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ПРЕДОТВРАЩЕНИЕ ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ СВЯЗАННЫХ С ЗАГРЯЗНЕНИЕМ ПОВЕРХНОСТНЫХ ИСТОЧНИКОВ ВОДОСНАБЖЕНИЯ ИОНАМ ТЯЖЕЛЫХ МЕТАЛЛОВ

PREVENTION OF ACCIDENTAL RELATED TO POLLUTION OF SURFACE WATER SOURCES WITH HEAVY METAL IONS

KOVALOV Pavlo,[1] *VINOGRADOV Stanislav*,[2] *PONOMARENKO Roman*[3]

АНОТАЦИЯ: В статье рассматриваются методы реагентого удаления ионов железа и марганца из поверхностных водных источников. Преимущества и недостатки метода аэрацию воды. Способы повышения эффективности удаления железа и марганца путем аэрации воды. Отмечено, что повысить эффективность удаления ионов марганца до уровня, соответствующего требованиям нормативных документов, возможно путем использования метода аэрации при обеспечении подачи воздуха под давлением 2,5 атм. в закрытую реакционную, камеру обеспечивающую пребывание обрабатываемой воды на протяжении не менее 20 мин. Таким образом, возможно осуществлять воздушный поток в двух режимах.

Ключевые слова: поверхностные источники, ионы тяжелых металлов, загрязнение, питьевая вода.

ABSTRACT: In the article the reagent methods of removing iron and manganese ions from the surface water sources. The advantages and disadvantages of the ejection aerate the water. Ways of increasing the efficiency of removal of iron and manganese by ejection aeration. Noted that to improve the removal efficiency of manganese ions to the level corresponding to the requirements of normative documents should not use the gutter device ejection aeration and ensure air supply at a pressure of 2.5 atm. in a sealed reaction chamber with dimensions providing treated water does not stay less than 20 min. Thus it is necessary to carry out the charge air flow in two modes,

Key words: surface sources, heavy metal ions, the pollution ejection, drinking water.

INTRODUCTION

Centralized water supply in Ukraine provided about 80 % of the population. In drinking water, along with others (organoleptic, microbiological) indicators of water quality is regulated by the content of heavy metals (iron and manganese), which are capable of forming ions with humic acids, water-soluble complex compounds that increase the migration ability of these ions in the water – sediment.[4] Their content in the water of the river Dnepr, as the main source for drinking water in Ukraine exceeds the level set by the sanitary – hygienic standards ([Fe] ≤ 0,3 mg/decimeter^3, [Mn] ≤ 0,1 mg/ decimeter^3)[5] the period of rapid algal blooms (summer and spring) several times.[6]

The reasons for the deterioration of quality of drinking water produced from surface water sources are: continuous improvement of human impact on the natural surface water sources; imperfect and not focused on the current composition of natural water technology for potable water.

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[4] Hvesik M.A. Urgent problems of protection and restoration of water resources of Ukraine // International scientific-practical conference «Actual problems of the environment from human impact», 18-20 May 1994, Kremenchug, p. 85 - 93.

[5] Hygienic requirements for drinking water intended for human consumption: PHealthRandR 2.2.4-171-10. [Effective from 01.06.2010]. - K.: The Ministry of Health of Ukraine, 2010. - 89 p. - (State sanitary rules and regulations).

[6] Tretyakov O.V. The problem of the population providing safe drinking water from surface sources of drinking water in suchasni minds. // Science etc. UCPU «Problems emergencies»: art. 180 - 185.

Most of the existing drinking water treatment plants are working under the simplified processing technology of source water: coagulation-mechanical filtration (coarse filter, fine filter bulk or drum)-disinfection (usually chlorination). Neither of these stages of water does not provide complete removal of heavy metal ions from the raw water.

Increasing the amount of iron and manganese ions in potable water may cause an emergency associated in particular with the threat to public health because of heavy metals, reaching a certain concentration in the human body accumulates in the liver and kidney, causing poisoning and mutation.

