The Dynamics of Changes in the Concentration of Polluting Components in Discharges of Enterprises of Electrometallurgical Profile and the Development of a Range of Environmental Measures for Wastewater Treatment

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Abstract. A study of the dynamics of change in the concentration of pollutants discharges from electrometallurgical enterprises was carried out. Analytical data are presented for the following ingredients: suspended substances, dry residue, chlorides, sulfates, nitrates, nitrites, ammonium nitrogen, fluorides, iron in general. Possible ways of reducing harmful discharges into the water intake facility (Oskol River) have been analyzed, and the most effective method of combating them for the conditions of the Oskolsk electrometallurgical industrial complex (OEMIC) has been chosen. The use of electrolytic hydrogen for the electroflotation of pollutants from aqueous solutions in the technological processes of water treatment for reuse in the water supply systems of electrometallurgical enterprises is proposed.

1. Introduction
Oskol Electrometallurgical industrial complex is a modern enterprise specializing in the production of long products from high-quality structural steels, pipe billet oil and boiler range. OEMIC is located in the Staroskolsky district, 24 km kilometers south of the residential area of the city of Stary Oskol, in the north-east of the Belgorod region (at a distance of about 150 km), on the border with Ukraine.

The assessment of wastewater quality and its impact on the hydrochemical regime of the Oskol river was based on laboratory data on the composition and quality of OEMIC wastewater discharged into the river. Analytical data were analyzed for the following ingredients: suspended solids, dried contaminant, chlorides, sulfates, nitrates, nitrites, ammonium nitrogen, fluorides, total iron, according to [1, 2]. Data on the composition of wastewater were considered in close connection with background concentrations of pollutants in the water of the Oskol river at a point 500 m above the discharge site and at a point 500 m below the discharge site [3]. Since OEMIC wastewater is discharged within the boundaries of a settlement, in accordance with the methodology for calculating the maximum allowable wastewater discharge (MAD), the maximum permissible concentration (MPC) of substances for public water use facilities, $C_{MPC}$, is taken as a parameter.
The diagram (figure 1) is presented as a percentage, in quantitative terms: Biological oxygen consumption (BOD) - 2.04 mg/l; Dried pollutant - 914 mg/l; Nitrogen nitrate - 8.1 mg/l; Sulfates-186 mg/l; Chlorides - 352 mg/l; Petroleum products - 0.17 mg /l; Chemical oxygen consumption (COC) - 31.2 mg/l; Total iron - 0.17 mg/l; pH - 7.5.

![Diagram showing percentage distribution of pollutants](image)

**Figure 1.** Relative averages of concentrations of pollutants components in water prior to its purification: biological oxygen consumption - 0.14%; dried pollutant – 61.2%; nitrogen nitrate – 0.54%; sulfates – 12.46%; chlorides – 23.58; petroleum products – 0%; chemical oxygen consumption 2.10; Total iron – 0%.

2. Consider the results of an experiment on the use of hydrogen in local treatment facilities for the removal of organic components contained in wastewater

Waste water electroflotation was performed 3 times, changing the conditions of the experiment. In the first case, waste water electroflotation was performed without pretreatment. For the other two methods, electroflotation of waste water was carried out with the addition of 0.1 g of aluminum sulfate and the same amount of iron (III) chloride as coagulants per 2 liters of waste, respectively.

The most significant results are obtained by adding FeCl₃ to wastewater. The presence of FeCl₃ results in virtually instantaneous coagulation and flaky brown oil precipitate. The electroflotation of such a solution is easier than in the other two cases and a thick brown oil foam is formed after 5 minutes. Subsequent layers of such foam have a darker color than the first case (in the first case the foam was friable and had a brownish shade of the lipid part) and by volume 50% larger. After flotation, the smell of such a solution becomes almost imperceptible (light ether smell), and the solution itself after filtration on filter paper of the FM brand became transparent (in two other cases the solution after filtration had a greenish color and a sharp smell of essential oils). The foam itself contains Fe(OH)₃, which enters into a qualitative reaction with NH₄CNS in an acidic environment. The greenish particles in such a foam indicate the incorporation of Fe(OH)₂, which is contained in the solution after electroflotation (it begins to enter into a qualitative reaction with NH₄CNS after some time, being oxidized in air). A completely different foam is obtained in the presence of Al(OH)₃ (more dense and white compared to the first case) and 20% more in volume than in the first case. Apparently, the white color and the increased volume of the foam is explained by the presence of Al(OH)₃ formed during the electrolysis of the solution.

