

Environmental–Toxicological Characteristics of Waters and Their Sources at Magnitogorsk With the Its Iron and Steel Industry

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Abstract: This study summarizes the information necessary to characterize and assess the quality of drinking and industrial water supply in industrial centers with metallurgical engineering and provides information about the pollution impact on the natural environment. The study shows the influence of air pollution, of the soil pollution on the environment of water objects; it also demonstrates the role of the quality of water supply for establishing a higher risk of health problems for children.

Introduction

Magnitogorsk is located in the south-east of the Chelyabinsk region, on the eastern slopes of the Ural Mountains, and near the headwaters of the Ural River (Fig.1,2). The Ural River flows through the city. The left river bank has been transformed into a plant cooling pond, receiving industrial waste water for the iron and steel plants. Water purification is carried out through a system of dams (settling pond principle). The local water supply relies on three infiltration sources, which abstract groundwater and are related to the Ural (54° 42' 2.81" N, 59° 25' 2.32" E), Malyj Kizil (53° 35' 49.26" N, 58° 26' 59.87" E), and Yangel'ka (53° 34' 14.8" N, 58° 38' 17.2" E) Rivers in Magnitogorsk.





Fig.1. Map of the Ural River basin



Fig.2. Map of the Ural River with source and estuary

Magnitogorsk is a large industrial center of iron and steel industry, with the metallurgical plants, being the main sources of environmental pollution [1]. Industrial emissions contain a complex of potentially toxic organic and inorganic substances. The high air pollution index (Air Pollution Index API- 16,6 at the minimum index – 4) reflects high health risks for the population. 32 047 samples of atmospheric air were taken and analyzed by Branch of Institute of biomedical and environmental problems of the southern Ural scientific center of the Russian academy of medical sciences (sUSC RAMS) during 2010-2011 in cooperation with the Federal Service on Surveillance in the Sphere of Consumer Rights Protection and Human Welfare. Additionally, research has been performed on suspended particulate matter (SPM content) in the local aquatic environment. Results showed an excess of the maximum concentration limit (MCL) of SPM (2.6), for formaldehyde (4.3), for benzopyrene (5.7), and for nitrogen dioxide (1.4) [2].

Moderately winding, muddy, overgrown with aquatic vegetation rivers in the upper reaches of the Ural River determine the high water permeability of the soil, which is an active medium for the migration of many chemical elements which form readily soluble aquatic organisms: Na, K, Ca, Cs, Ba, Li. Monitoring of soils in Magnitogorsk showed that 70.7% of the samples did not meet the environmental and toxicological standards [3]. Excessive amounts were encountered for Ni, Cu, Zn, Cd, Hg and benzopyrene (BaP) [4]. According to the Russian scale score danger of soil contamination on total pollution index soils throughout the city must be classified as hazardous. The local landscape and terrain determine the characteristics of soil degradation processes, driven by a sharp decline in natural resilience and ecosystem services capacities. Negative characteristics of the soil structure additionally influence water supply and the municipal disposal system.

Malo-Kizil'skiy water abstraction area is located in a flood plain of the river Malyj Kizil. There are 18 operating wells with depths ranging from 20 to 100 m. Water treatment isn't provided. Disinfection method is accomplished by liquid chlorine. Water quality complies with the requirements of Sanitary Regulations and Norms (Standards) "Drinking water. Hygienic requirements for water quality of centralized drinking water supply systems" [5].

Verhnee-Kizil'skiy water abstraction area is located in a flood plain of the river Ural. There are 31 operating wells with depths ranging from 40 to 80 m. Aquifer has hydraulic connection with the surface water body of the river Ural. Iron and manganese maximum residue limits (MRL) are registered up to 0.44 mg/dm³; 0.21 mg/dm³ nature overbalance relatively in water sources. Iron and manganese concentration is reduced to 0.3 mg/dm³ and to 0.12 mg/dm³ relatively right after the water mixing in the tanks on 2-nd elevation pumping plant. The project water treatment for manganese and iron hasn't been taken into account.