The main tasks of civil protection as the development and implementation of measures for the prevention and prevention of emergency situations, as well as the development and implementation of research programs aimed at the prevention of emergency situations. Therefore the problem of removal of heavy metals from surface water sources in the preparation of drinking water to a concentration of certain regulations[1] is relevant for civil protection system in Ukraine.

1 ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS.

A great contribution to solving the problems of drinking water made the following scientists: G. I. Nikoladze, G. G. Rudenko, I. Hollyuta, V. P. Kudesy and other.[2]

According to Nikoladze G.I. efficient treatment of surface water sources of iron and manganese are reagent methods.[3]

Reagent methods based on the introduction of raw water what – a substance that promotes the transition of soluble forms of ferrous iron (II) and manganese (II) insoluble in the trivalent and tetravalent form, respectively. This can be achieved in two ways: by introducing oxidant (atmospheric oxygen, ozone, chlorine and its compounds, potassium permanganate, and other), or raising the pH above 8 water (milk of lime, soda and other pH-correctors) and a combination of these methods. After the transfer of iron and manganese into insoluble form of the compound retained in the filter bed thickness fine filter and purified water is supplied to the further preparation of drinking water.

Of the oxidizing agents most safe and cheap is atmospheric oxygen, the basic method of the water supply in the air is aeration. Aeration method is that in a water–air created developed surface interphase contact intensification of mass transfer occurs between the water and atmospheric air through the dispersion, bubbling, splattering, or the simultaneous combination of these methods.[4]

The most common methods of air – vacuum suction jet (using different designs of ejectors for air leaks in the water flow) and pressure aeration – air supply to the water flow compressor.

With the implementation of these methods is provided by the course of reactions:

$$2Mn^{2+} + O_2 + 2H_2O \rightarrow 2MnO_2\downarrow + 4H^+ \quad (1)$$

$$4Fe^{2+} + O_2 + 10H_2O \rightarrow 4Fe(OH)_3\downarrow + 8H^+ \quad (2)$$

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[1] Hygienic requirements for drinking water intended for human consumption: PHealthRandR 2.2.4-171-10. [Effective from 01.06.2010]. - K.: The Ministry of Health of Ukraine, 2010. - 89 p. - (State sanitary rules and regulations).

[2] Nikoladze G.I. Water: book / G.I. Nikoladze. - M.: Stroyizdat, 1979. - 140; Kulskiy L.A. Reference properties, analytical methods and purification. Volume One. - Kyiv: 1980. – 1206; G. Rudenko, V. Kravchenko, V. Polyakov. Purification of drinking water using filters // Chemistry and technology of water. - 1979. № 1. Pp. 66 – 69; Pariyar Ch.B. The purification of natural waters from compounds of iron, manganese and ammonium slurry etc. // Proc. Doc. 49th scientific. - Tech. Conf. - Kharkov: 1994. p. 114.

[3] Nikoladze G.I. Water: book / G.I. Nikoladze. - M.: Stroyizdat, 1979. - 140;

[4] Tretyakov O.V. The problem of the population providing safe drinking water from surface sources of drinking water in suchasni minds. // Science etc. UCPU «Problems emergencies»: art. 180 - 185.

Similar reactions occur with the above oxidation Fe^{2+} and Mn^{2+} active chlorine or hypochlorite:

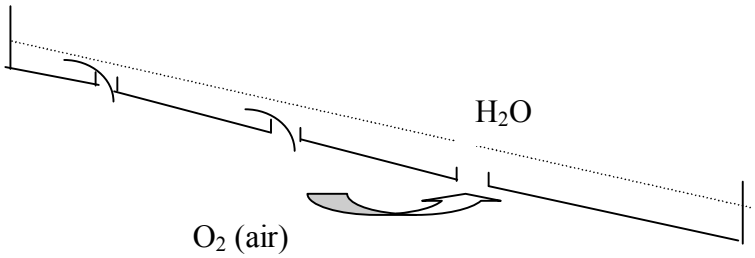
$$Mn^{2+} + 2Cl^0 + 2H_2O \rightarrow MnO_2\downarrow + 2Cl^- + 4H^+ \quad (3)$$

