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DESALINATION OF SYRDARYA WATER BY POLYAMIDE (PA) MEMBRANES

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ABSTRACT

South Kazakhstan water is an important source of drinking water in an increasingly scarce world. An adequate integrated assessment of water quality from the point of view of its suitability for human use therefore remains a pressing issue. The purpose of this work is to assess water quality using nano-filtration methods, using the example of the South Kazakhstan is- Syrdarya River, and their suitability for use by the population. The main advantage of nano-filtration methods is the production of better-quality water without harmful bacteriological and microbial contamination. Determination of the water permeability index, sodium, magnesium adsorption coefficients, microelement content, cation, and anionic composition. The results showed that the main pollutants of the Syrdarya River in the studied region were sulfates, nitrites, copper, and magnesium. Sulfate content 548 mg/l (5.5 MPC), nitrite 0.028 mg/l (1.4 MPC), copper 0.003 mg/l (3.0 MPC) and magnesium 71.5 mg/l (1.8 MPC). The results of the after purification of in a membrane apparatus in the absence of toxic substances of the third and fourth hazard classes, as well as odor and taste, points no more than 1-2, the biological demand for oxygen is reduced by 92, 5%, and the chemical oxygen demand is reduced by 100%. The results of water purification of the Syrdarya rivers in a membrane apparatus in percentages: nitrites 84%, nitrate 15%, sulfates 84%, mineralization 95%, and the odor and taste index is zero, which meets sanitary and hygienic requirements and is suitable for sustainable use as drinking water in the South Kazakhstan region. The system guarantees the removal of up to 99% or higher of inorganic salts, up to 99.5% of organic substances, and 100% removal of bacteria and viruses.

Keywords: Polyamide Membranes, Water Quality, Nanofiltration, Syrdarya.

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INTRODUCTION

One of the goals of sustainable development is to ensure the availability and rational use of water resources and sanitation for all. Important indicators for this goal of sustainability are the percentages of the population that uses safely managed drinking water and has access to safely managed sanitation, improves water quality, increases water-use efficiency, and ensures freshwater supplies. Central Asia has huge freshwater resources, however, they are unevenly distributed throughout the country, as a result, many areas of southern Kazakhstan and Central Asia lack water suitable for water supply to the population, irrigation, and irrigation of agricultural land.[1,2,3] The intensification of agriculture implies the increasing use of various insecticides and herbicides that enter surface waters and make them unsuitable not only for drinking but also for the irrigation of agricultural crops. In the conditions of industrial areas, water pollution with heavy metals prevails, in megacities; household waste plays an important role among the factors of deterioration in the quality of drinking water.[3] The human right to use high-quality drinking water was recognized in 2010 at the UN General Assembly. Every second person from the entire population of the planet uses water from a water pipe.[4] The health of the population largely depends on the quality of drinking water, since water is the main medium and reagent of vital metabolic processes in the human body – respiration, etc. In addition, water is the main component of the human body: from 70

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to 85% of the weight. Electrolytic dissociation reactions occur in the aqueous medium, and colloid solutions are dispersed here. In case of deviations of water quality from the generally accepted standards of norms, the development of endemic diseases among the population is possible.[5] In the case of a lack of fluoride, the incidence of caries among the population can be up to 70% of all cases of dental treatment, if fluoride is present in excess, on the contrary, cases of fluorosis are noted.[6] Recently, cases of man-made disasters have become more frequent, when wastewater and industrial water emissions occur. Further, these waters penetrate into aquifers underground.[7] For the Republic of Kazakhstan, as in many other countries of the world, there is an increasing shortage of fresh water volumes. According to the ecologist, measures are being taken by the state, and significant. Of particular relevance are studies devoted to the consideration of this issue within individual territories, and model regions. This is due to the fact that it is quite difficult to make a forecast for a large territory based on the prevailing trends in the quality of drinking water, since the situation may be diametrically opposite in different regions. At the same time, the results of data analysis on the state of groundwater in the model region can be used for territories with similar geological, climatic, and hydrological characteristics. The Syr Darya is the longest and second most watery river after the Amu Darya in Central Asia. The long-term average water discharge is 724 m^3 / s (27 km below the Chirchik confluence). Formed at the confluence of Naryn and Karadarya in the eastern part of the Ferghana Valley.[8-9] Known membrane apparatus for filtering and water flow, containing a housing with inlet and outlet pipes, fixed disc filter membranes, mesh elements mounted for rotation, and cylindrical elements of porous elastic material, freely located between the membrane and the mesh element with the possibility of rolling over the surface membranes. A device for cleaning liquids is also widely used, containing a cylindrical body with a pipe for the inlet of the liquid being cleaned, located tangentially to the generatrix of the body, pipes for the output of purified and under-cleaned liquid, a tubular membrane module containing a frame with drainage holes and with an outer semi-permeable membrane, installed with a gap relative to the inner body walls.[10-11] But, this device has such disadvantages as rapid wear of elastic elements during rotation over the surface of the membrane and low productivity of the device. This paper attempts to redress the imbalances in previous studies by developing and proposing a membrane apparatus that has such advantages as simplifying the design of the apparatus, increasing the efficiency of mixture separation, and increasing the duration of the membrane.

