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DEMINERALIZATION OF SEA WATER

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Abstract

A study of the method of minimizing energy costs in the technology of sea water demineralization by reverse osmosis has been carried out. It is proposed to use the preliminary treatment of water by the method of electroactivation, as a complex effective process of demineralization with associated purification from organic substances and prevention of deposits on membranes. The dependences of the parameters of electrochemical action on the composition of seawater have been determined, graphical dependences of the degree of water purification on various parameters (current strength, voltage, distance between electrodes, time of electroactivation, volume of sampling of acidic water in the process of unipolar electroactivation) have been obtained. The analytical control of the process was carried out and the technology of demineralization was proposed as a method of using the electrochemical activation process in the preparation of seawater for the stage of membrane purification.

Keywords: sea water, electroactivation process, degree of purification.

State of the problem

One of the main problems of the integrated processing of seawater into technological (for example, for the Port Plant, Odessa) is their high mineralization, as well as organic and biological deposits during demineralization at the stages of ultrafiltration and reverse osmosis.

Today, about 90% of the total capacity of desalination plants in the world is provided by distillation single-, multi-stage and thermocompression plants. The distillation method is energy-intensive, therefore, the use of installations is advisable in those regions of the world that have sufficient energy resources. If distillation, freezing or reverse osmosis are effective for water with a salt content of more than 10 g / l, then at a lower salt content (2 ~ 3 g / l), the ion-exchange method is recommended, and in the salt concentration range of 2.5~10 g / l - electrodialysis or reverse osmosis. Each of these methods has both positive and negative qualities and is applied within certain concentration limits. New developments carried out by the ICCWC of Academy of Sciences of Ukraine for the production of demineralized water offer complex multistage water purification schemes with the processing of concentrated brines. The most difficult part of the salt extraction technology is to reduce the content of. CO_3^{2-}, SO_4^{2-}, Cl^- ions with 25000 21000 mg/dm^3 till 2500mg/dm^3. These processes are very energy intensive and costly. In addition, methods such as electrodialysis, reverse osmosis, sodium cationization are economically feasible to apply only when the mineralization is below 2500±100 mg/dm^3. Thus, the urgent task is to prepare seawater for membrane technology by preliminary demineralization.

Proposal of the problem solve

It is proposed to use the complex preparation of highly mineralized water by the method of electrochemical activation.

Electrochemical activation is a physical-chemical process, a combination of electrochemical and electrophysical effects on water in the space discharge zone on the surface of the electrodes. In this case, a nonequilibrium state in the solution is achieved due to the transfer of charge across the "electrode - membrane - electrolyte" interface.

One of the advantages of the method is the directional movement of hydroxyl ions in the electroactivator. Hydroxyl ions, which are formed on the electrode, when using permeable membranes, are not associated with hydrogen cations, but increase the pH of the cathode volume to 10-12. In this case, 70-80% of the current efficiency is achieved, for example, by reducing the hardness of the water. Several competing reactions occur under the influence of free hydroxyl ions in the cathode region and at the cathode surface:

$$Ca^{2+} + 2OH^- \rightarrow Ca(OH)_2;$$

$$2Ca^{2+} + 2OH^{-} + SO_4^{2-} \rightarrow Ca(OH)_2SO_4\ ;$$

$$OH^{-} + HCO_3^{-} \rightarrow CO_3^{2-} + H_2O\,;$$

$$Ca^{2+} + CO_3^{2-} \rightarrow CaCO_3\,;$$

$$Mg^{2+} + 2OH^{-} \rightarrow Mg(OH)_2\,;$$

$$Fe^{3+} + 3OH^{-} \rightarrow Fe(OH)_3\,.$$

Due to the high concentration of the chlorine ion in the anodic region the Cl^- and on is oxidized and a number of oxygen-containing ions are formed according to the known mechanisms of electrode reactions:

$$2Cl^{-} - 2e^{-} + H_2O \rightarrow 2ClO^{-} + 2H^{+}\,;$$

$$6Cl^{-} + 6OH^{-} - 6e \ \rightarrow 2ClO_3^{-} + 4Cl^{-} + 3H_2O$$

An increase of the active chlorine concentration leads to the disinfection of seawater. The synthesized hypochlorite ion oxidizes dissolved organic substances in the anode region, suppresses the vital activity of microorganisms, which simplifies the technology of water treatment. The drop in the concentration of organic compounds is also associated with their adsorption and coprecipitation on freshly formed colloidal particles of hydroxides of the cathode region.

