Purification of natural water of Dnieper River by ozonation

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Abstract

Here, we considered the problem of purification of natural waters of Dnieper river from pollution by ozone. Ozonation - the only modern method of water treatment that allows you to not only remove bacteria and germs, but also improve the organoleptic properties of water. It was conducted quantitative and qualitative analysis of the Dnieper water, the theoretical basis of the process of ozonation of water and investigated the possibility of using this method to clean the water. So, we studied the conditions of application of ozone for water purification of Dnieper River from various kinds of pollution in order to use this water for the city of Cherkassy as an economic - drinking water.

Аннотация

Рассмотрена проблема очистки природных вод реки Днепр от загрязнения с использованием озона. Озонирование - единственный современный метод обработки воды, который позволяет не только удалить бактерии и микробы, но и улучшить органолептические свойства воды. Были проведены количественный и качественный анализ загрязнений воды реки Днепр, рассмотрены теоретические основы процесса озонирования и представлены исследования, которые показали возможность использования этого метода для подготовки питьевой воды. Таким образом, изучены технологические и экономические условия применения озона с целью получения питьевой воды для города Черкассы.

Keywords: water, ozonation, color, bacteria, ozone dose, cleaning.

Introduction

We studied the conditions of application of ozone for water purification of Dnieper River from various kinds of pollution in order to use this water for the city of Cherkassy as an economic - drinking water.

The scheme of experimental setup for treatment of natural water of the River of Dnieper by ozonation is shown in Figure 1.

Ozone is produced in the ozone generator with a system of drying gas flow of air, which is served into the system. The generator may operate in air, air - oxygen mixture and pure oxygen. During the experiments we used air. The Ozone generator - in fact, is a radiator, which consists of two electro conductive parts and electrodes, which are located at a small distance from each other. Constructively, the electrodes are two cylinders. If you connect the electrodes to a source of alternating current of high voltage, than ozone is formed between these electrodes (transformed air oxygen). The air, that passed through the source of silent discharge , must pass a deep cleaning and drying to a water content of not more than 0.05 g/cm^3. Possibility of production of ozone on place of consumption - this is a great advantage over the other chemical reagents. Drying system and air purification includes three vessels, which are series connected with absorbers. The first of them - silica gel, the second – absorber of brand of NaX, the third - phosphorus pentoxide, which allows you to clean the gas flow from the water vapor.

