

# Study of Fresh Water Pollution with Metal Ions in the South Ural Region

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**Abstract** – The article presents spectrophotometric study of the content of biogenic and abiogenic chemical elements in surface and underground natural waters of the South Ural and other regions. The concentrations of the most important biogenic and abiogenic elements in these waters were determined. The excess concentrations of antimony and manganese in the samples were found. The problem of creation of regional selective filters for drinking water removing xenobiotics from it with a significant excess of MPC is formulated.

**Keywords** – *spectrophotometric research; qualitative and quantitative analysis; biogenic; abiogenic; chemical elements; natural waters*

## I. INTRODUCTION

Aquatic ecosystems present the habitat of the majority of living organisms on the Earth and the most important resource for human life support. The consequences of pollution of natural waters affect the health of ecosystems and humanity. The problem of clean water is becoming more acute in modern time. Water is not only necessary for a human to ensure his life, but not a single industry can function without it. Humanity is in need of water, while its vast reserves are used only to a very limited extent. The fact is that not all water is suitable for use.

The results of the analyzes show that in Russia every fourth sample deviates to a greater or lesser degree from the chemical indicators of water quality, and according to bacterial indicators, every fifth sample is dangerous to human health. This is especially relevant for open land-based sources of water use. The studies show that it is the result of irrational and often improper use of water sources.

## II. POLLUTION OF HYDROSPHERE AND RESEARCH METHODS

The composition of water is determined in specialized analytical laboratories. In such laboratories, sensitive spectrophotometers, photoelectric colorimeters, gas and liquid chromatographs, and potentiometers are used to determine the concentration of anions and cations [1].

Content of metal ions in river and lake water of various sources of the South Ural region in comparison with the northeastern regions of the United States [1]

| Water sample                            | River fresh water |       |       |       |       |
|---|-------------------|-------|-------|-------|-------|
|   | Mn                | Fe    | Zn    | Pb    | Sb    |
| Element                                 |                   |       |       |       |       |
| 1*                                      | 0.186             | 0.050 | 0.003 | 0.305 | 21.11 |
| 2                                       | 0.086             | 0.231 | 0.016 | 0.250 | 227.9 |
| 3                                       | 0.080             | 0.404 | 1.170 | 0.252 | 136.1 |
| 4                                       | 0.012             | 0.081 | 0.043 | 0.355 | 18.17 |
|   | Lake fresh water  |       |       |       |       |
| Element                                 | Mn                | Fe    | Zn    | Pb    | Sb    |
| 5                                       | 0.025             | 0.154 | 0.416 | 0.118 | 175.9 |
| 6                                       | 0.027             | 0.024 | 0.380 | 0.001 | 115.7 |
| 7                                       | 0.011             | 0.021 | 0.224 | 0.348 | 42.76 |
| 8                                       | 0.021             | 0.033 | 0.004 | 0.029 | 33.94 |
| maximal permissible concentration, mg/l | 0.10              | 0.30  | 3.0   | 0.01  | 0.005 |

a. \* Note: 1 – the Ural river; 2 – Akhunovo village (Chelyabinsk Region) river, 3 – Kizil river (Chelyabinsk Region); 4 – Mississippi river, Duluth (USA); 5 – lake, Karagaikii bor (Chelyabinsk Region); 6 - Urgan lake (Chelyabinsk Region); 7 - Itasca lake (USA); 8 - Pokegama lake (USA); Chelyabinsk Region - (Russia) [1].

b. The classic titrimetric chemical methods are not out of use. Talking about drinking water, its biological indicators should be checked. Specialized microbiological laboratory perform this process. The composition of water is regulated by the Sanitary Rules and Regulations (for example, for drinking water it is 2.1.4.1074-01). These norms are strictly regulated by law and require the creation of highly efficient treatment facilities for the disposal and treatment of wastewater [2, 3].

c. Table 1 shows the content of some of the most important biogenic and abiogenic trace elements in natural fresh water sources used for economic and fire-drinking use.

