OBTAINING WATER WITH A HIGH DEGREE OF PURITY BY USING REVERSE OSMOSIS

Nicolae Chirilă
"Petru Maior" University of Tg. Mures
chirilan@upm.ro

ABSTRACT

In this paper, we used the method of reverse osmosis in order to obtain water with a high degree of purity. For this aim, we used the TKA 20-120ECO device. We completed physic-chemical determinations for the water of supply, as well as for the water obtained after the osmosis process. The results that we obtained are relevant and interesting.
Keywords: *pure water, reverse osmosis, physical-chemical determination.*

1. Introduction

In the case of the watery solutions, when two solutions of different concentrations are separated by a semi-permeable membrane, water will penetrate the membrane from the more diluted solution to the more concentrated one, with a remarked tendency of equalizing concentrations in both cells, and thus of reaching a balanced state.

This process, known as **osmosis**, stops when the hydrostatic pressure exerted upon the more concentrated solution reaches a certain balance value called osmotic pressure (figure 1). The osmotic pressure varies proportionally with the concentration of the solution dissolved into water and with temperature.

The normal process of osmosis can be reversed if a higher pressure than osmotic pressure is exerted upon the concentrated solution. In this case, a circulation of water in the reverse-sense will occur, due to the high external pressure. Thus, clean water will be obtained in the next container out of salt-rich water.

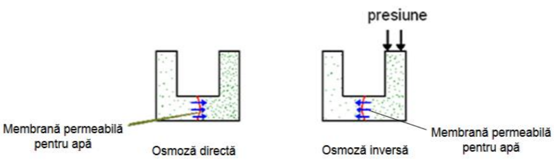

Fig. 1. The osmotic process

Reverse osmosis is one of the processes that makes desalination (or removing salt from seawater) possible. Beyond that, reverse osmosis is used for recycling, wastewater treatment, and can even produce energy.

Stages of reverse osmosis:

- During the initial filtration stage, tap water or well water (pressurized by a booster pump) is passed through a particle filter (a pre-filter) that removes silt, sediment, sand, and clay particles that might clog the reverse osmosis membrane.
- The water is then forced through an activated carbon filter that traps minerals and contaminants such as chromium, mercury, copper, chloramine and pesticides. It also removes chlorine, which is important, as chlorine will shorten the life of the membrane.
- Water is transferred under pressure into the reverse osmosis module, allowing only clean water to pass through the small pores in the membrane. Impurities unable to pass through the membrane are left behind and flushed down the drain.
- Treated water is then sent to a storage tank.
- Treated water is passed through an activated carbon filter before use to further improve the water's taste and smell.

Most mineral constituents of water are physically larger than water molecules. Thus, they are trapped by the semi-permeable membrane and removed from drinking water when filtered through a reverse osmosis system. Such minerals include salt, lead, manganese, iron, and calcium. Reverse osmosis will also remove some chemical components of drinking water, including the dangerous municipal additive fluoride. Commonly municipal water contains such contaminants as chlorine and volatile organic chemicals (VOCs). Because these contaminants are physically smaller in size than water, the semi-permeable membrane cannot prohibit them from passing through with the water. Thus, they remain in drinking water. Reverse osmosis, also, by removing alkaline mineral constituents of water, produces acidic water. Acidic water can be dangerous to the body system, causing calcium and other essential minerals to be stripped from bones and teeth in order to neutralize its acidity. Trace elements of minerals were intended to be in water; their removal leaves tasteless, unhealthy drinking waterReverse osmosis, also, by removing alkaline mineral constituents of water, produces acidic water. Acidic water can be dangerous to the body system, causing calcium and other essential minerals to be stripped from bones and teeth in order to neutralize its acidity. Trace elements of minerals were intended to be in water; their removal leaves tasteless, unhealthy drinking water.

Filtration in the reverse osmosis process is carried out through modules consist of a pressure vessel for which the filter membranes.

Membrane configuration is the following:

- a layer made of a polyester network with support role, 120 µm thickness;
- a micro porous polysulfide intermediary layer 40 µm thick;
- ultrafine barrier layer at the upper side, consisting of polyamides and containing carboxyl groups carboxyl 0.2 µm thick.

The main factors influencing the performance of systems based on reverse osmosis are:

- pressure
- temperature
- recovery
- salt concentration in the feed flow.

Performance membranes are affected by certain impurities which can be found in the feed stream, such as metal oxide hydrates, precipitated calcium, organic matter and biological etc.

Supply water pretreatment systems reduces membrane considerably improves their performance and their contamination

Cleaning the membranes, where their contamination is relatively simply because of the high pH stability and thermal resistance membranes.

2. Experimental part.

In order to obtain high-purity water by the process of osmosis we used the installation TKA 20 ECO-TKA 120. the construction scheme of such an installation is presented in the figure below.