Thus, the electrochemical purification method is a universal method for preventing calmatation (sulfate deposits), as well as membrane biofouling, which is effective for water purification technology with further use of the reverse osmosis stage.

The advantages of the method are - the possibility of using the method under atmospheric pressure, in the presence of organic compounds; replacement of semi-permeable membranes with permeable ones; simplicity of design; the possibility of improving the design.

Purpose of the work

Study of the electroactivation reduction of the salinity of seawater by 45-50% and the development of a technology for complex purification and demineralization of highly saline waters at the stage of pretreatment by the method of unipolar electrochemical activation to prevent various deposits at the stage of final demineralization of water by membrane methods.

Main material presentation. For the study, we took the seawater of the Tiligul estuary (near the city of Odessa).

Water analysis was carried out by the following methods: total water hardness was determined according to DSTU ISO 6059:2003 (ISO 6059:1984, IDT) Water quality – Determination of the sum of calcium and magnesium – EDTA titrimetric method); for determination of in the studied water was applied Silver nitrate titration with chromate indicator (Mohr's method) method in accordance with DSTU ISO 9297: 2007; he dry residue was determined by the gravimetric method according to GOST 18164-72; the sulfate content was determined by the turbidimetric method according to GOST 4389-72, and the determination of pH was carried out by potentiometric method.

Table 1

The composition of water from the Black Sea near the Tiligul estuary

Cations	The content of cations	
	mg/l	mg·eq/l
Ca^{2+}	370	18,5
Mg^{2+}	715	58,8
Na^{+}	2985	128,6
K^{+}	730	18,7
Total	4773	224,6
Anions	The content of anions	
	mg/l	mg·eq/l
Cl^{-}	868,77	19,8
SO_4^{2-}	1,092	47,5
HCO_3^{-}	341	5,6
Всього	2301,77	72,9

The total mineralization of water is P = 7075 mg/l or 7,1 g/l; pH of the water is 7,5.

Figure 1 shows a laboratory installation for *seawater* treatment by electroactivation. Before feeding the test water to the installation, it was pre-filtered through a paper filter to remove coarse suspended solids.

A laboratory demineralizer has been developed and created, its operation has been studied in various modes using model solutions. The research results were used to create a stand apparatus - an electrochemical activation reactor.

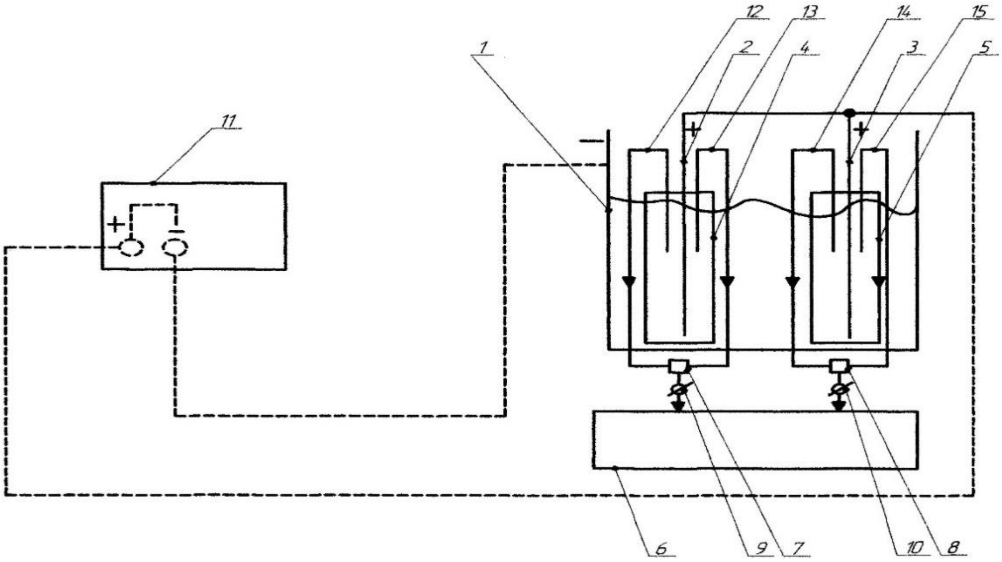

Figure 1 Scheme of a laboratory installation for water purification by the method of electroactivation. 1 - electroactivator case (cathode) 2, 3 - electrodes (anodes) 4,5 - tarpaulin bags for electrodes; 6 - tank for anolyte; 7, 8 – pumps; 9,10 - taps for anolyte sampling; 11 - power supply unit; 12, 13, 14, 15 - anolyte sampling pipes.