The objectives of this work were:

1. To develop a membrane device for the desalination of Syrdarya River (Shardara and Koksarai reservoir) waters
2. To determine effective conditions and modes of desalination of water
3. To provide sustainable safe and affordable drinking water, improve water quality, increase water-use efficiency, and ensure freshwater supplies of waters.

EXPERIMENTAL

Materials and Methods

Fabrication and Characterization of Membranes

For the desalination of underground waters, a membrane made of aromatic polyamide MGA-90. Technological and physicochemical characteristics of semi-permeable membranes are described in Table-1 and 2.

Table-1: Technological Characteristics of Semi-Permeable Membranes

Membrane brand	Selectivity for NaCl, 5 g/dm3, %	Permeability at p = 5 MPa, dm3/(m2 day)
MGA-90	90	350

Table-2: Main Characteristics of Membrane Water Purification

Productivity, m3/hour	Working pressure, MPa	Filtrate-concentrate ratio in %
50	3	80/20

Mass transfer at the surface of an ultrafiltration membrane is usually considered from the standpoint of the film theory, according to which laminar boundary layers appear at the phase interface, within which concentration gradients exist. The main resistance to mass transfer is concentrated in these layers. During the ultrafiltration process, solvent and low molecular weight solutes predominantly pass through the membrane. An increase in the concentration of retained substances in the boundary layer near the surface membrane properties is known as concentration polarization. Tables-3 to 4 present the main characteristics of membrane desalination, energy consumption, overall dimensions of the device, and requirements for the quality of water supplied to the reverse osmosis plant.

Table-3: Main Characteristics of Energy Consumption

Power supply	Consumption power, kWt	Email pump power Maprotec, Grundfos, kW
380V/50Hz	3.0	20.0

Table-4: Main Overall Dimensions of the Device

Diameter, m	Height, m	Membrane type	Porosity, %	Pore diameter, µm
0.4	0.6	Osmonics	80	0.001

Filtration Experiments

Membrane apparatus[10], containing a cylindrical body with a pipe for inlet of the liquid to be treated, located tangentially to the generatrix of the body, pipes for the outlet of purified and under-cleaned liquid, a tubular membrane module containing a frame with drainage holes and with an external semi-permeable membrane, installed with a gap relative to the inner walls of the body, the membrane apparatus is also additionally provided with an elastic element made of a porous material in the form of a cylindrical roller and located with the possibility of rotation along the axis of the apparatus, and the membrane modules can also rotate vertically along their axis and parallel to the elastic element.[11] Figure-1 shows a general view of the membrane apparatus: in Fig.-2 top view of the apparatus with a section of the lid of the apparatus.

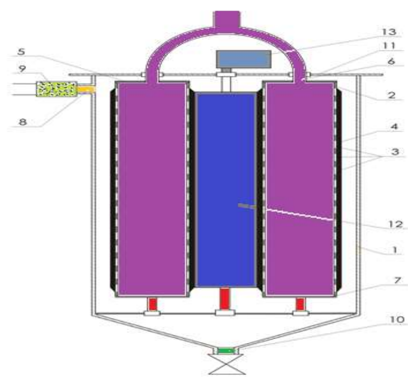


Fig.-1: 1 body of a Cylindrical Membrane Drain, 2 - Pipes for the Passage of Desalinated Water 3-Drainage Holes, 4-semi-permeable Membranes, 5 Valve Covers, 6-a Pipes for the Discharge of Desalinated Water, 7 Empty Bottom, 8 - a Pipe for the Introduction of Desalinated Water, 9-a Large - Pore Filter 10-Pipe, 11-a Removable Cover, 12-an Elastic Element, 13-an Electric Motor

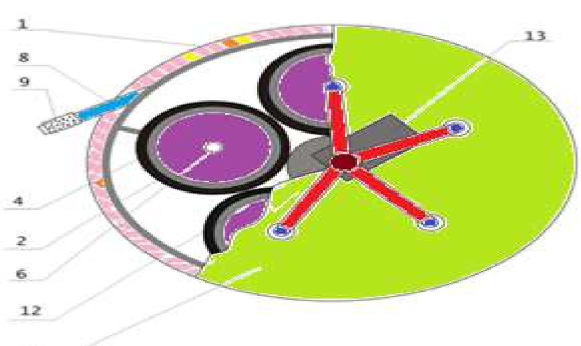


Fig.-2:Top View of the Membrane Apparatus: 1 Body of a Cylindrical Membrane Drain, 2 - Pipes for the Passage of Desalinated Water 3-Drainage Holes, 4-semi-permeable Membranes, 5 Valve Covers, 6 Pipes for the Discharge of Desalinated Water, 7-an Empty Bottom, 8 - a Pipe for the Introduction of Desalinated Water, 9-a large - Pore Filter 10-Pipe, 11-a Removable Cover, 12-an Elastic Element, 13-an Electric Motor

