Impact of pollutants of natural and anthropogenic origin on the quality of wastewater in Ekaterinburg

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Abstract. The object of the study was river water, which was sampled 500 m before and 500 m after the point of discharge of wastewaters from industrial activities. The concentration of chlorides, magnesium, and calcium in all the studied samples was below the value of the acceptable limit concentration. The pH of the water samples and the sulphate concentration were within acceptable limits. The concentration of iron, ammonium, and nitrite in water samples was higher than the value of acceptable limit. It was suggested that water pollution with iron and nitrite was mainly due to natural processes, and the presence of ammonium and oil products could be explained by anthropogenic sources.

1. Introduction
Wastewater is discharged into water bodies from the territories of industrial enterprises and populated areas through the sewerage system or by gravity, and its properties are deteriorated as a result of human activity. The composition of industrial wastewater directly depends on the type of production. The increased content of components in wastewater has an impact on water quality, and, therefore, on the quality of life of people. Ekaterinburg is one of the largest industrial and production centres in Russia. Water of the proper quality is required to ensure the industrial complex, housing, and communal services. The main reason for the pollution of water bodies is the absence or abnormal operation of treatment facilities. Preservation and restoration of water bodies requires: stopping wastewater discharge without treatment, construction and reconstruction of treatment facilities, introduction of new treatment methods, construction of post-treatment facilities, transfer of production processes to closed-drain water supply systems, and introduction of progressive water-saving technologies. In 2016, on the territory of the Sverdlovsk Region, 297 water users carried out wastewater disposal into surface water bodies. 226 water users operated 347 treatment facilities with subsequent discharge of treated water into surface water bodies. After all, it is known that wastewater from cities, settlements, and industrial enterprises of the Sverdlovsk region flows into water bodies located in the basins of six rivers: Chusovaya, Ufa (the Caspian Sea basin), Iset, Pyshma, Tura, and Tavda (basin of the Kara Sea) [1]. The most common pollutants entering surface water bodies with wastewater are: suspended solids, heavy metal compounds, oil products, nitrite ions, nitrate ions, and ammonia nitrogen.

In this regard, it is important to know the quality of wastewater and its impact on the rivers of Ekaterinburg and the Sverdlovsk region. The purpose of this work is to assess the impact of wastewater on the water quality of the rivers of Ekaterinburg city and the Sverdlovsk region.

The increased content of nitrate ions in the waters leads to an increase in the content of methemoglobin, which in turn cannot serve as a carrier of oxygen from the lungs to the tissues.
the formation of significant amounts of it, the transporting function of the blood is sharply disturbed. Under the influence of certain types of gastric microorganisms, nitrates are reduced to nitrites, which block the formation of haemoglobin by the fact that, when recovering, they convert iron from bivalent to trivalent [2]. The greatest danger of an increased content of nitrates in the body lies in the ability of the nitrite ion to participate in the reaction of nitrosation of amines and amides, as a result of which nitros compounds are formed, which have carcinogenic and mutagenic effects [3].

It is known that the water chlorination procedure is used to purify water, but a number of by-substances are also formed which are very harmful to humans. Professor Joseph Price points to the link between the practice of water chlorination and atherosclerosis. When chlorinated water, which contains an excessive amount of chlorine, enters the body, it reacts with cholesterol in the blood, which accumulates on the walls of the arteries, narrowing them, depriving them of elasticity, and provoking ruptures [4]. An inhibitory effect on gastric secretion occurs when drinking water containing an increased amount of sulphates [5]. Water, which contains a high content of petroleum products, has a negative effect on the human body, in particular on the central nervous system, genetic inheritance, and slows down the formation of blood cells. The fact is that petroleum products contain a carcinogenic component – non-pyrene [6].

Calcium and magnesium have a positive effect on the body when used in moderation. The bulk of calcium is concentrated in bone tissue, which serves as a kind of buffer for circulating ions with blood flow [7]. Magnesium is the most important intracellular element of all cells and tissues, participating together with the ions of other elements in maintaining the ionic equilibrium of body fluids. It is a part of enzymes associated with the exchange of phosphorus and carbohydrates, activates plasma and bone phosphatase, and participates in the regulation of neurochemical transmission and muscle excitability [8]. At increased concentrations of iron, the water becomes cloudy, turns yellow-brown, and has a characteristic metallic taste. All this makes such water practically unsuitable for both household and drinking use. The main function of iron in the body is electron transport as well as transport and storage of oxygen [9].