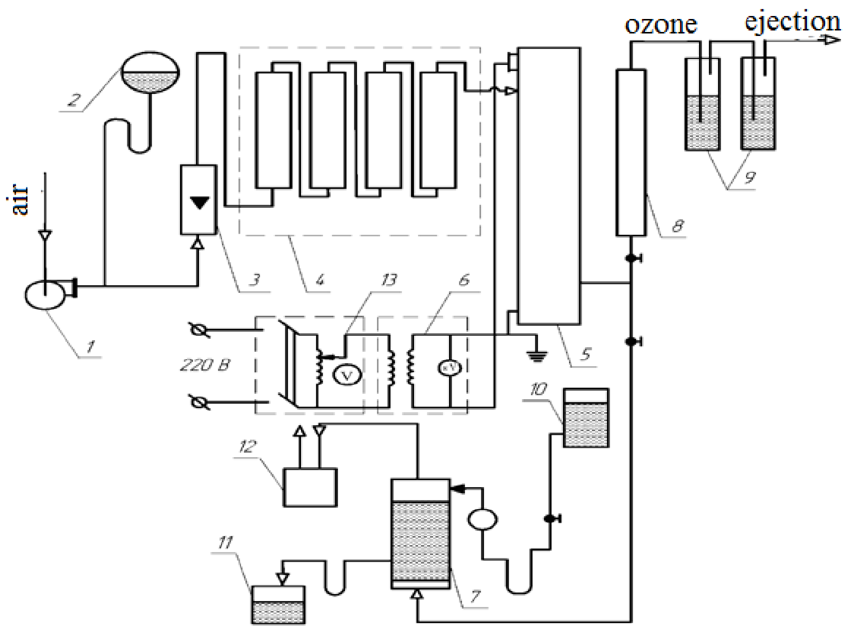

Figure 1 The scheme of plants for ozonation: 1 - compressor; 2 - monostat; 3 - flowmeter; 4 - the block of air drying; 5 - the ozone generator; 6 - step-up transformer; 7 - bubble column; 8 - spectrophotometer; 9 - Drexel glass with a solution of KI; 10 - a container of cleaning solution; 11- the tank with clean solution; 12 - drip tray; 13 - the linear autotransformer.

The dried gas mixture is sent to the ozonator, voltage is applied to electrodes from a step-up transformer (the voltage is 9.5 - 11 kV). The resulting ozone is fed into the bottom of the bubble column through the porous plate. For determining of ozone in the gaseous phase, we used a technique iodometric titration.

For the control of the gas phase, lines were connected to the scheme of the gas analysis, which consist of two series connected absorption vessel, the gas meter and rheometer.

Chromaticity of water is determined by the photometric method - by comparing the samples of test liquid with solutions, that mimic the color of natural water. Determination of the optical density was performed at a wavelength λ = 430 nm, the layer thickness 50 mm. The optical density was measured at the FEC at λ = 430 nm and l = 50 mm.

Photometric method for determination of iron is based on the reaction of formation of two - and trivalent iron with sulfosalicylic acid of complex compound of yellow color. Determination of the optical density was carried out at λ = 430 nm, the thickness of the liquid layer l = 50 mm.

The oxidizability of water is determined by the permanganate. Oxidation is carried out by potassium permanganate with heating.

When the water of the river of Dnieper treated with ozone-air mixture with low doses, there is a series of parallel physico-chemical and biological destructive-oxidation processes, competing with each other:

1. Ozonation of bacteria. The effect of water disinfection with ozone depends on several factors: number of bacteria, species of bacteria, water temperature, the presence of readily-

oxidizable impurities. The bactericidal dose of ozone for 99% inhibition of bacterial cells of all kinds in the Dnieper water at the time of vegetation is 2.1 - 2.4 mg/dm^3. The contact time: 6 - 8 minutes; the concentration of ozone in the ozone-air mixture is 20 g/m^3.

2. Destruction of spores, cysts, and various pathogens. The bactericidal 99% effect of is achieved at a dose of ozone from 0.3 to 1.85 mg/dm^3. The contact time - from several seconds to 20 - 25 minutes. The suppression of majority of colonies of microorganisms at a concentration of ozone in the ozone-air mixture 20 g/m^3 is 4 - 7 minutes.

3. The time of contact of the phases decreases with increasing doses of ozone with 15-16 minutes to 3 minutes.

4. Discoloration of water.

5. Removal of tastes and odors of water.

6. The reaction of ozone with an easy-oxidized microorganisms.

All these processes are competing with reactions of suppression of life aquatic, especially, the elimination of protozoa from the water (type of Dracena and microalgae).

In such a way, the ozone is used for the purpose, which we are interested In, partially, since it has a number of simultaneous processes, in which the speed of the same order.

Effect of ozone on bacteria and viruses is a high speed fast-flowing process. In parallel experiments, it was found, that the processing of the clarified water, which contains the microbe number of 1.7 million. pers / ml and the index number 10000, disinfection takes place completely at 20-40 seconds.

Moreover, for cold water (8 °C) - 25 seconds is enough; for water with a temperature of 16-20 °C - 40 seconds. The dose of ozone during the experiments was 1.65 mg/dm^3. Increasing the ozone dose up to 2.25 mg/dm^3 did not produce a significant growth of rate of bactericidal decomposition. The interesting fact is, what with increasing temperature increases the contact time of the phases. This shows, that ozone is the basic agent, which is dissolved in the water. It means, that the biological processes, that unlike the chemical liquid, depend on the concentration of dissolved ozone.