The membrane apparatus contains a cylindrical body 1, inside which membrane modules are installed, consisting of a tubular frame 2 with drainage holes 3 for the passage of the liquid to be purified, where semi-permeable membranes 4 are located on the outer surface, the upper end of the tubular membrane module has a removable cover 5 and is connected to the branch pipe 6 outlets of the purified liquid, and the lower end has a blank bottom 7. Housing 1 is equipped with a branch pipe 8 for introducing the liquid to be purified, located tangentially to the generatrix of the housing, due to which turbulence of the liquid flow is created, and a coarse filter (CSF) 9. The membrane unit works with the following principle: water for desalination is filtered through a filter filter (9) with large holes, passing through a pipe (8) located tangentially in the membrane housing. The water to be purified is made in a ring movement in the membrane unit, the largest particles are sent to the periphery under the influence of physical forces and precipitate, which contributes to the long-term preservation of the membrane's purification capacity. Salt water is purified from impurities and salts by passing through semi-permeable membranes, and through special drainage holes 3, penetrating inside the membrane module, special desalinated water is discharged through the outlet pipe (6). When the membrane unit is operated in filtration mode, the pipe (10) for the discharge of uncleaned liquid is closed. When the apparatus is operating, there is a blockage of the membrane 4 surface, which leads to an increase in the pressure difference in the tubular-membrane module. When the magnitude of the pressure difference reaches the given one, the elastic roller element (12) is automatically activated by means of an electric motor (13). When the elastic roller-shaped element (12) is activated, it comes into contact with the surface of the membrane and (4) removes contaminants with a tangential water jet by washing, resulting in the membrane (4) being cleaned and washed, and the unrefined liquid is discharged through 10 pipes. In this way, the membrane cleaning ie regeneration frequency prevents its Wear 4. The elastic element is made of porous elastic material, which does not damage the surface of the membrane and cleans mechanically. After the membrane unit for water desalination has been operating for up to 2.5-3 years, the membranes inside it are replaced with new ones. For research conducted on membrane treatment of nitrates, chlorides, and sulfates in groundwater, an experimental device was used, shown in accordance with Fig.-3. The experimental installation works as follows: water of primary production (1) is supplied from the tank by means of a pump(2) through a filter(3) of large cleaning to the membrane (4) device. Purified water (filtered) is sent to the container(5), and contaminants (concentrate) (6) to the container. When the pressure drop measure reaches the Tis value, an electric (7) motor drives the elastic camshaft element.

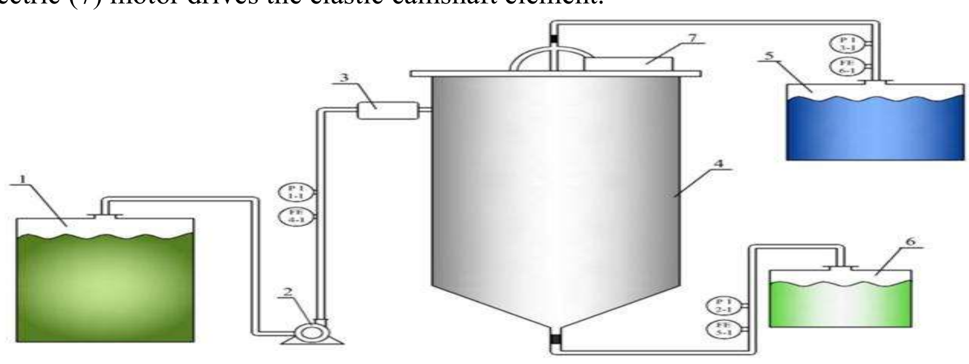


Fig.-3: Scheme of an Experimental Installation for Desalination of Groundwater
1-Production Water Tank; 2-Pump; 3-Large Cleaning Filter; 4-Membrane Device; 5-Container For Treated Water(Filter); 6-Container For Contaminants (Concentrate)

In some situations, filtration methods' energy consumption in the process is relatively low: the design of the device is simple and compact, does not require a qualified specialist to work on the device, and work equipment can be easily automated; Since the filter is very clean, it can be connected to the water supply system. Thus, the use of an elastic element reduces the wear of the membrane and increases the efficiency of cleaning the surface and pores of the membrane.[8] The parameters of devices that can be used in the creation of new and modernization of existing equipment for deep water purification. The water quality assessment of the Syrdarya River was carried out using the hydrochemical water pollution index (WPI) and the results are presented in Table-5.