$$Fe^{2+} + Cl^0 + 3H_2O \rightarrow Fe(OH)_3\downarrow + Cl^- + 3H^+ \quad (4)$$

$$Mn^{2+} + ClO^- + 2H_2O \rightarrow MnO_2\downarrow + Cl^- + 2H^+ \quad (5)$$

$$2Fe^{2+} + 3ClO^- + 3H_2O \rightarrow 2Fe(OH)_3\downarrow + 3Cl^- + H^+ \quad (6)$$

Experimental study of ejection method involved Pariyar Chet Bahadur [4]. In the study used an experimental setup consisting of a receiving chamber slit aerator placed in a tray on which the water flows by gravity to a settling tank (Draw. 1).



Drawing 1 The scheme ejection aerator

Moving water tray is provided with sloping turbulent flow of water in areas where the slits are formed vacuum zone providing suction air into the water flow and fast oxygenation to the equilibrium concentration, at a suitable temperature. The proposed design provides a set of dispersed water-air mixture through the depth and length of the aerator.

The degree of purification of water from iron and manganese using this method ejection aeration determined by the formula [1]:

$$Э = \left[1 - \exp\ (-K \cdot [O_2]\tau)\right] \cdot 100 \quad (7),$$

where: K – the oxidation reaction rate constant, [1/min.];

τ – the total residence time of water on the installation:

$$\tau = \tau_a + \tau_{от} + \tau_ф, \quad (8),$$

where: τ_a – aeration time;

$\tau_{от}$ – retention time;

$\tau_ф$ – time filtering.

The effectiveness of iron removal ($Э_1$) and manganese ($Э_2$) of natural water of this method are given in the table 1.

Table 1 The effectiveness of removal of iron ($Э_1$) and manganese from the natural water ($Э_2$) by the ejection of aeration

$Э_1$	C_{FE}, mg/decimeter^3,(source)	$Э_2$	$C_{мп}$, mg/decimeter^3, (source)
65,64%	1,95	36%	5,01
91,58%	2,97		
98,48%	6,60		

Method ejection aeration efficiency values from removing iron and manganese from the natural water content (table), ensures high efficiency removal of iron, but the extremely low removal efficiency of manganese from raw water, the residual concentration of which exceeds the norm by more than 30 times.

[1] Andronov V.A., Ponomarenko R.V. Features emergencies emergencies related to anthropogenic impacts on surface waters. // ST. Science etc. UCP Ukraine «Problems emergencies» Issue. 7: UCP Ukraine 2008. p. 12-22.

2 STATEMENT OF THE PROBLEM AND ITS SOLUTION.

Establish the reasons for the low efficiency of removal of manganese ions from natural water when it is processed by the ejection of aeration. Develop recommendations to improve the effectiveness of removal of manganese in the implementation of this method in order to achieve its concentration in drinking water that meets established standards.