Annually the world economy dumps 1,500 km<sup>3</sup> of sewage of varying degrees of purification, which require 50–100-fold dilution to give them natural properties and further purification in the biosphere. It does not take into account the water of agricultural production. The global river flow (37–45 thousand km<sup>3</sup> per year) is insufficient for the required dilution of wastewater. Thus, as a result of industrial activity, fresh water ceases to be a renewable resource.

The representatives of animal world can contribute to the self-purification of water bodies from bacteria and viruses. Each mollusk filters over 30 liters of water per day. The biological factors of self-purification of water reservoir include algae, mold and yeast fungi. The purity of water reservoirs is impossible without the protection of their vegetation. Only on the basis of deep knowledge of ecological status of each water reservoir, effective control over the development of various living organisms inhabiting it, the positive results can be achieved, ensuring transparency and high biological productivity of rivers, lakes, reservoirs, underground sources and wellsprings. Other factors also adversely affect the processes of self-purification of water reservoirs. Chemical pollution of water reservoirs with industrial effluents reduces natural oxidative processes and kills microorganisms. The disposal of thermal waste water by thermal power plants has the same effect [2]. It is obvious that the use of open reservoirs for fire and domestic water supply requires more complex water treatment than the use of the same water for industrial or agricultural purposes [4].

Figure 1 shows the main ways of pollution of the hydrosphere.

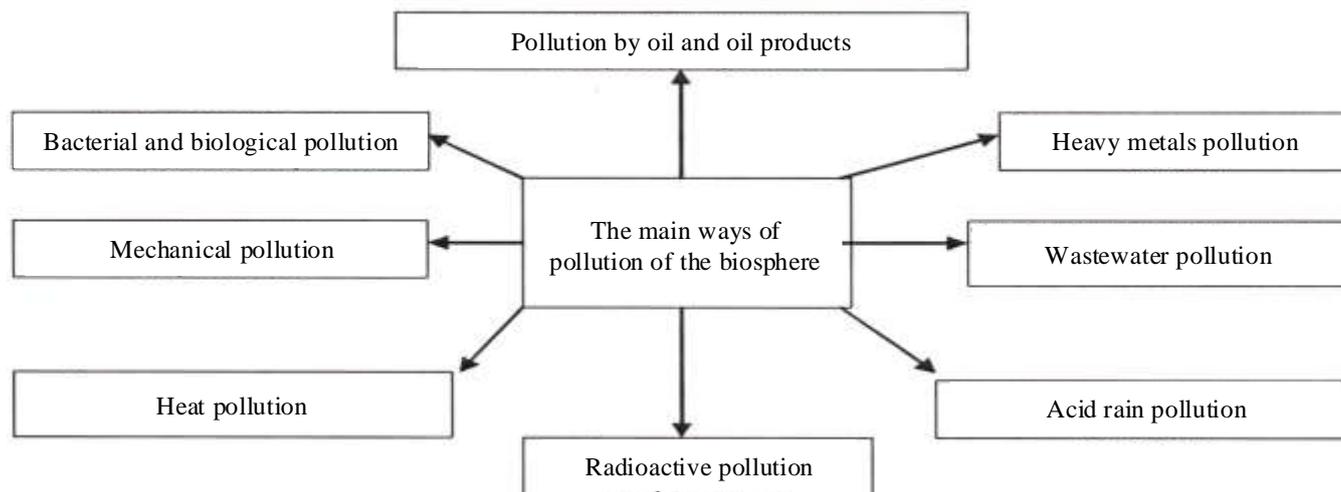


Fig. 1. Ways of pollution of natural waters

The most reliable source of water is groundwater, for which both water-bearing wells are used for centralized and private water supplies. Systematic studies devoted to the determination of the content of ions of some metals (*Hg, Cd, Pb, Cu, Zn, Ni,*

*Mn*) in water samples from wells in various parts of the south of the Chelyabinsk region are carried out by the specialized laboratory of Magnitogorsk Sanitary and Epidemiological Center (Table 2). The studies were carried out using the

standard method of atomic absorption spectroscopy (cold vapor method and plasma atomization) using state standards for the determined chemical elements [3].