Consider the characteristics of the individual ingredients discharged with effluents in the river Oskol, in terms of their impact on the body of water.

Dissolved oxygen in wastewater and water of water bodies is spent on the oxidation of organic substances present in water (Figure 2). The oxygen consumed for this is replenished, mainly due to its dissolution from atmospheric air.

Suspended solids may be present in wastewater due to insufficient treatment or re-suspension of precipitation in the water distribution system (Figure 3). To reduce the content of suspended...
substances in the wastewater of the plant, physical and chemical treatment of wastewater by liming with coagulation and subsequent filtration on pressure sand filters is provided.

The dry residue determines the total salinity of soluble solid components, mainly inorganic substances (Figure 4). The discharge of highly saline water into a body of water can lead to a change in the salt composition of the river and to an imbalance in the biocenosis. Chlorides are not highly toxic compounds, however, at high concentrations of chlorides in water, mucous membranes are irritated (Figure 5). Sulfates is one of the least toxic anions, however, at high concentrations of sulfates in water, complete bowel movement, dehydration, and gastrointestinal upsets are observed (Figure 6).

The presence of ammonia nitrogen in the water of reservoirs is an indicator of possible bacterial contamination, the presence of wastewater and livestock waste. Ammonia is a major component of mammalian metabolism (Figures 7, 8).

Chemical oxygen consumption (COD) (Figure 9) is known to be the amount of oxygen (or oxidant per oxygen) in mg/l required to completely oxidize the organic substances contained in the sample. COD is a more complete characterization of wastewater contamination than biological oxygen demand (BOD). Therefore, COD is an important indicator of the quality of wastewater and may indicate the potential danger of potential environmental damage to the water body.

![Figure 2](image2.jpg)

**Figure 2.** Dynamics of changes in the concentration of dissolved oxygen in wastewater.

![Figure 3](image3.jpg)

**Figure 3.** Dynamics of changes in the concentration of suspended solids in wastewater.
Figure 4. Dynamics of changes in the concentration of dried pollutant in wastewater.

Figure 5. Dynamics of changes in the concentration of chloride in wastewater.

Figure 6. Dynamics of changes in the concentration of sulfates in wastewater.
Figure 7. Dynamics of changes in the concentration of ammonium cations in wastewater.

Figure 8. Dynamics of changes in the concentration of nitrates in wastewater.

Figure 9. Dynamics of COD changes in wastewater.
Common iron. Iron cations $\text{Fe}^{2+}$ and $\text{Fe}^{3+}$, as well as other metals, can enter the chain of biochemical processes and replace other ions of vital metals in protein molecules and products of intermediate biochemical reactions, for example, $\text{Ca}^{2+}$ or $\text{Mg}^{2+}$ cations, thereby blocking the normal course of biochemical reactions (Figure 10).

![Figure 10. Dynamics of changes in the concentration of iron cations in wastewater.](image)

Summarizing the obtained data, one can note the scatter of excess of the background value for a number of pollutants, moreover, in different months of the year. Further analysis of the dynamics of changes in the concentration of pollutants in wastewater from the enterprises of the electrometallurgical profile and the reasons for their fluctuations by months will be considered in the following publications. When performing the research, the works [4-20] were used.

3. Conclusion

Thus, we can conclude:
- in General, the rational water supply system that exists at the plant, which provides for the use of water in recycling cycles, allows to reduce water consumption;
- the use of electrolytic hydrogen for the processes of electro flotation of pollutants, especially of organic origin from aqueous solutions, can be successfully applied in technological processes of water treatment, for reuse without discharge into the treatment plant system; the use of this technology will increase the efficiency of water supply systems of electrometallurgical enterprises.

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