The results of the process of destruction of algae and protozoa for a contact time of 12 minutes are shown in the table 1. Number of protozoa was determined totally.

Table 1 The efficiency of the biological water purification of Dnieper River.

№	**Source water number of pieces./dm^3**		**Water after ozonation, number of pieces./dm^3**			
	winter	**summer**	**ozone dose**			
			1,0	1,65	2,25	3,0
1	28		12	2	0	0
2	16		9	4	0	0
3	14		7	1	0	0
4		46	30	10	9	0
5		42	25	18	9	0
6		38	22	17	8	0

By the graphical interpolation it was found, that for winter water the dose of ozone for the complete suppression of protozoa is 1.8-2.2 mg/dm^3. When the temperature increases in the summer, there is increase the number of protozoa in 1 liter of water, and also decrease the solubility of ozone. The dose of ozone increases and it is 2,8-2,84 mg/dm^3. Let us take as a basis the average result of 2.82 mg/dm^3.

While the ozonation, it was found, that complete suppression of life of blue-green algae achieved in the samples with the dose ozone - 2.25 mg/dm^3, for the ozone dose of 1.65 mg/dm3 - destroyed up to 90% of microalgae; to 1.0 mg/dm^3 - 70%.

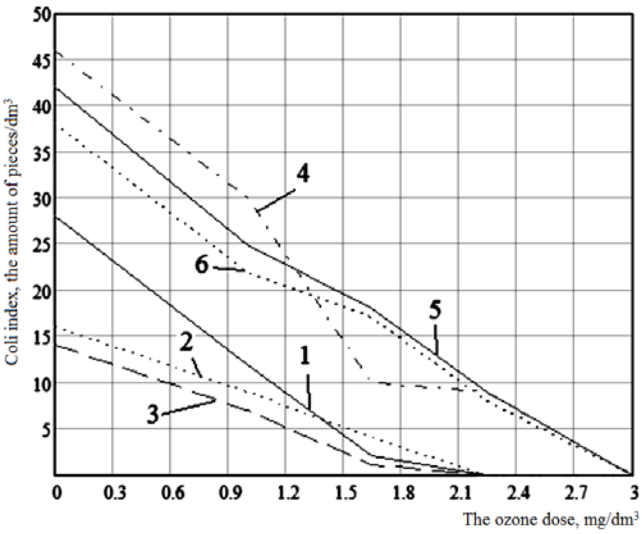

Figure 2 Results of oxidative action of ozone-air mixture on microorganisms at different concentrations of ozone. 1,2,3 - winter water; 4,5,6- summer water.

Reducing the contact time of the ozone-air mixture with water, leads to a dramatic reduction of effectiveness of the ozonation. So, with the ozone dose of 2.25 mg/dm^3 for a contact time of 12 minutes, achieved 80% inhibition protozoa, for a contact time of 9 minutes, it falls to 50%.

This is easily to explain by the rate of dissolution of ozone in the water. For distilled water the saturation time of ozone in the same apparatus over a wide range the concentration of O_3 and the ratio of gas: liquid is 11-12 minutes. Autoclaving of water samples produced in the standard laboratory autoclave with a mixer on 5 liters. The autoclave was filled with 3.4 liters of water and air was supplied with the ozone-air mixture (C (O_3) = 20 mg/dm^3). The air volume is 0.2-0.5 dm^3 depending on the necessary dose of ozone.

The system pressure was created by the technical nitrogen and maintained at 0.5-0.6 MPa. After staying the water in an autoclave 12-13 minutes, its samples were sent for analysis. Results of ozonation samples of the water of Dnieper river under the pressure are shown in Table 2.

