
| Chaikovsky          | Satisfactory                                             | Satisfactory                                  |
| Average             | Satisfactory                                             | Satisfactory                                  |
| In the Krai          | Permissible                                              | Satisfactory                                  |

Consequently, social factors play a significant role in the prevalence of parasitic diseases among the population along with the ecological state of water bodies, which generally leads to the infection of ichthyofauna.

**4. Conclusion**

1. Perm Krai is endemic to the prevalence of parasitic diseases transmitted by water. The formation conditions of their foci are both of a natural and anthropogenic character.
2. The main anthropogenic factor is the discharge of polluted wastewater into the water bodies of the Krai. A significant part of the wastes is attributed to domestic wastewater, which accounts for the infection of fish with biohelmints pathogens.

3. Comparison of the prevalence of parasitic diseases among the population and the environmental assessment of the surface waters showed that there is no close, direct connection between them, as apart from the anthropogenic load, social factors play a significant role in the situation as well, which is confirmed by the survey data.

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