Table-5: Water Quality Class Depending on the Value of the Water Pollution Index

Water	WPI values	Water quality classes
Contaminated	3.5	IV

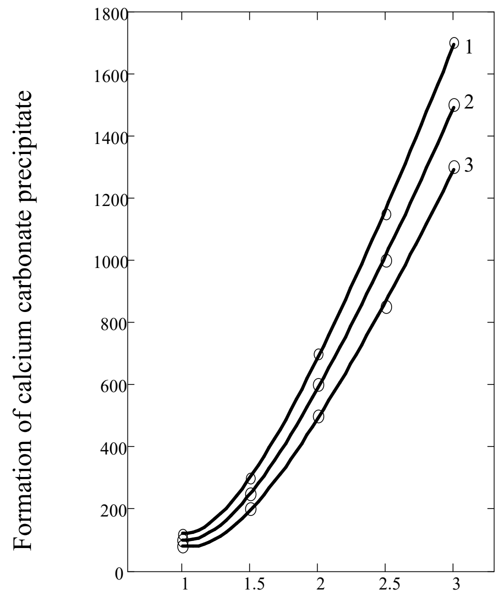
For a combined assessment of the water quality of the Syrdarya River, hydrochemical and hydrobiological indicators were used, i.e. assessment of the condition and rules for taxation of fishery water bodies according to GOST 17.1.2.04–77 [170] (Table 5).
This is the only document that, at the standard level, defines a system for detailed assessment of water bodies according to the following indicators[19-20]:
– quality of water and bottom sediments;
– hydrological regime;
– flora and fauna, highlighting groups of commercial organisms.
Water quality in accordance with GOST is characterized by the following indicators:
– salinity, hardness, and hydrogen index (pH);
– trophosaprobicity;
– content of harmful substances.
The document regulates in sufficient detail the classification according to the ionic-salt composition (halobic zones), hardness, and hydrogen index.

Characterization of the Water Sample

The measurements of the permeate mass and conductivity were automatically registered via a MatLab 9.7 (MathWorks, Natick, MA, USA). Another important issue in the design of membrane installations is the accuracy and reliability of the method of measuring the salinity of the water flow. For continuous monitoring of the quality of the water flow, a conductometric method based on the measurement of its conductivity is used. Conductivity is a quantitative characteristic of dissolved components and can be determined by direct measurement of the flow of a water stream. The standard unit of conductivity in water treatment is micro-Siemens (mS or mmho). The conductivity of natural waters can range from 20 mS for meltwater and up to 70,000 mS for seawater. The concentration of relevant cation was measured by inductively coupled plasma spectroscopy (ICP).[13-16]

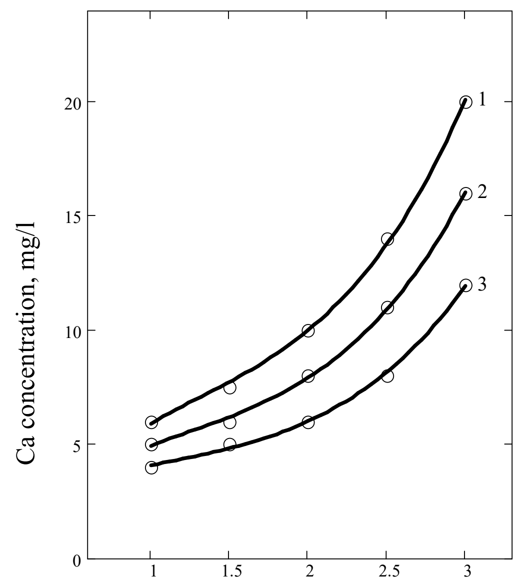
RESULTS AND DISCUSSION

Quality assessment criteria are any set of quantitative indicators that characterize the properties of the objects under study and are used for their classification or ranking. The main problems of filtration technology for producing drinking water can be considered: 1) assessment of selective properties and selection of membranes; 2) study of sediment formation and the choice of methods to combat them. In this regard, we have carried out the following studies: study of sedimentation and criteria for the quality of water supplied to membrane plants; influence of sediment and forecast of water quality during plant operation; and methods to combat sedimentation. When solving the problem of sedimentation, various types of sediments were considered, primarily crystalline sediments of poorly soluble substances. In most cases, when using low-pressure reverse osmosis, the main type of sediment is calcium carbonate. In some cases, precipitation of silicates and calcium sulfate occurs. Figure-4 shows the growth of calcium carbonate precipitate directly in the membrane apparatus. The figure shows that crystalline precipitates are formed in membrane devices due to design features. An increase in the concentration ratio and pressure leads to an increase in sedimentation. Next, we proposed a methodology for predicting a decrease in productivity and selectivity, as well as the rate of accumulation of $CaCO^3$ sediment. Prevention of sediment formation is combined with membrane regeneration and flushing, which removes sediment from the membrane surface. Depending on the amount of water in the filtrate tank, the filtrate yield is set (the ratio between the consumption of filtrate and concentrate), or the volumetric concentration ratio. The greater the filtrate yield, the greater the salt concentration in the filtrate. This technique simulates the operation of a filtration unit and allows one to determine the parameters of purified water depending on the specified value of the filtrate output. Figure-5 shows the dependence of the rate of sedimentation on the concentration ratio. The figure shows that the higher the membrane selectivity value, the higher the rate of sedimentation.[21-22] Experiments were carried out with NaCl solutions that were added to tap water (Fig.-6). Here, the increase in total salt content occurs due to an increase in the concentration of NaCl. Figure-5 shows the dependence of Ca concentration on the concentration factor of the source water, where the increase in salt content occurs due to an increase in SO4 concentration. Figure-6 shows the dependence of productivity on the duration of operation in the installation developed by the membrane. The graph shows that the use of elastic elements for regeneration can significantly increase the average specific performance of the membrane in filtration mode and extend the filter cycle until chemical regeneration is carried out from one month to two or more. The dependences of the concentration of organic substances in the circulating solution on time were obtained, and based on the mass balance; the dependences of the amount of adsorbed contaminants on time were obtained (Fig.-7). It is clear from the graphs that it is necessary to carry out pre-purification and retention of particles less than 1 micron in size. Figure-8 shows the dependence of the filtrate yield on the filtrate speed, i.e.plant productivity for filtrate of desalinated mineralized water. At a speed of 2 m/s, a productivity of 50 m3/hour of desalinated water was recorded.