Table 2 Efficiency of water purification of Dnieper River from the simplest under the pressure

№	**The dose of ozon, mg/dm^3**			
	0	1,0	1,65	2,25
1	46	25	12	0
2	42	22	12	0
3	38	20	10	0

By graphical interpolation we determine the required dose of ozone, for the calculation of the process of the bubble water treatment by the ozone-air mixture. It is 2.82 mg/dm^3. For injection system of ozonation under the pressure - 2.25 mg/dm^3.

Research showed, that the ozonation of water affects the water color. In this, the maximum rate of color is 37 ° at the dose of 5 mg/dm^3 and a contact time -10 min, without the further treatment, which corresponds to GOST 2872-84.

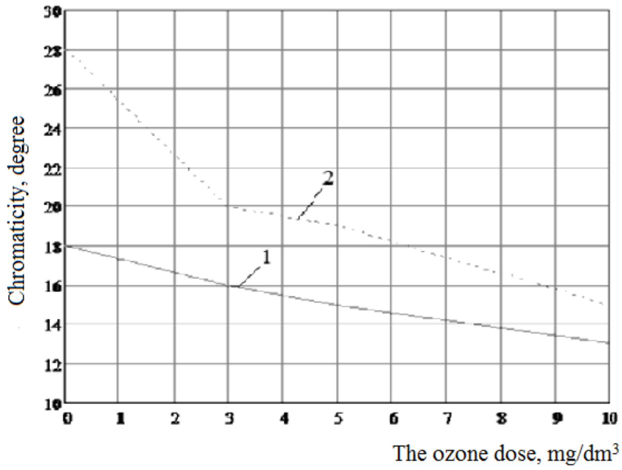

Figure 3 Graphical dependence of water color of the river of Dnieper and the ozone dose: 1 - the experience №1; 2 - the experience №2.

The turbidity of river water caused by organic substances and some substances of mineral origin -by suspended particles. The turbidity of both waters decreases already at the minimum ozone dose of 3 mg/dm^3 and more effectively extends the decrease than its index increase.

The results of ozonation of waters showed, that the process of reduction of turbidity take place gradually.

Following the ozonation, water, which investigated, been tested by oxidation. As the oxidizing agent it was taken the potassium permanganate, as the analysis with the oxidant with high precision can be carried out in the laboratory of the Institute, and more necessary reagents are available.

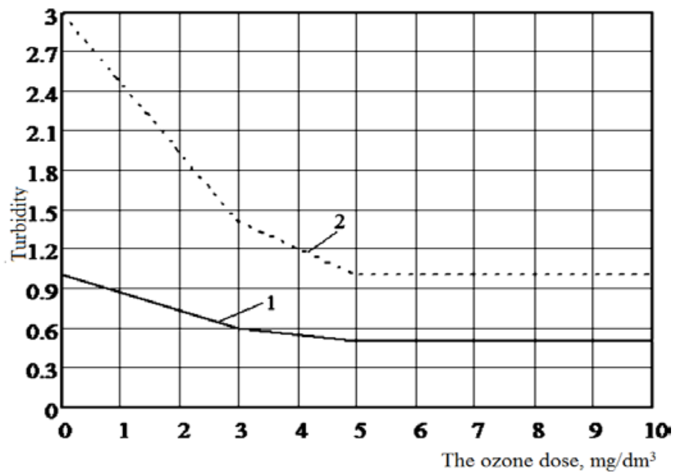

Figure 4 Graphical dependence of the turbidity of the water of Dnieper and ozone dose: 1 - the experience №1; 2 - the experience №2.

We studied the dependence of the oxidizability from the ozone dose. Figure 5 shows plots, which show the degree of reduction of oxidizability from the ozone dose. In order to determine the actual amount of ozone, that went to the oxidation of organic matter as well as some easy-oxidizable inorganic compounds, were constructed the response function.

Line 1 shows the concentration of ozone at the inlet of the contact chamber.

Line 2 , which was obtained during the ozonation of natural water with layer of 1m (the height of the bubbling layer) and a contact time of 10 minutes.