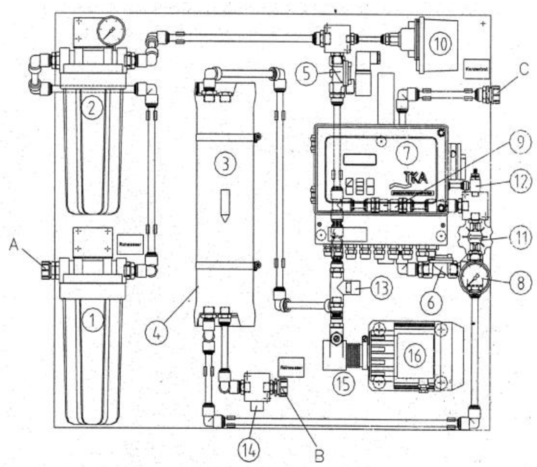

Fig. 2 Water purification equipment by reverse osmosis used in laboratory

1 Activated charcoal filter (to retain particles with a diameter bigger than 5µm);
2 Hardness cartridges;
3. Reverse osmosis module;
4. Reverse osmosis module composed of pressure pipes and reverse osmosis membranes;
5. Supply water electro valve;
6. Purification electro valve;
7. Electric control panel;
8 Manometer;
9. Directional valve;
10. Pressure switch;
11. Pressure control valve;
12. Valve for the concentrated solution return;
13. Measurement cell for the supply water conductivity;
14. Measurement cell for the purified water conductivity.
A. Supply water input connection;
B. Purified water output connection;
C. Concentrated solution output connection.

Cellulose acetate was among the first materials used to produce semi-permeable membranes and it was obtained in special conditions (cellophane with special properties). Later it was possible to obtain semi-permeable membranes from stable polymerized materials (polyamides, mixed acetate esters – cellulose butyrate, mixtures of acetate and cellulose nitrate etc). Currently, it is possible to obtain membranes which allow the discharge of the dissolved substances, especially of the ionic types, in a proportion of 95-99%. The membranes used for the osmotic separation are very thin (0,2 µm) and fragile. The membranes used in the reverse osmosis are subjected to big pressure differences of 20–100 bar, which makes it very difficult to install the practical equipment which needs to be fully waterproof, compactly structured and able to avoid clogging and polarization of the concentrated solution. The study of the membranes and the development of the processes of separation by membranes involve a trans-disciplinary approach including polymer chemistry, physical chemistry, mathematics etc. In the process of reverse osmosis the substance transport is done via a mechanism of diffusion in the homogenous polymeric stratum. Nowadays, the most commonly used membranes are the composite membranes which ensure a smooth diffusion into the polymer matrix.

3. Results and discussions

At the beginning, we analyzed the physical and chemical properties of the input water and performed the same test for the water subjected to the process of reverse osmosis. The obtained results are recorded in table 3.1 and 3.2.

The hardness determinations employed acid-base titration, with 0,1n hydrochloric acid for temporary hardness and complexometric titration, with 0,1n EDTA for permanent hardness.

Water type	pH	Conductivity [µS]	D_{temp} [°ger]	D [°ger]
Tap water	6,8	224,6	4,48	7,28
Post-osmosis water	6,7	48,95	1,12	3,2

Table 3.1 Values of the determined physical and chemical parameters

Water type	Nitrite [mg/l]	Nitrate [mg/l]	PO_4^{2-} [mg/l]	NH_4^+ [mg/l]
Tap water	3	0,2	25	<0,1
Post-osmosis water	0,7	0,1	0,6	<0,1

Table 3.2 Values of the determined chemical parameters

The conductivity measurements were determined by means of the Accumet AB30 conductometer, at 20°C.

The nitrites, nitrates, phosphate and ammonia determinations employed the Visocolor spectrophotometric method.

It follows from the information in the tables above that there has been a concentration drop for all the tested ions. The proportions differ from one ion to another but the decreases are significant from 75% in the case of nitrite ions to 50% in the case of nitrate ions and up to 80% in the case of phosphate ions.

4. Conclusion

It can be concluded that the water obtained by the process of reverse osmosis is pure, demineralized and almost sterile water.

The use of this procedure opens generous perspectives to obtaining highly pure water especially nowadays, when the lack of water has become an acute problem in some parts of the globe. The applications of reverse osmosis in used water treatment can be used in the following conditions:

- The reduction of the used water quantity by obtaining concentrated solutions with a smaller volume;
- In the cases when there is a possibility to recuperate useful materials;
- If water recycling is mandatory in areas with a lack of water;
- The possibility of concentrating pollutants in small volumes of water, thus reducing the pollutant discharge expenses.

Today, water issues have become an extremely pressing global threat. With climate change come unprecedented environmental impacts: torrential flooding in some areas, droughts in others, rising and falling sea levels. Add to that the threat of overpopulation -- and the demand and pollution a swelling population brings -- and water becomes one of the paramount environmental issues to watch for in the next generation.

5. Bibliography:

[1]. N Chirila, *„Chimia mediului. Apa”,* Editura Univ. „Petru Maior” Tg. Mureş, 2010.

[2]. Rusu T., Moldovan L., Avram Simona, *Managementul activitatilor pentru protectia mediului*, Ed.Mediamira, Cluj Napoca, 2003.

[3]. Rojanschi, V., Bran, F., Diaconu, G., *Protecţia şi ingineria mediului*, Editura Economică, Bucureşti, 1997.

[4]. Trufas, C., *Calitatea apei*, Editura Agora, Călăraşi, 2003.

[5]. Carmen Teodosiu, *Tehnologia apei potabile şi industriale*, Editura Matrix Rom, Bucureşti, 2001.

[6] F. R. Peellman, J. Drinan, *The drinking water handbook,* TechnnomicPublishing Co, Landcaster, 2000.

[7] S. Madeni, *The Application of Membrane Technologic for Water Desinfection,* Water Research, 1999

[8] D.G. Stevenson, *Water Treatment Unit Process,* Imperial College Press, London, 1997

[9] www.osmoza-inversă.ro

[10] www.filtru-apa.ro