Concentration ratio of source water

Fig.-4:Formation of calcium carbonate precipitate in a membrane device: 1 – pressure 4 MPa; 2 – 3 MPa; 3 – 2 MPa



Concentration ratio of source water

Fig.-5:The effect of Ca concentration depending on the concentration factor with NaCl solution:1 – pressure 4 MPa; 2 – 3 MPa; 3 – 2 MPa

As the source (desalinated) water at the Syrdarya River, water with a total salt content of 1060 mg/l and a total hardness of 16 mg-eq/l is used (Table-6). In terms of its salt composition, this water is classified as brackish according to the classification of I.E. Apeltsin and V.A. Klyachko or slightly brackish according to the classification of I.L. Mongait. According to the number of coliform bacteria in water, as can be seen from the results of sanitary and bacteriological analysis, this indicator exceeds the standard for drinking water by 13 times, and by the number of bacterial colonies in 1 ml of water by 2.4 times (Table-7). Phosphates in water are not dangerous for the membrane apparatus; on the contrary, a dose of up to 20 mg PO-34/l reduces sedimentation on membranes.

It is also known that the presence of sodium hexametaphosphate (SMPH) in water inhibits the deposition of gypsum $CaSO_4$ $2H_2O$ on the surface of membranes. The presence of silicates in water can negatively affect the operation of the membrane apparatus because The influence of not only iron but also aluminum hydroxides on the formation of silicate deposits is known. Petroleum products present in water negatively affect the membrane desalination process. When their concentration is above 10 mg/l for 50 hours, the performance of the membranes drops by 1.5 times, and the salt content decreases from 91-94% to 55-

60%.[24-26] Membrane desalination water treatment is widespread and is the undisputed leader where the water temperature for desalination does not exceed 32–33 °C with a salinity level of about 35–38 g/l.

Table-6: Physico-Chemical Composition of the Waters of the Syrdarya River after Treatment

No.	The name of indicators, unit well	Syrdarya river		Drinking water, standards (standards of CIS countries)
		before cleaning	after treatment	
1	Hydrogen value (pH)	7	7	6.0-9.0
2	Dry residue (total salt content), mg/l	1060.0	250	1000.0
3	Sulfates (SO2- 4), mg/l	564.0	90	500.0
4	Total hardness Job(Ca2++Mg2+), mEq/l Calcium (Ca2+), mEq/l Magnesium (Mg2+), mEq/l	16.8	1.7	7.0
		5.2		
		11.6		
		4.25	0.1	
		0	0	
5	Total iron Feob (Fe2++Fe3+), mg/l	0.5	0.1	0.3
6	Nitrates (NO-3), mg/l	10.34	8.5	45.0
7	Nitrites (NO-2), mg/l	0.08	0.01	3.0

As a rule, in seawater with such parameters, just one pass through the membrane reduces the salinity to 300-450 mg/l. To obtain not just desalinated, but fresh drinking water, several types of additional purification are required. The advantage of a membrane desalination system is the ability to create mixed-type plants that allow optimizing productivity in case of significant fluctuations in the daily or seasonal ratio between water and electricity production. In terms of typical output, a single-module system can produce about 4000–7000 m3 or more of fresh water per day. Most of the membranes of these installations are very sensitive to the presence of various bacteria in the water, as well as chlorine, which is used to combat the formation of scale and deposits of animal and plant origin, without which almost no system can do. Therefore, it is necessary to provide for preliminary purification of the source water to avoid clogging of the working membranes.

Table-7: Sanitary and Bacteriological Composition of the Syrdarya River

No.	Name indicators	Unit measurements	Drinking water (CIS countries standards)	Content	
				before cleaning	after cleaning
1	COD (chemical oxygen absorption)	mg O2/l	not > 15.0	16.0	0.1
2	BOD(biochemical oxygen demand)	mg/l	not > 3.0	4.5	0.9
3	Coli index	The number of coliform bacteria (coliforms) in 1 liter of water	not > 3.0	39.0	1
4	General microbial number, t 37 ºC	Number of bacterial colonies in 1 ml of water	not > 100.0	240.0	<50

The pressure of the source water for desalination depends on the level of its salinity (Fig.-9). The operating pressure required for membrane separation systems varies depending on the salinity of the feed water. For example, the conversion ratio maybe 50% for water from open and relatively cold seas (up to 26 °C) and drop to 35% for saltier seawater, provided that the water temperature does not exceed the maximum permissible level for the membranes. Due to the acceleration of the flow, desalination productivity increases with increasing water temperature, but the effectiveness of the working membranes is limited by the salinity parameters of the water.