The analysis, that showed the concentration of ozone, conducted the first two minutes – after 10 seconds, the second two minutes - 20 seconds, rest for 6 minutes. - after 30 seconds. On the basis of experience, we can conclude, that for the destruction of ozone the consumption of ozone is less than it is supplied in the contact chamber. Knowing the consumption of ozone and the volume of test liquid, we are building a dependency of using the ozone on the height of the liquid.

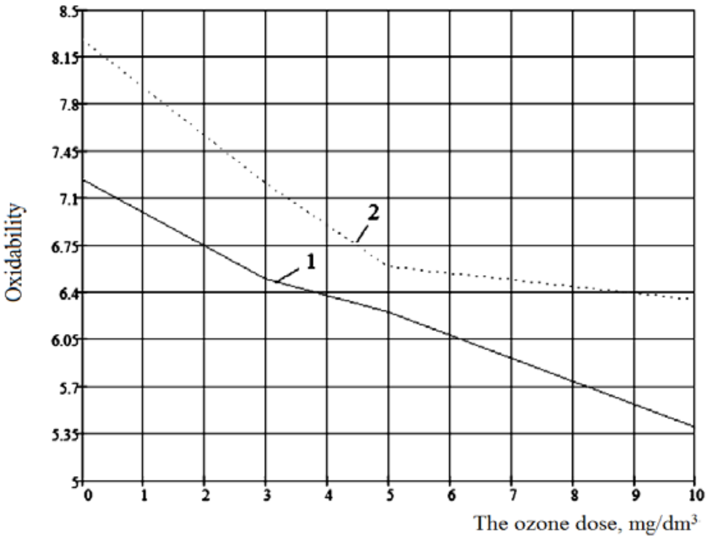

Figure 5 The graphical dependence of the oxidizability of water of the river of Dnieper and ozone dose: 1 - the experience №1; 2 - the experience №2

At the analyzed water, we also determined the iron content. Analysis has shown, underground sources contain it in large amounts, more than in the water of the river of Dnieper.

Experiments were carried out under the similar consumption of ozone. Dependence of the iron content from the ozone dose, shows, that the minimum dose of the oxidant affects the iron content and lowers it. The process goes smoothly, and almost in a straight line.

When the quantity of iron in water large, we observe a proportional relation of iron on the dose of ozone.

The curves, that show changes in the content of iron in the water, depending on the dose of ozone, are shown in Figure 6.

The obtained results of the study provided the basis for tehniko-economic calculations of the ozonation technology.

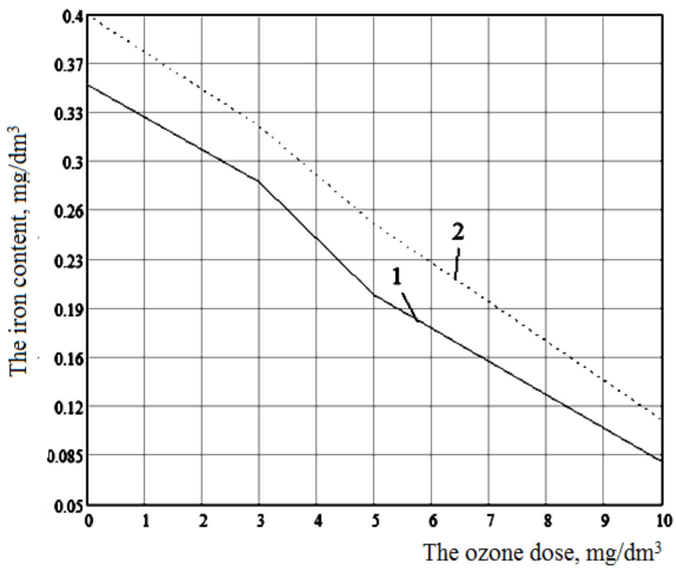

Figure 6 The graphical dependence of the iron content in the water of the river of Dnieper and the ozone dose: 1 - the experience № 1; 2 - the experience № 2

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