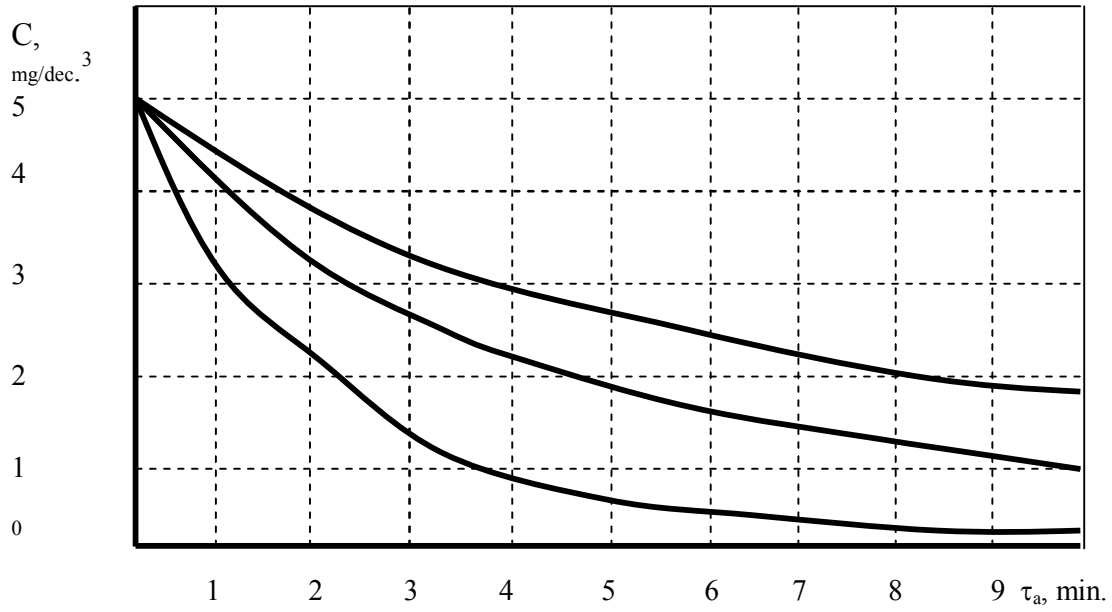
The basic factors that influence the degree of removal of manganese from surface water sources by the ejection of aeration are the initial concentration (C_0) of the manganese ions in water, the concentration of dissolved oxygen in the water and aeration time. In other words, the translation efficiency of manganese (+2) in the insoluble form of manganese dioxide is determined by the kinetics of the reaction (1). Based on the kinetic equation of the oxidation reaction of manganese ions, dissolved oxygen obtained in [8] in an industrial installation:

$$\ln \frac{C}{C_0} = -K \cdot [O_2] \cdot \tau_a \qquad (9)$$

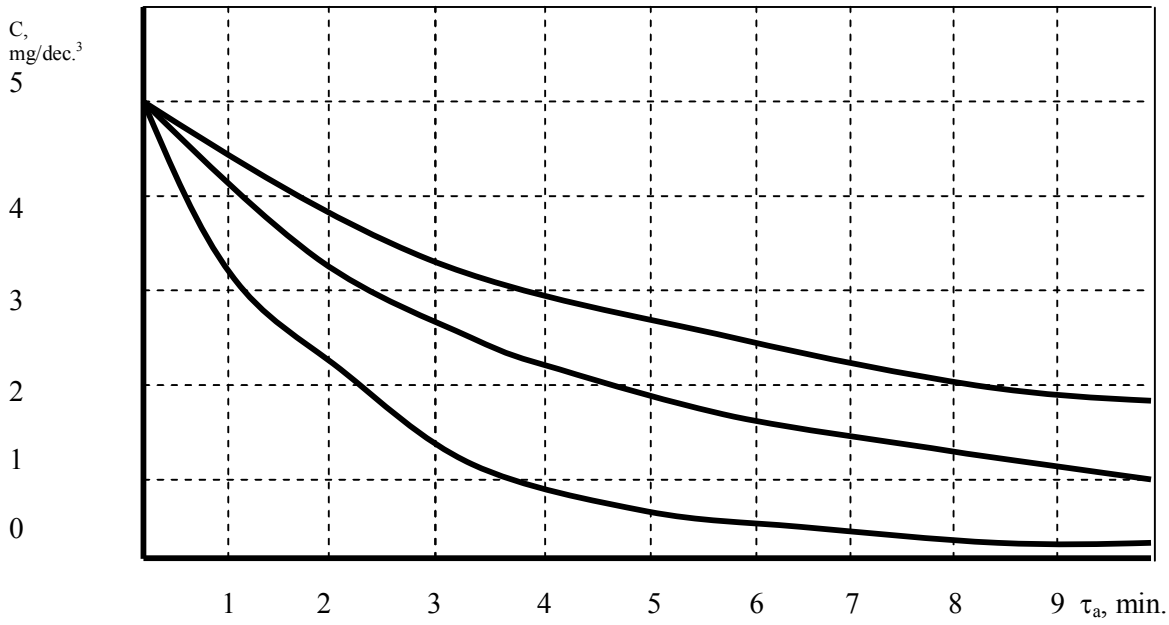
where: C – residual concentration $[Mn^{2+}]$, mg/decimeter^3;
C_0 – initial concentration $[Mn^{2+}]$, mg/decimeter^3;
τ_a – time aerate the water, min.