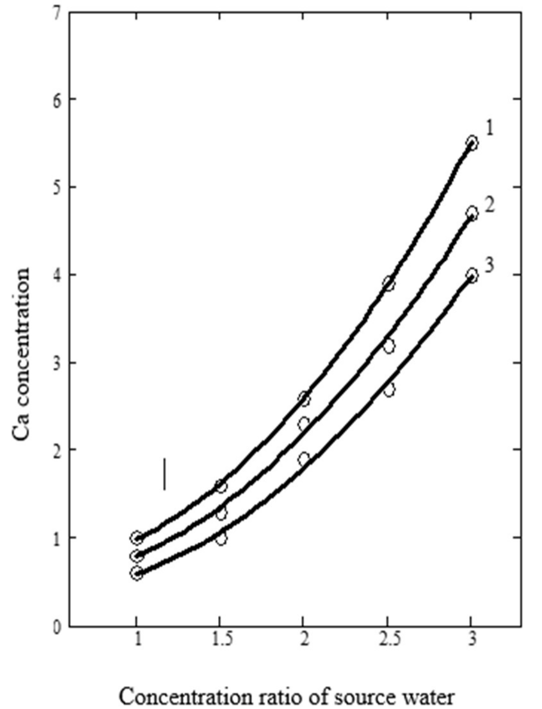


Fig.-6: The effect of Ca concentration on the concentration ratio with Na_2SO_4 solution

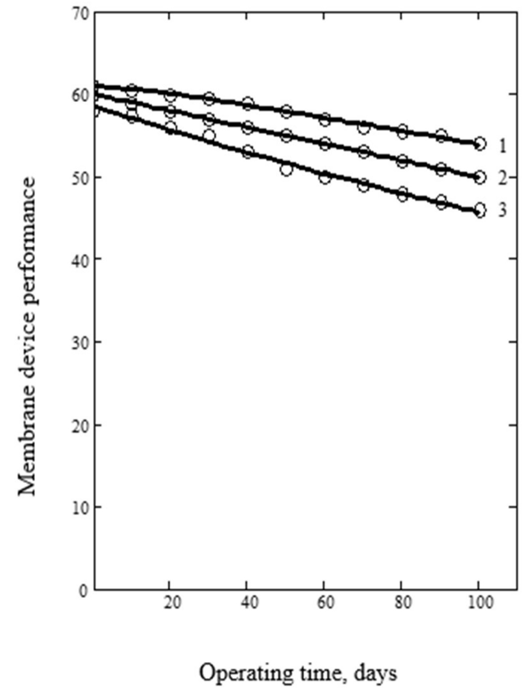


Fig.-7: The effect of membrane device performance on operating time: 1 – flow speed 1 m/s; 2 – 2 m/s; 3 – 3 m/s

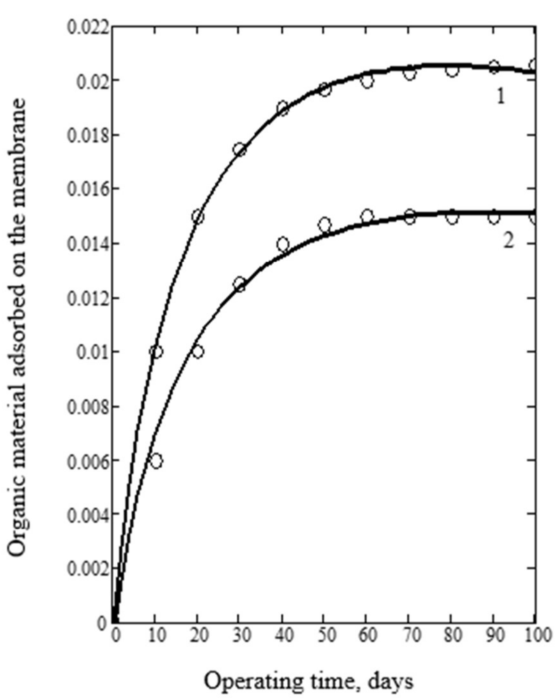


Fig.-8: The effect of organic material adsorbed on the membrane on time: 1 – flow speed 1 m/s; 2 – 2 m/s;

