

**Metals accumulation in sediments and whitefish of Kola Peninsula lakes,
Murmansk region, Russia**

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On the basis of researches of whitefish pathology and concentrations of metals (Ni, Cu, Zn, Co, Mn, Sr, Al) in its organs, which have been carried out for the last 20 years in Kola Peninsula lakes subject in various degree to influence of the emissions and wastewaters of mining and metallurgical enterprises, the dependences of metal accumulation and pathologies of whitefish from total and mobile concentrations of metals in sediments were determined. Whitefish is chosen as test-organism because it is benthophage and final part in foodweb of metal accumulation from water column and sediments, and its state is good index of lake water quality.

The highest accumulating ability in relation to Ni and high correlation with total and mobile concentrations of this element in sediments has been noticed in the most functionally important whitefish organs - kidney, liver and gills. It can be the good indicator of pollution of surface waters by this metal. The levels of disease incidence of whitefishes are in tight dependence on total and mobile concentrations of Ni in sediments. Since value of total concentration of Ni 200 µg/g dry wt. in sediments the percentage of diseased fishes is sharply increased. With increasing total and mobile concentrations of Cu, Zn and Co in sediments there are decreasing contents of these heavy metals in the functionally important whitefish organs, that is caused both features of metal metabolism and antagonistic interaction with other elements, first of all - Ni.

There is a lot of data, showing antagonistic interactions between Ni and Cu, explained not only by competition for common protein-carriers, but also by ability of Ni to replace Cu in various cell of metabolites. The contents of Cu in gills were increased with increasing concentrations in sediment. The highest coefficient of correlation with the mobile forms of Cu is probably connected with the fact, that during consumption of benthos by whitefish, particles of sediments polluted by Cu settle on gills, and that highest concentrations of dissolved and suspended forms of metals, including Cu, are in near-bottom water layers. Since value of total concentration of Cu 100 µg/g dry wt. in sediments the percentage of diseased fishes is sharply increased.

The concentrations of Zn and Co in organs of whitefish are in wide range. Zn accumulates in the highest absolute values in comparison with other investigated metals, despite of its lower contents in sediments, particularly in polluted water areas. The decrease of Zn contents in organs of whitefish with increase of concentrations in sediments is noticed, this dependence is especially found for the organ with the maximal contents Zn - gill. In the whole dependence of the contents of Zn in gills and kidneys reminds distribution of Cu in kidneys of whitefish. It is possible to explain it by antagonistic influence of Ni on Zn. Zn strengthens toxicity of Ni and Cu, which polluted superficial waters of region. The distribution of Zn in organs of whitefish from zones polluted by wastewaters of the mining and metallurgical enterprises is similar to Cu: with increasing contents of metal in sediments its accumulation in the vital is reduced. At the same time, the distribution of concentrations of Zn not always coincides with those for Ni and Cu, therefore does not come to light of precise dependences of disease incidence of whitefishes from concentration Zn, as it was noticed for Ni and Cu. The exception is dependence of disease index of fishes from mobile concentrations of Zn in sediments ($r=0.55$).

Co accumulates in the lowest absolute values in comparison with other investigated metals, as well as Co has the lowest contents in sediments. The decrease of the contents of Co in whitefish organs with increase of concentrations in sediments is noticed, this dependence is especially observed for the organ with the maximal contents of Co - skeleton. In the whole dependence of the contents of Co in whitefish organs reminds distribution of Cu and Zn. It is possible to explain it, as well as in case of distribution of Cu and Zn, antagonistic influence Ni on Co. Since value of total concentration of Co 30 µg/g dry wt. in sediments the percentage of diseased fishes is sharply increased. Coefficients of correlation of disease incidence of whitefishes with the contents of Co in sediments have rather high values ($r = 0.43-0.50$). Therefore, it is possible to speak about influence of increasing contents of Co on fishes, in combination with increasing contents of Ni and Cu this negative influence still amplifies.

The influence of the increasing concentrations of Ni, Cu, Zn and Co in sediments on whitefish state under water pollution by a number of metals conducts to increasing disease incidence. The correlations of whitefish disease incidence with mobile concentrations are higher ($r = 0.56-0.85$), but even with total concentration they are sufficiently high ($r = 0.34-0.85$). Combination of increased concentrations of Ni, Cu, Zn and Co in water and sediments for fishes are more toxic in many times, than each element separately.

Manganese accumulates in organism of fishes in the higher absolute values than Ni and Cu, but in values than Zn, in spite of the fact that the concentrations of Zn in water and sediments are usually much lower. The distribution of Mn in whitefish organs from its total and mobile concentrations in sediments differs from the earlier considered metals - from total has negative dependence, from mobile - positive. Therefore, it is

possible to conclude that the accumulation of Mn in whitefish organs is determined by concentration of the mobile forms in sediments. It is accepted to consider Mn as not very toxic element for water biota. This also proves by our investigations – parameters of disease incidence of whitefish have negative coefficients of correlation ($r = -0.20 \dots -0.46$) with total and mobile concentrations of Mn in sediments.

In zones of influence of mining and metallurgical enterprises and in territories of natural strontium geochemical provinces of the Kola Peninsula there is accumulation of Sr in all vital organs of fish. Sr is able to be accumulated in all systems of fish organs, in maximum quantities – in a skeleton. The pathologies of osteine (scoliosis), infringement of processes of development and paröstosis of brainpan (osteoporosis) are connected with development of suffering from gravel. Increased concentrations of Sr in water and sediments and its accumulation in the vital fish organs are connected to replacement of salts of Ca by other elements, in this case Sr. The reliable dependences of the percentage of diseased fishes from total concentrations of Sr in sediments are revealed.

The precise dependence of accumulation of Al in whitefish organs (liver, skeleton, gills) from the contents in sediments is revealed. The increased contents of Al in water, suspended substances and sediments is marked in zone of influence of wastewater of a patite industry, where the concentrations of Al in gills and skeleton of whitefish in tens time are higher in comparison with other lakes. The percentage of diseased fishes is growing up with increasing total concentrations of Al in sediments. The appreciable increase of disease occurs at excess of total concentration of Al in sediments up to value 25000 µg/g dry wt. (2.5 %).

The results of investigations of natural objects (reservoirs), in a various degree subject to anthropogenous influence, for definition of values of allowable concentrations of metals in sediment, influence of metals on their accumulation in organs, disease incidence of whitefishes were used. The contents of metals and their combinations in water, suspended materials, sediments in these reservoirs are in wide range, therefore it is difficult with a high probability to separate influence of each metal on water biota. Nevertheless, the supervision on natural reservoirs is advantage before other experiments with water biota. The unique data on anthropogenous loadings and response of water biota on this influence are received. These can be used for development of theoretical bases of an estimation of anthropogenous influence, its restrictions and reduction.