A combination machine for industrial wastewater purification

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Abstract. The statistic information about the amount of discharge of pollutants into water sources in Russia is studied. Also, the main problems of wastewater purification are discussed. According to the literature survey, the perspective directions in wastewater purification, as a result of the manufacturing activity of the food industry enterprise, are brought out here. It is offered to choose an electrochemical treatment as a basic stage of wastewater purification. And finally they offered to use a sorption final treatment. A machine called an electrolyzer-adsorber which was made by the authors is presented and described. The main technological parameters, which influences on the level and power-intensity of the electrochemical sorption purification happening in the machine are listed. The results of the experimental researches in choosing the optimum parameters in the wastewater purification machine called the electrolyzer-adsorber were studied at the one of the Volgograd food industry enterprise.

Introduction

There are a lot of industrial enterprises which has a plenty of wastewater as a result of their activities in Russia. According to the information [1], every year about 52 km³ of wastewater, 19.2 km³ of which is needed to be clean, is discharged into the water objects of Russia. More than 72% (13.8 km³) of sub-standard water is poorly cleaned, 17% (3.4 km³) is without cleaning and only 11% (2 km³) is cleaned to the fixed standards. At the same time about 11million of pollutants are discharged into the waters of our country every year. 25% of the total discharge of wastewater is industry. Food industry enterprises are not an exception. There is wastewater here, which has a complicated composition of organic pollutants as a result of activity [2]. Corrosion of the collectors, damage of the oxygen conditions and changing of the microflora, which has a negative influence on the biological purification, all this happens when such wastewater gets into the city drainage system [3, 4].

Studying the literature survey, devoted to the problems of the wastewater purification of the food industry enterprises, shows that both native and foreign scientists [5, 6] search for the methods, machines and wastewater purification technologies from organic and inorganic pollutants. However, this problem is still unsolved. That is why, improvement of the known methods of purification and creating new multifunctional technical machines, is undoubtedly of current interest, because it can solve not only problems of high anthropogenic load on water resources but also make conditions of sub-standard water in enterprises’ water rotation [7, 8]. Also, it essentially increases and provides ecological safety of the industrial project at all. To solve the following problems the authors put a
goal. It is to work out a simple and reliable machine, which has a small space, is easy in service and has a high level of the wastewater purification of food industry enterprise.

Some mechanical, physicochemical and chemical methods of the purification were tested in the laboratory. According to the previous results, the main requirement [9, 10] of the purification of the wastewater is to bring up the concentration of the pollutants as it can be not only discharged into the city drainage system but used in the technological process [11] also. It is obviously a method of the electrochemical machining together with the previous mechanical clearing and the following final treatment by the way of the sorb method.

The electrochemical method was chosen as a main one because it has some advantages in comparison with microbiological and reagent ones. First, it helps reduce working area for setting the machine. Second, it gets an opportunity to correct physicochemical options of the liquid and extract of worth elements. Third, it makes technological scheme of purification and machine service easier. Moreover, it decreases salinity of water. And finally, it makes automation work all the constructions easier [12, 13]. Not to mention the fact that in most cases the electrochemical method of wastewater purification is ecologically clean, because it omits the secondary water pollution with anionic and cation residues, which are usual for the reagent methods [14, 15]. Introducing the sorption method using granular carbon [16, 17] in the final stage of the deep wastewater after treatment let delete impurities with wide chemical consistency to the state of any residual concentration. As a result, it is possible to reuse the water on the technical factory needs [18, 19]. However, the efficiency of the process of pollutants extraction is connected with the choice of filter materials. They can be activated carbon, natural minerals and solid factory wastes, which have rather pore structure [20].

It is known that Russian and foreign scientists are inventing multifunctional machines such as an electrochemical filter, an electro-dialyzer, an electro-floto-corrector, which have efficiency up to 10m³/h [21]. Using this perspective direction in wastewater purification technology, the authors offer a construction of the combination machine, which combines both electrochemical oxidation and sorption after treatment (figure1).

After previous mechanical cleaning sludge liquor leaves the accumulator tank and is entered through the drain water pipe 2 into the electrolyzer-adsorber 3. Speed of the water column lifting, depended from the device efficiency, is set with the pump through the horizontally alternate perforated plates of the electrodes 4. They are set on the contact guide pegs 13, where electrochemical oxidation of the wastewater pollutants happens. Reaching the overflow of the adsorber 7, electrochemically treated wastewater goes to the first chamber of the double-chamber adsorber 5, which is filled with the sorbent. Then, it goes to the second chamber of the adsorber and, after getting the set level, the cleaned water is removed through the drain valve 8. With the help of the scraper system, looked like the paddle stirrer 9, which is operated with the gearbox10, froth is drained in the flotation receiver. After that it goes to the further treatment. Gaseous substance and sediment necessarily happen in the process of the machine exploitation. Such gaseous substance is deleted through the gas branch pipe 12, which is on the cover of the electrolyzer, and accumulated sediment is deleted with the washing the machine with the help of the tap 1.

There is some main process information, which is influenced on the level and power-intensity of the electro oxidation sorption cleaning. They are: starting concentration of the pollutants in the wastewater, water pH, conductivity, current density, time of the flow of direct current treatment, electrode material (anode and cathode), distance between them, a material and height of the sorption load etc.

Determination of the optimal technological parameters of the electrochemical oxidation and sorption final treatment, which provide a stable operation of the water purification, takes place at the one of the Volgograd food industry enterprise. It happened with the help of the combination machine for industrial wastewater purification (figure1), invented by the authors. The results can be seen in the table 1.