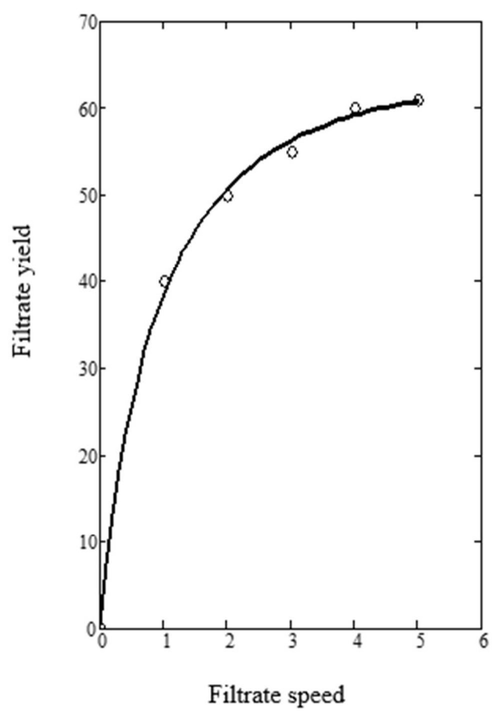


Fig.-9: The effect of filtrate yield on filtrate speed

In very hot climates (from 38 to 44 °C), the premises where membrane desalination plants are installed must be equipped with an air conditioning system, which inevitably leads to an overall increase in energy consumption. The main disadvantage of membrane desalination methods is membrane fouling. In order for membrane devices to maintain long-term performance, it is necessary to correctly select the technological scheme of water treatment modes before desalination and carry out periodic measures to restore the characteristics of semi-permeable membranes that have changed as a result of the operation of the devices. One such method is the hydraulic flushing of membrane blocks. To achieve a turbulent regime, which corresponds to effective flushing of the membrane surface, it is necessary to create fluid flow rates in the membrane channel tens and hundreds of times higher than the fluid flow rates in operating mode. But such an increase in speed is not possible. Figures-10 and11 show the dynamics of membrane permeability as a function of time (in years) and source water temperature at an operating pressure of 3 MPa. The condition of the water, its temperature, as well as pre-treatment have a significant impact on the service life of the membranes. Comparing the operation of systems with and without hydraulic flushing, it was found that when implementing the hydraulic flushing mode by increasing the flow rate of the initial solution by 2-3 times and simultaneously decreasing the pressure, the filter cycle of the membrane unit increases by more than 3 times. Based on a set of studies carried out and the results obtained, an algorithm for controlling membrane systems was developed, which is based on the use of periodic hydraulic flushing.

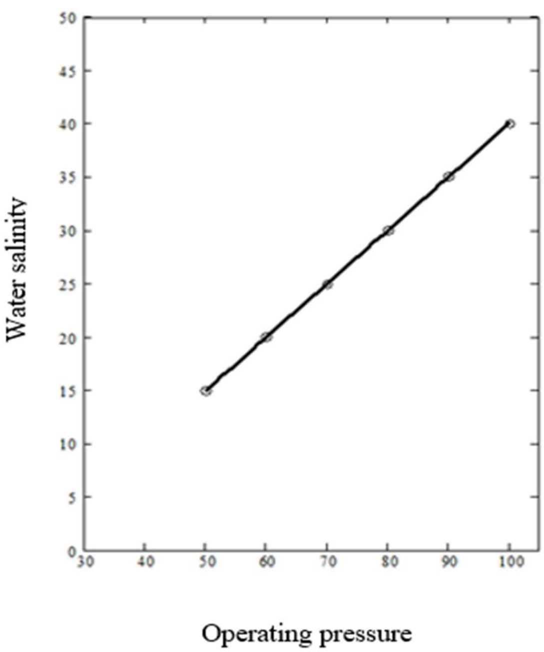


Fig.-10: The effect of operating pressure on water salinity

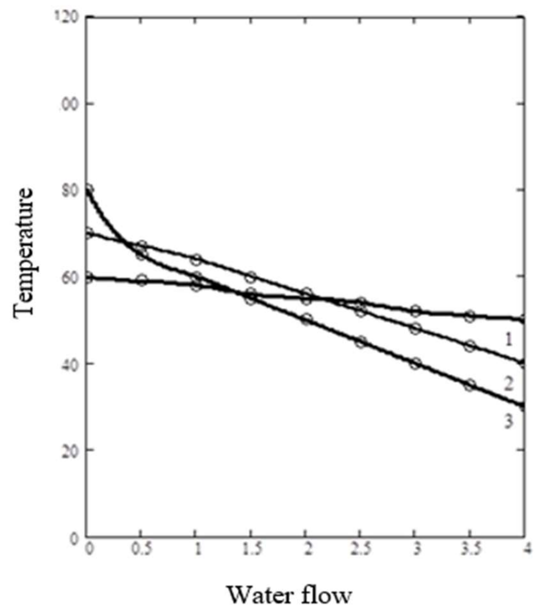


Fig.-11: The effect of water flow on temperature
1–water temperature 20 0C; 2–water temperature 25 0C; 3–water temperature 300 C

A membrane water purification plant is one of the main components of the water treatment system and is designed for deep water purification using composite membranes. The system guarantees the removal of up to 99% and higher of inorganic salts, up to 99.5% of organic matter, and 100% removal of bacteria and viruses. The system has a line for returning purified water (permeate) back into the cycle (to the inlet line to the high-pressure pump) to reduce the concentration of salts in the source water. This allows you to obtain purified water (permeate) with a total salt content of 3 mg/l or less. The surfaces of the PA membranes were examined for the content and location of the elemental composition of the concentrate using a scanning electron microscope (SEM) (Fig.-12).

After experimental tests, the surfaces of the PA membranes were examined for the content and location of

the elemental composition of the concentrate using a scanning electron microscope (SEM) (Fig.-13).
It is known that there are two main ways of organizing macromolecules in the polymer matrix of a membrane.[3,6-11] In the first case, the ends of the polymer chains are free, and in the second case they are "cross-linked". Let us consider the case of free ends of polymer chains in the matrix.