With a current of 6 A, a voltage of 10 V, the water was purified from a number of impurities. The research results are listed in Table 2.

Table 2

Purification degree of model solutions.

Indicators	Purification degree, %		
	Experiment №1	Experiment №2	Experimen №3
Salt content	45,3	50,64	59,39
Hardness	48,05	67,21	74,15
Oxidation	76,06	78,40	80,10
Sulfates	40,4	54,89	56,22
Chlorides	49,28	58,61	58,99
Bicarbonates	80,40	81,60	87,00
Ca^{2+}	69,70	69,50	70,45
Mg^{2+}	56,30	58,12	60,11
Fe^{3+}	95,2	96,2	98,4

Complex cleaning of model solutions is made at the following technological indicators: current density 1,0 – 1,5 A/dm^2, the amount of electricity by experiments (kW·h /m^3): №1 – 2,5, №2 – 3,8, №3 – 5,1. As follows from table 2, a high degree of primary demineralization of the source water is achieved with one-stage treatment. The power consumption according to the experiments was (kW·h /m^3): №1 – 4,6, №2 – 8,9, №3 – 14,2

For stand tests, a continuous flow apparatus with electrodes of a special design was developed, which allows processing 3 m^3 /h aqueous solution.

Figure 2. Photo of a stand installation of water electrical activation.

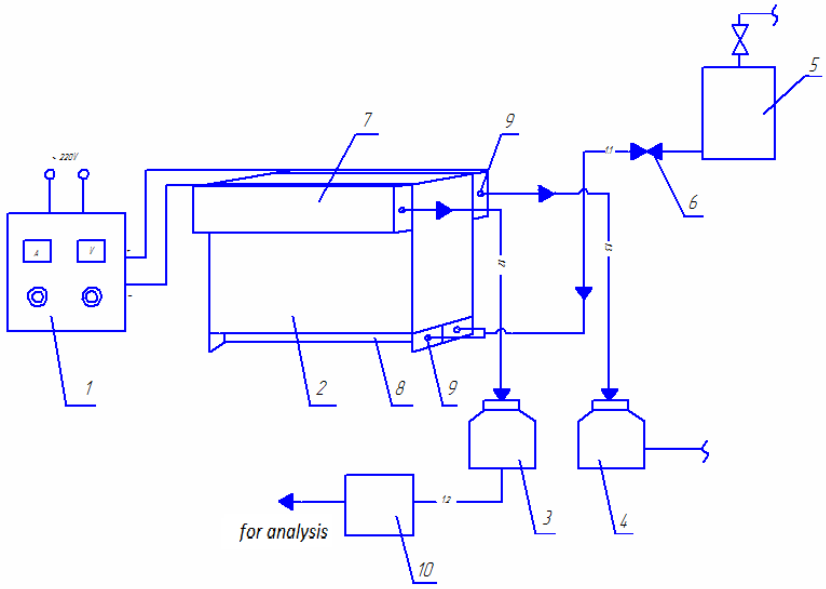

Figure 3. Scheme of a stand installation of electrical activation
1 - power supply; 2 - main container; 3 - container for catholyte; 4 - tank for anolyte; 5 - test water container; 6 - tap 7 - water drainage chamber; 8 - water supply chamber; 9 - choke; 10 - anolyte sump.

During chemical electroactivation, various parameters were changed: amperage (I, A), voltage (U, V), time (t, s), acid water sampling volume (V, dm3), as well as the distance between the electrodes (L, mm).

Figure 4 shows the data on the reduction of the organic compounds and microorganisms content.