Yangel'skiy water abstraction area is located in a flood plain of the river Yangelka, 30 km from the city. There are 8 operating wells with depths ranging from 80 to 100 m. Ground waters have hydraulic connection with the surface water body of river Yangelka. The Sanitary Regulations and Norms (Standards) 2.1.4.1074-01 are exceeded in total hardness of water and reach the maximum up to 8.1 mg-eq./dm³ in water sources [5, 9]. Level of total hardness of water is from 7.0 to 7.5 mg-eq./dm³ on the 2-nd elevation pumping station [8]. The water disinfection in water abstraction is produced with liquid chlorine. The share of water samples from underground sources is equal to 9.3% according to the Territorial Federal Service on Customers' Rights Protection and Human Well-being Surveillance. It's recognized that the water supply system plays a strong role in the formation of various diseases in humans as a result of an increasing anthropogenic pressure.

Materials and Methods

In 2012 studies were conducted in 5 points for 21 indexes for the purposes of public health monitoring, in order to assess the impact of quality of drinking water on public health of Magnitogorsk population: water hardness, pH-value, chlorine, ammonia, nitrites, nitrates, iron, chlorides, sulfates, arsenic, fluoride, manganese, copper, zinc, lead, nickel, cadmium, cobalt, total bacterial count, total coliform bacteria, thermotolerant coliform bacteria [6].

There is the list of priority chemicals which pollute the drinking water of centralized drinking water supply:

- iron, manganese and its compounds – from the source of water supply;
- chlorine – during the drinking-water treatment;
- iron – during the water transportation (fig.3).

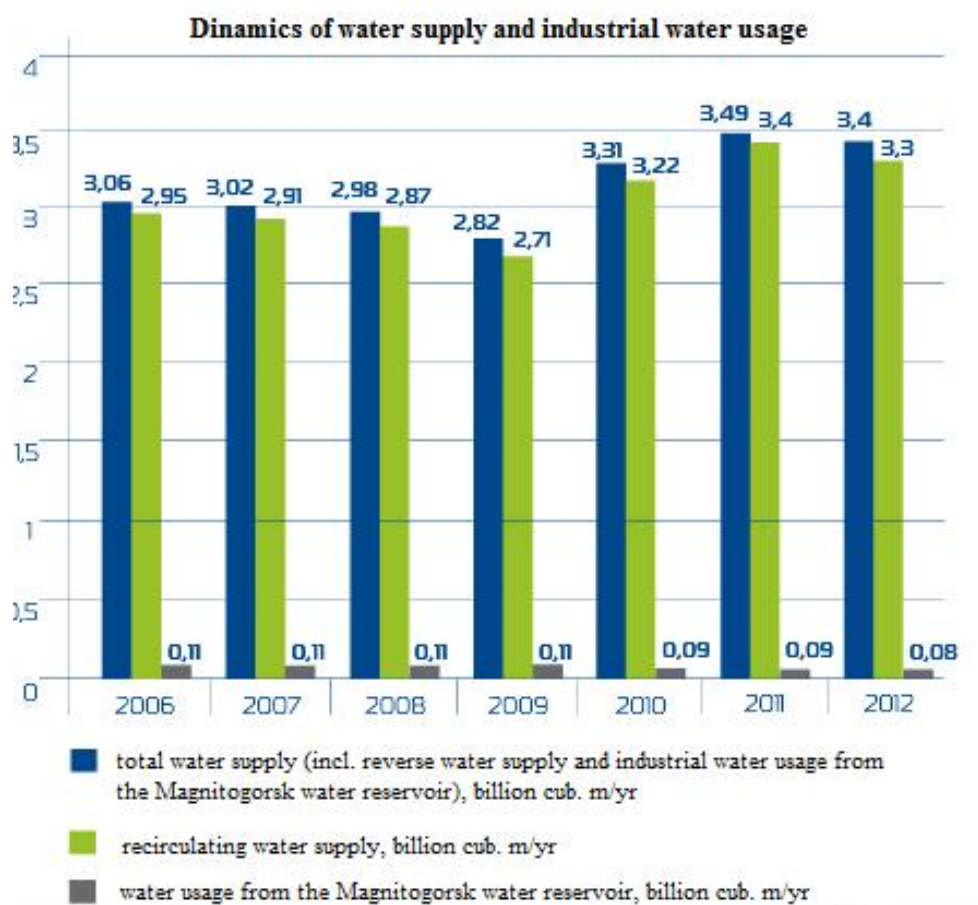


Fig. 3 Dynamics of water supply and industrial water usage

In total 60 of examined water samples didn't meet sanitary norms and regulations [5] for iron – 5%, manganese – 10%, nickel – 5%, total hardness of water – 3.3% content in drinking water [7]. Compliance is assessed by comparing the results of the analysis of samples taken from supplies with the required standards set out in the Regulations (Table 1).