Was evaluated possible separation efficiency of manganese ions in the solid phase by changing the concentration of dissolved oxygen and aeration time. The results of evaluation are shown in Draw. 2 and 3.

From these results it follows that to achieve a residual concentration $[Mn^{2+}]$ <0,1 mg/decimeter^3 at 10 min aeration time required to provide the concentration of dissolved oxygen at 42.3 mg/decimeter^3, it is not possible to provide a mode of carrying out aeration in the ejection open the drawer. Increasing the time to 20 minutes of aeration desired dissolved oxygen concentration – 21.2 mg/decimeter^3. To achieve a concentration of dissolved oxygen in a confined space in accordance with Henry's law, it is necessary to create a partial pressure of oxygen – 0.49 atm., which corresponds to the excess air pressure – 2.5 atm.

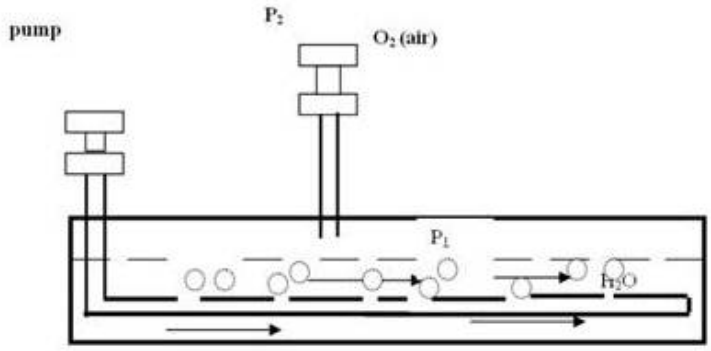


Drawing 2 Dependence of the change in the concentration of manganese ions in the source water from the aeration time when the concentration of dissolved oxygen in water:
1 – 10.75 mg/decimeter^3, 2 – 21.2 mg/decimeter^3, 3 – 42.3 mg/decimeter^3



Drawing 3 Dependence of the change in the concentration of manganese ions in raw water by dissolved oxygen concentration in the aeration time: 1 – 10 min.; 2 – 20 min.

Thus, to improve the efficiency of removal of manganese ions to a level consistent with regulatory requirements,[1] should not use the device ejection chute aeration, and is necessary to ensure the supply of air at a pressure of 2.5 atm. in a sealed reaction chamber, with dimensions of stay providing treated water for at least 20 min (draw. 4).



Drawing 4 The scheme of injection-ejection aerator

Combustion air supply is necessary to organize simultaneously in two modes – bubbling through the water along the entire reaction chamber and discharge the air over the water surface, which will ensure acceleration of the dissolution of oxygen in water. Using this initial water aeration regime provide not only complete removal of iron (II), but also manganese ions (II).

It is advisable to create geometric reaction chamber several sectional with a focus on the possible increase in the concentration of manganese ions in the original natural surface water source.

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[1] Hygienic requirements for drinking water intended for human consumption: PHealthRandR 2.2.4-171-10. [Effective from 01.06.2010]. - K.: The Ministry of Health of Ukraine, 2010. - 89 p. - (State sanitary rules and regulations).

CONCLUSIONS.

The causes of low efficiency of removal of manganese from the natural water at its ejection aeration. Proposed route and apparatus for improving the efficiency of the removal of manganese ions by injection - ejection aeration.

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