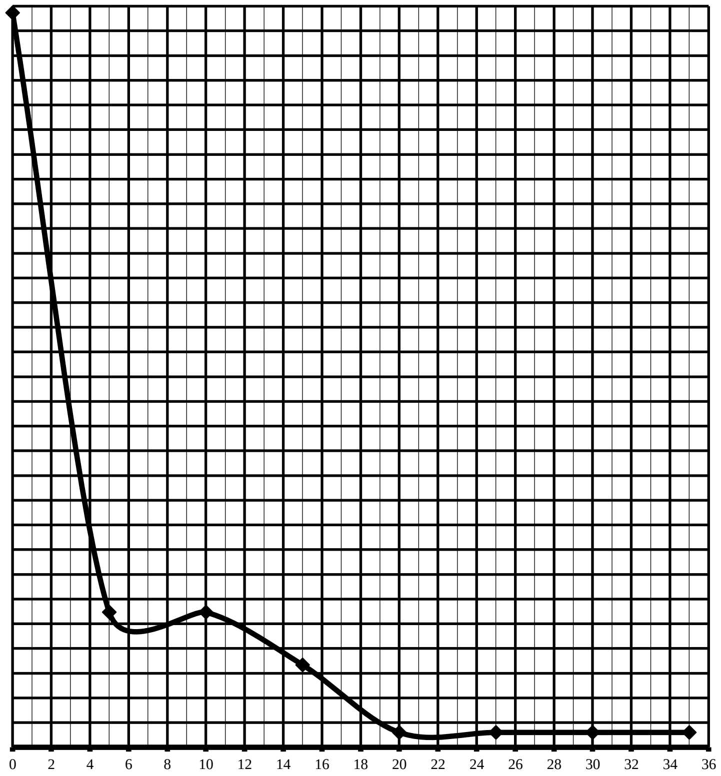

Figure 4 Dynamics of the decrease in the organic compounds content to time (in minutes).

Concentration of Ca^{2+} and Mg^{2+} ions decreases in time by a factor of 10 in the process of electrical activation of seawater; solids content - by 28-30%; the concentration of sulfate ions decreases by 73-75%; bicarbonate ions - by 67- 69%; concentration of iron and heavy metals - by 67-72%; organic compounds - by 58-65%, microorganisms - by 89-94%.

The data obtained were summarized in Table 3.

Table 3

Results of primary water purification by the method of electroactivation

Water quality indicators	Test results		
	Source water	После очистки методом электроактивации	degree of purification, %
Dry residue, mg/dm^3	9806	4665	52,4
Sulfates, mg/dm^3	450	270	40
Chlorides, mg/dm^3	2958	700	76,3
Total hardness, mg/dm^3	43,8	20,5	53,2

Electricity consumption for demineralization and water purification is equal 12,0-12,8 kW·h /m3. This is the sum of energy consumption for the transportation of water at the stage of electroactivation and electrodialysis, 38−45% of which falls on the stage of electroactivation.

A technological scheme for desalination, disinfection and reduction of organic matter content in catholyte and anolyte after seawater purification is proposed.