2. Methods
The data of the analysis of water samples from rivers collected in Ekaterinburg in 2011-2016 are systematized in this work. Content of iron, calcium, magnesium, petroleum products, chloride, sulphate, nitrate, nitrite, and ammonium as well as pH value were assessed as water quality indicators. Calcium and magnesium were determined in water by a titrimetric method with EDTA using indicators T murexide and eriochromic black [10, 11]. Nitrates and nitrites were determined photometrically with sodium salicylate and Griss reagent, respectively [12, 13]. All the samples were taken at a distance of 500 m before and 500 m after the points of industrial wastewater discharge into rivers. All the indicators were compared with the permissible limits for pollutants in natural water bodies according to the Order No. 96 (dated April 28, 1999) of the Committee of the Russian Federation for Fisheries [14].

3. Results
The obtained results have shown that the concentration of chlorides, magnesium, and calcium in all the studied samples is lower than the acceptable limit (AL) (Figs. 1a-c). However, the increased content of iron, ammonium, nitrites, and nitrates was detected in most of the samples (Figs. 1d-f, 2a). The increased iron content in wastewater samples can be associated, on the one hand, with a high background natural iron content, and, on the other hand, with a low AL (0.1 mg/l) for water in fishery reservoirs. No significant difference was observed in the iron content of the wastewater samples before and after the discharge point. This indicates a natural origin of iron in river waters. Increased concentrations of iron in the rivers of the Ural region (the Tura and Chusovaya rivers) were also noted by Tairova et al. [15] and Revvo et al. [16]. In the case of sulphate (Fig. 2b), only one sample (before wastewater discharge) showed a concentration slightly higher (8 %) than the AL; therefore, the presence of sulphate in rivers may be considered negligible.
Sources of increased concentration of nitrites, nitrates, and ammonium in wastewater samples can have both natural and anthropogenic origin. The increased content of nitrites can be associated with a low AL value (0.04 mg/l). There is no significant difference in the values before and after the point of sampling, which indicates the natural origin of high content of nitrites in river waters. Excess content of ammonium is observed in almost half of the samples after the wastewater discharge point, which may indicate an anthropogenic source of this pollutant. Most of the samples had an acceptable pH value (Fig. 2c). However, five samples showed a slight deviation towards the acidic environment. Two samples showed a significant decrease in pH after the wastewater discharge point, from 7.19 to 6.48 and from 7.08 to 5.98, which may indicate an anthropogenic reason for this pH decrease due to release of acidic waste. Both samples refer to the same sampling points on Kedrovka River (a tributary of Tavda River) in 2012 and 2013. In other years, a less significant water acidification was observed in this river. Oil products can have anthropogenic origin only (Fig. 2d). All five samples exceeding AL were collected in Iset River within Ekaterinburg city. Therefore, this deviation can be explained by emissions of hydrocarbons from private and public transport of the city, not by industrial emissions.
Figure 2. Content of: (a) NO\textsuperscript{3}, (b) SO\textsubscript{4}\textsuperscript{2}, (c) pH value and (d) oil products in river water samples. B – 500 m before the wastewater discharge point; A – 500 m from the wastewater discharge point; AL – acceptable limit of pollutants in water of natural reservoirs.

4. Conclusion

Systematization and analysis of data on the assessment of the wastewater quality was carried out in this work. Analysis of the data on the concentrations of pollutants in river waters above and below the wastewater discharge sites coming from various enterprises of the Sverdlovsk region shows that the most deviating from the established standards were: iron concentration, ammonium nitrogen, and nitrite nitrogen. It is suggested that water pollution with iron and nitrite is mainly due to natural processes, and the presence of ammonium and oil products can be explained by anthropogenic sources. According to the analysis carried out in this work, continuous monitoring of the most polluting substances (iron, ammonium, nitrites, and nitrates) should be organized in the rivers. This is very important both from environmental and public health points of view.

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