The analysis of the results shows that in the case of groundwater sources, there are practically no deviations from the standards [5].

It is obvious that the use of open reservoirs for fire and domestic water supply requires more complex water treatment than the use of the same water for industrial or agricultural purposes. The most reliable use of natural water sources is groundwater, for which both water-bearing wells are used for centralized and private water supplies.

### III. RESULTS

Table 2 shows the studies conducted by the specialized laboratory of Magnitogorsk Sanitary and Epidemiological Center. The studies were performed in order to determine the content of ions of some metals in water samples from wells in various regions of the south of the Chelyabinsk region and Magnitogorsk itself. The studies were carried out by atomic absorption spectroscopy [5] (cold vapor method and plasma atomization).

TABLE I. RESULTS OF THE STUDY OF WATER SAMPLES FROM UNDERGROUND SOURCES OF CENTRALIZED WATER SUPPLY IN VARIOUS AREAS OF THE SOUTH OF THE CHELYABINSK REGION IN 2018

| Region<br>Sampling point                     | Result * |    |    |    |    |    |    |
|--|----------|----|----|----|----|----|----|
|  | Hg       | Cd | Mn | Cu | Ni | Pb | Zn |
| Agapovskii<br>Well № 3065                    | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Agapovka village                             | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Verkhneuralskii<br>"Control"<br>Water supply | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| "Severnii"<br>Water supply                   | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Verkhneuralsk                                | 0        | 0  | 1  | 0  | 0  | 0  | 0  |
| Well №5187                                   | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Magnitogorsk<br>Iangelskii<br>Water supply   | 0        | 0  | 1  | 0  | 0  | 0  | 0  |
| Kizilskii<br>Water supply                    | 0        | 0  | 1  | 0  | 0  | 0  | 0  |
| Malokizilskii<br>Water supply                | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Kizilskii<br>Granitnii village               | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Kizilskoe                                    | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Uvalskii                                     | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Well №7621                                   | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Nagaibakskii<br>Fershampenuaz<br>village     | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Kasselskii village                           | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Chernorechenskii<br>village                  | 0        | 0  | 0  | 0  | 0  | 0  | 0  |
| Ostrolenskii village<br>Well №221            | 0        | 0  | 0  | 0  | 0  | 0  | 0  |

\* 0 – comply with maximal permissible concentration; 1 - exceed permissible concentration

The analysis of the results shows that in the case of groundwater sources there are practically no deviations from the standards [3]. There is a slight excess in manganese in some sources.

As an example, the authors present the results of one typical study of two sources of water supply in Magnitogorsk. The studied samples have a slight excess in manganese typical for other studied samples. The high quality of the studied water is reasoned by rather deep occurrence of artesian sources and powerful karst natural layers, due to which effective natural purification of natural waters occurs near Magnitogorsk (Table 3).

The formation of chemical composition of surface and underground natural waters is mainly determined by two groups of factors: direct factors - directly affecting water (i.e. the effect of substances that can enrich water with dissolved compounds or, conversely, separate them from water), the composition of rocks, living organisms, human activities; indirect factors - determining the conditions in which the interaction of substances with water takes place: climate, relief, hydrological mode, vegetation, hydrogeological and hydrodynamic conditions.