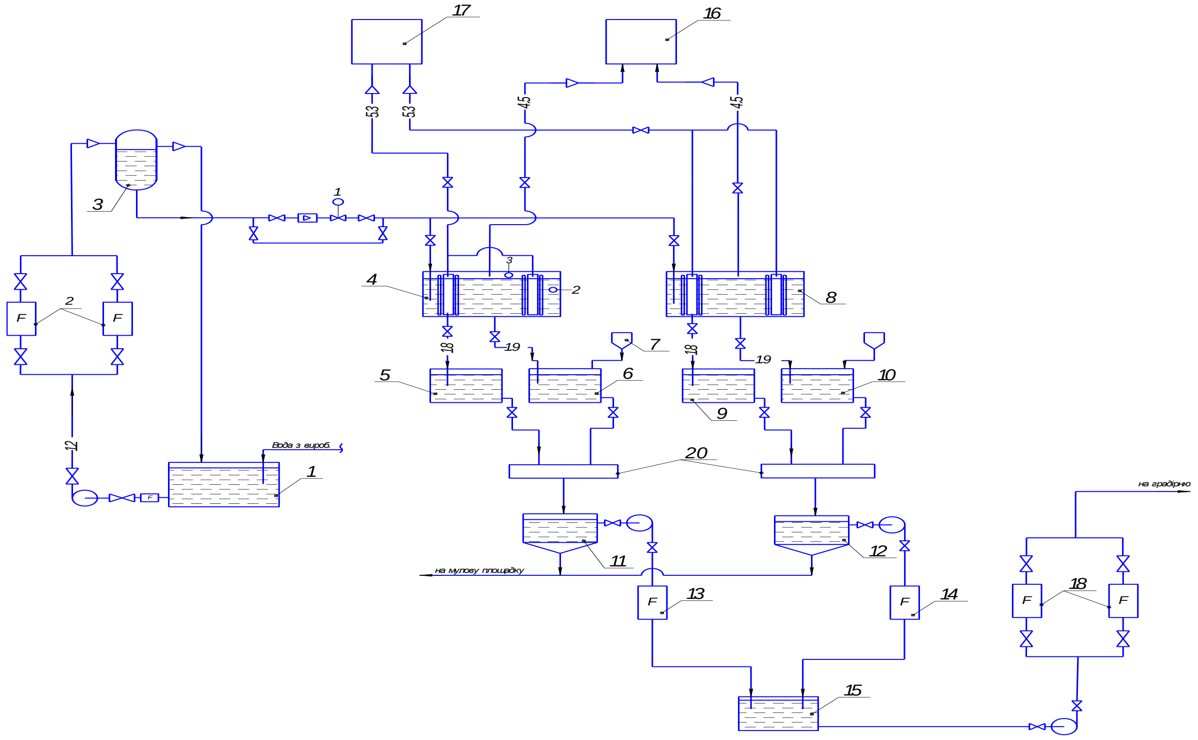

Figure 5 Technological scheme of seawater purification using an electroactivator

The water coming from the seawater collector is directed to the collector 1... The pump is fed through the filter 2 to the water seal 3. then it is fed into the electroactivators 4,8 where the primary cleaning process occur. During the cleaning process, gas is formed in the anode space, which flows through the pipeline into the gas holder 17. The gas formed at the cathode enters the gas holder 18. The formed anolyte enters the collection of the anode water flow 5,9; catholyte solutions - into the collecting tank of cathode water 6,10. Add coagulant from hopper 7 to the collection of cathode solutions. After that, after settling and filtration, the anolyte and catholyte enter the neutralizers 20, where water is mixing and neutralized. Further, purified water is prepared for the membrane desalination stage. The purified water flow enters through additional sedimentation tanks 11,12 and quick filters 13,14 in the collector of purified water 15. by pump through the filter 18 from the tank 15 enters the stage of demineralization by reverse osmosis.

The resulting sludge from the settling tanks 11,12 is sent for disposal.

Conclusion. When using the electroactivation stage as the primary stage of water preparation for the membrane system, it is possible to reduce energy consumption by 35-40%.

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TARGET MODELS OF INTEGRATED RISK MANAGEMENT FOR IT PROJECTS

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Abstract

The article presents the definition and concept of the developed system of target models for integrated risk management for IT-projects management. There is presented the mathematical model for the developed system of target models for integrated risk management for IT-projects. It is considered the complex nature of risk with corresponding distinguished components related to project constraints. There are performed calculations for the ordinary IT-project within detected threats and opportunities based on the developed approach. The analysis of the small IT-project was carried out taking into account the developed system of target models for integrated risk management.

Keywords: risk management, integrated risk management, risk, threat, opportunity, IT-project.

Introduction. There is a vast variety of the models for the risk management that helps to achieve project success [8, 9]. However, there is the room for improvement for any project. That is why it was decided to research the complex nature of the risks, both threats and opportunities, and use the approach for target models applying to the risk management with the analogy of medicine. The target models of the integrated risk management concept originated from the targeted therapy for the cancer treatment in the medicine [7]. Each risk whether this is threat or opportunity should be ranked and placed in the target model for each project constraint to calculate the sum risk for each project constraint and make the decision for project management.

Review of publications on the topic. The analogy of the medicine and project management has been established in the various papers. The authors have a classification of deviations based on the "diseases" from threats in projects, which built by analogy with the classification of diseases in medicine [4, 5, 6, 10]. Also, there was developed a model that allows to estimate the relative and absolute synergistic effects of deviations from threats and opportunities in the project and general synergetic effect between threats and opportunities in the IT project [5, 9]. The author has certain analogies between project management and medicine, as well as features of deviation management in projects that allow such analogies [10].

The aim of this study is to develop and apply the target models of the integrated risk management for the IT-project based on the complex nature of risks depending of the project constraints.

Results and discussion.

The classical risk management identifies risk as an uncertain event or condition, if it occurs, has a positive or negative effect on a project`s objectives [1]. This statement could be described by the following formula

$$R_i = \sum_{i=1}^{n} P_i \cdot V_i \qquad (1)$$