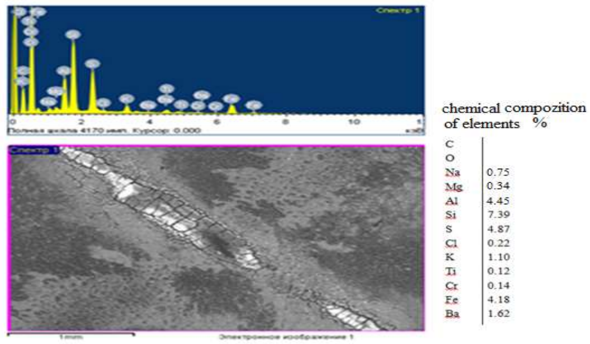


Fig.-12: Chemical Composition of the PA Membrane after Desalination

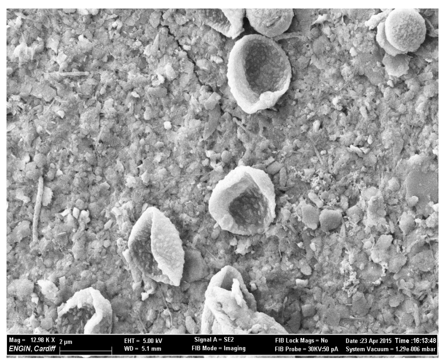
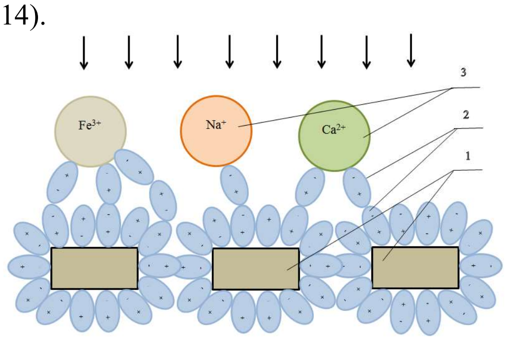


Fig.-13: Location of the Elemental Composition of the Concentrate on the Surface of PA Membranes

As follows from statistical physics, in this case, the thermal motion of the free end fragments of the polymer chains of the membrane matrix can be considered as undergoing thermal motion in relative independence from the thermal motion of the main part of the chains. Then suppose that the type of connection of the terminal fragments with the main part of the chain can be defined as a hydrogen connection with salt ions (Fig.-14).



1 - membranes, 2 - water molecules, 3 - ion elements

Fig.-14: Arrangement of Water Molecules and Element Ions on the Membrane Surface

Thus, the use of this membrane apparatus design reduces membrane wear and increases the efficiency of cleaning the membrane surface. An increase in the membrane surface and a decrease in concentration polarization make it possible to increase the productivity of the apparatus, avoid premature membrane contamination and failure, a high degree of demineralization, and a decrease in the total salt content of water.[26-27]

CONCLUSION

During the research, it was revealed that the concentration of substances in water does not reflect the toxicological load on the ecosystem, since it does not take into account the processes of accumulation of substances in biological objects and bottom sediments, i.e. the background associated with the accumulation of pollutants in the aquatic environment is not taken into account. Reservoirs are an important drinking water resource in the face of growing global scarcity. Therefore, the question of an adequate comprehensive assessment of water quality from the point of view of their suitability for use by the population remains relevant. The purpose of this work is to assess water quality using nanofiltration methods for use by the population using the example of the Syrdarya River. The main advantage of nanofiltration methods is the production of higher-quality water without harmful bacteriological and microbiological contamination. The results showed that the waters in the study region in terms of the main pollutants of the Syrdarya River are sulfates, nitrites, copper, and magnesium. The water pollution index was 1.97. The data obtained were compared with the register of cardiovascular morbidity and oncology cases, and a positive correlation (0.75) was obtained between the location of the reservoir and the registration of disease cases. A membrane water purification plant is one of the main components of a water treatment system and is designed for deep water purification using composite membranes. In our proposed membrane device, there are pores in the membrane that freely allow water molecules to pass through and do not allow hydrated ions of dissolved salts to pass through due to their size. It is assumed that water and some salts penetrate the membrane using two parallel processes: diffusion and penetration through the pores under the influence of applied pressure. The results of the sanitary and hygienic assessment of the Syrdarya River after purification of groundwater in a membrane apparatus in Table-2 show the absence of toxic substances of the third and fourth hazard classes, as well as odor and taste, points no more than 1-2, the biological demand for oxygen is reduced by 92, 5%, and the chemical oxygen demand is reduced by 100%. The results of groundwater purification of the Syrdarya River in a membrane apparatus in Table-3 are given in percentages: nitrites 84%, nitrates 15%, sulfates 84%, mineralization 95%, and the odor and taste index is zero, which meets sanitary and hygienic requirements and is suitable for sustainable use as drinking water in the South Kazakhstan region. This is similar to the results of other studies previously conducted [20,21,22]. The system guarantees the removal of up to 99% or higher of inorganic salts, up to 99.5% of organic substances, and 100% removal of bacteria and viruses. The system has a line for returning purified water (permeate) back into the cycle (to the inlet line of the high-pressure pump) to reduce the concentration of salts in the source water. This produces purified water (permeate) with a total salt content of 3 mg/L or less.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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