Table 1. Pollutants discharge, (tons per year)

Pollutant	Mass discharge of wastes (2011)	Mass discharge of wastes (2012)
Total iron, Fe	29,4	43,7
Manganese, Mn	15,5	11,1
Petroleum product	62,7	64,3
Sulphates, SO_4^{2-}	51 388,3	39 338,4
Fluoride, F^-	271,7	255,0
Zink, Zn^{2+}	53,6	31,7
Other	104 045,4	74 073,2
Total	155 866,6	113 817,4

Data on the hygienic status of the territory of water quality in the distribution network is presented in Table 2.

Table 2. Condition of the distribution network of central drinking water supply of Magnitogorsk and water quality at the withdrawal point

Index	2010	2011	2012
Distribution network spread (km)	888.0	902.8	915.67
Percentage of water samples that do not comply with sanitary and chemical standards (%)	16.0	11.0	15.9
Percentage of water samples that do not comply with microbiological standards (%)	0.0	1.0	1.5
Incl. disease-producing agents	0.0	0.0	0.0

Drinking and surface water, which does not conform to ecologic-hygienic requirements (according to the content of iron and manganese), can be the reason for pathogenic pathway: blood diseases, diseases of the central nervous system, skin and blennosis, immunological disorders. High total hardness level in underground water intake sources can be the reason for kidney stone disease. Microbial contamination of public drinking water can threaten human health. Some individuals are more sensitive to infection and they are more susceptible to different symptoms. It is important to pay more attention to children's health in this question.

Results and Discussion

Analysis of the quality of drinking water in 2012 compared with 2010 showed that:

- Percentage deviations chemical indicators remained at the same level.

In general, the reason for the deviations of drinking water quality is high natural content of iron, manganese for chemical indicators in a number of well water abstractions in Verhne-

Kizil'sky water abstraction and high level of total hardness in the Yangelsky water abstraction.

- Deviations percentage of microbiological indicators increased; these deviations are more related to the previous dry period.

Previous studies of identified chemical carcinogens inserted into environment in the forecast situation of their minimal carcinogenic risk to the population have showed the structure of carcinogenic danger for objects in model: atmospheric air – arsenium, cobalt and nickel; drinking water - beryllium, cadmium, plumbum; industrial water-cooling pond – formaldehyde; surface water, reservoirs and atmospheric air – ethyl benzene. Integrated entry into the environment is characteristic for a benzapiren, bensole [7]. These afore-referenced substances only carcinogenic, mutagenic but have embryotoxic and genotoxic characteristics as well.

It had analyzed the results of clinical continuous examination of children and adolescents of the industrial city. It has been shown that 30% of 6-7 year old children have an immune deficiency; 6.3% of children have growth disturbance (in Russia – 2%). The assessment of a physical and mental status of teenagers of 15-17 age showed that one-third of patients (32.8%) had physical disabilities; 31% – reduction in the rate of mental activity (memory, stability and attentional deficits deficits); 40% of teenagers have a chronic diseases [2, 7]. Priority risk factors for the development of pathology in children and teenagers anthropogenous, social and psychological causes. The assessment of the impact of the water factor on the health in the ecological and hygienic studies has been insufficient, while the water factor is one of the mandatory components of the complex analysis of communication of environmental factors and living conditions of the population on the state of their health. The generated data suggest the necessity of improving the environmental monitoring of chemical pollution of groundwater and water sources by regarding medical and biological indicators of human health. They can be used for justifying of the use of high-tech and effective methods of water purification [6, 8, 9].

Further research is necessary to reveal relationships between the mentioned phenomena and evaluate influence on water bodies. Collection of new data will allow developing a complex of regional arrangements to keep water resources and ecosystems of Ural River and Magnitogorsk Reservoir in safety and introduce these arrangements into practice.

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