TABLE II. RESULTS OF THE STUDY OF WATER SAMPLES FROM UNDERGROUND SOURCES OF CENTRALIZED WATER SUPPLY OF MAGNITOGORSK

| Sampling point                          | Results, mg/l |           |               |        |        |             |
|---|---------------|-----------|---------------|--------|--------|-------------|
|   | Cd            | Mn        | Cu            | Ni     | Pb     | Zn          |
| Iangelskii<br>Water supply              | <0.001        | 0.33±0.06 | 0.0074±0.0022 | <0.005 | <0.002 | 0.018±0.004 |
| Kizilskii<br>Water supply               | <0.001        | 0.28±0.05 | 0.0077±0.0022 | <0.005 | <0.002 | 0.018±0.004 |
| maximal permissible concentration, mg/l | 0.001         | 0.1       | 1.0           | 0.1    | 0.01   | 3.0         |

### IV. CONCLUSION

The composition of water can change under anthropogenic impact on natural water sources, these changes can occur quite quickly. Therefore, environmental changes should be made systematically and periodically, taking into account the synergistic effect of exposure to toxins. In water samples, depending on the tasks, researchers analyze from 10 to 30 abiogenic and biogenic ingredients, which include oxides of metals and nonmetals, aromatic hydrocarbons, heavy metals and nonmetals, allergens and pathogens. Water quality indicators are divided into groups: organoleptic indicators (smell, taste, color, and turbidity), chemical (content of various chemical compounds, including salts, metal ions, oil products, toxic elements) and microbiological indicators.

The listed ingredients affect the course of biochemical reactions in plant and animal cells, human health and the biosphere as a whole. These observations are classified as sanitary-toxicological studies. Environmental quality standards should reflect the requirements of various consumers for it and

ensure the preservation of the ecological balance in natural ecosystems within their self-regulation. The requirements of human for the quality of natural resources are practically independent of climate, landscape, and other regional characteristics, and the normal functioning of ecosystems under the same load significantly depends on the totality of natural environmental factors of local and regional scales. The composition of water depends on many factors: the depth and direction of water bearer, the proximity of cultivated fields, landfills, sewage, etc. Hazardous components are maintained by clay soils, karst sediments, playing the role of a sorbent. These components easily overcome sandy layers of impurities, falling into underground water. In deeper wells, water is usually but not always cleaner than in shallow wells [6].

The filters of various designs can present additional means of the purification of drinking water. When creating such a complex, it is necessary to know precise composition of water used. It is obvious that there are no universal filters that purify water from all harmful impurities. Filters are very diverse and can vary in the principle of operation, configuration, design, and selectivity to different elements.

An important indicator is the life cycle of a filter. This is not just the amount of water that a filter can effectively clean, but it is the amount of water that meets the standards for the content of various components. If water is more polluted, a filter life is reduced, and it is necessary to frequently change the element of a filter. A replaceable filter element that has worked its life will not improve, but sometimes even degrade the quality of water. It is impossible to visually determine the degree of pollution of a filter. Therefore, it is necessary to calculate in advance how much water is passed through a filter per day, compare the result obtained with the rated resource and find out, thus, relying on the composition of water of a particular source, how long this filter can be used. All filter models are designed to remove pollutants in certain concentrations. When studying the pollution of natural surface, artesian industrial, drinking water, it is possible not only to formulate recommendations on their use and purification, but also to give recommendations on the creation of a selective water treatment system.

This system should remove exactly those ingredients that do not meet the standards, that is, they must be regionally oriented, sufficiently selective, recoverable, and highly effective in terms of productivity. The ion exchange resins (cation exchangers and anion exchangers), which can correct the alkalinity of water, the content of nitrates, heavy metals, and organic compounds, are quite effective in purifying water from ions. Carbon sorption filters improve the organoleptic characteristics of water, remove organic impurities and chlorine.

The pH correctors bind aggressive carbon dioxide. The decontaminators complete the preparation of drinking water. Usually at this stage water is treated with oxidizing agents, most often chlorine or its derivatives, and the oxidation products are then retained by a filter. Sometimes ultraviolet lamps, ozone exposure are used as a disinfecting element. The membrane filters, semipermeable film-membranes with pore sizes equal to the size of molecules are effective to remove dissolved ingredients, including bacteria. The main disadvantages of such systems are high cost and low productivity. Newly created filters based on composite carbon nanomaterials have a great future, although the biological activity and possible toxicity of nanomaterials is currently the most important fundamental and applied problem in physical materials science [7].

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