As it is seen in the table 1, the purification of wastewater with the help of the electrochemical oxidation method together with the sorption final treatment using the electrolyzer-adsorber under
right conditions lets increase water quality in such parameters as BOD, COD, SAM. It helps drain purified wastewater in the city canalization. This result is reached because of the electrochemical oxidation of the complicated organic compounds. They are gone under destruction of electric current and transformed into the simple components, which are deleted through the double-chamber adsorber with the sorbent.

**Figure 1.** A combination machine for food industry enterprise wastewater purification from the multicomponent pollutants (electrolyzer-adsorber): 1 – a tap for device rinsing; 2 – a drain water pipe; 3 – a body of the device; 4 – the plates of the electrodes of the electrolyte pot; 5 – an adsorber; 6 – a pipe for feeding drain water with electrochemical treatment to the adsorber; 7 – an overflow of the adsorber; 8 – a drain valve of the clean water; 9 – a scraper system, made in the view of the paddle stirrer; 10 – a gearbox of the scraper system; 11 – a flotation receiver; 12 – a gas branch pipe; 13 – guide pegs.

**Table 1.** Technological parameters and efficiency of the electrochemical and sorption final treatment of the wastewater of Volgograd food industry enterprise
### Summary

Wastewater, as a result of food industry enterprises activity, has a complicated composition of the pollutants. It is offered to clean previously mechanically treated wastewater in the electrolyzer-adsorber. Using this method it is allowed:

1) to clean wastewater to the permissible concentration, which are allowed to be drained into the city drainage system;
2) to correct main technological parameters of the purification, depending on the concentration of the pollutants. Taking it into consideration, it can be recommend using this machine to clean wastewater, which has similar composition.

### References
[1] Information on http://voda.mnr.gov.ru/
[2] Dedkov U M, Klimovitskaya L M, Kotov K S, Pochkin U N 1992 A Reference Book about Multicomponents Composition of the Watercourse and Wastewater at the Different Factories (KSU, Kazan).
[3] Kulikov P P, Kulikov N I, Naymanov A Y, Omelchenko N P, Chernishov V N 2009 The Theoretical Foundation of the Water Purification (a tutorial, Knowledge, Moscow).
[4] Grebennikova N M 2003 Assessment of the Influence of the Wastewater on the Water Quality in the City Watercourse ([text]; dis. … acad. a Master's degree, Novosibirsk) 150 p.
[5] Voronov V V, Yakovlev S V 2006 Watercourse and Wastewater Purification (Studentbook, Pub. Association of the building univercities, Moscow).
[6] Usfin U S, Leontiev L I, Chernousov P I 2002 Factory and Environment (ECC «Akademkniga», Moscow).
[7] Nikiforov L L 2008 Theoretical and Practical Foundation of the Improvement of the Wastewater Process of the Meat-Packing Houses ([text]; dis. … DEA Doctor of engineering, Moscow) 372 p.
[8] Moskvicheva E V, Sidyakin P A, Shchitov D V, Ignatkina D O 2014 Recycling of Waste Production into Secondary Raw Materials as a Condition of Maintenance of Industrial Safety at Enterprise (J. Bulletin of Volgograd State University of Architecture and Civil Engineering, Series: Construction and architecture) 37 204-211.
[9] Frog B N, Frog D B, Skurlatov U I 2004 Eco-Chemical Aspekts of the Wastewater Purification and Water Preparation ([text], The projects of the city infrastructure development: coll. of sc. Papers, Pub PLC «Mosvodokanal R&D establishment project», Moscow) 4 110-127.
[10] Koganovskiy A M, Klimenko N A, Levchenko T M, Muratovskiy R M 1983 Purification and Using Wastewater in the Industrial Water Supply (Chemistry, Moscow).
[11] Hence M, Armoes P, La-Kur-Yansen Y, Arvan A 2004 Wastewater Purification (Mir, Moscow).
[12] Krasnoborodko I G, Yakovlev S V 1987 Technology of the Water Purification (Stroyizdat, Leningrad).
[13] Moskvicheva E V, Moskvicheva A V, Ignatkina D O, Sidyakin P A, Shchitov D V, Kuzmina T A 2014 Study of Links Between Physical and Chemical Properties of Industrial Wastewater and Methods of Cleaning (J. Modern problems of science and education) 6 98.
[14] Feng Ch, Sugiuara N, Shimada S, Maekawa T 2003 Development of a High Performance Electrochemical Wastewater Treatment System (Journal of Hazardous Materials) 103 65-78.
[15] Usha N Murthy, Rekha H B, Bhavaya J G 2011 Performance of Electrochemical Oxidation in Treating Textile Dye Wastewater by Stainless Steel Anode (International Journal of Environmental Science and Development) 2 6.
[16] Godimchuk A U 2004 Studying of the Sorption Processes on the Natural Materials and their Thermo-Modified Forms (Chemistry and water technology).
[17] Lee C H 2003 Processing of the Third Pacific Basin Conference on Adsorption Science and Technology (World scientific).
[18] Sobgayda N A, Olshanskaya L I, Tarushkina U A, Nikitina T V 2007 Sorbents for Wastewater Purification (Ekip) 11 32–33.
[19] Serpokrilov N S 2009 Ecology of the Wastewater Purification with the Physicochemical Methods ([and etc.], Moscow, Pub. Association of the building univercities).
[20] Klimov E S, Buzaeva M V 2011 Natural Sorbents and Complexing Agent in Wastewater Purification (ULSTU, Ulyanovsk).
[21] Ilin V I, Kolesnikov V A 2005 Technology of the Electrochemical Wastewater Treatment with the Water Cycle (Water supply and sanitary engineering) 2 (1) 21-24.