DOI:10.5937/IIZS25292D

# THE MICROBIOLOGICAL CONTROL OF DEMINERALIZED WATER

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**Abstract:** Demineralized water is the basic raw material for the production of cosmetic products and household chemistry products at Beohemija DOO. Demineralized water is produced by reverse osmosis and every part of the process is subject to microbiological control, due to monitoring the state of the equipment itself from a microbiological aspect as well as obtaining the correct final product.
**Key words:** reverse osmosis, demineralized water, microbiological control

## INTRODUCTION

In the field of water treatment and purification, the process of obtaining demineralized water by reverse osmosis (RO) represents an exceptional technological achievement. Reverse osmosis is very effective at removing a wide range of impurities, including most minerals and ionized substances [1,2] Unlike ion exchange columns that use a strong acid or base for regeneration, reverse osmosis is much "greener" and cheaper to operate [2,3,4]. Demineralized water is often used in the production of various types of household chemicals, including detergents, cleaners, disinfectants, and many other products. This type of water is also useful in the cosmetics and pharmaceutical industries, where its high purity and stability are also appreciated.
The aim of this work is the microbiological control of demineralized water produced by reverse osmosis in Beohemija DOO, which is the basic raw material for the production of cosmetic products and household chemistry products.

### The process of demineralized water production in Beohemija DOO

The demineralized water production process at Beohemija DOO aims to produce demineralized water of appropriate quality: hardness, conductivity and pH value.
Demineralized water is used as a basic raw material in the household chemicals production plant in Beohemija DOO, as well as in the production of technological steam in thermal power plants.
Water softening is the process of replacing calcium and magnesium ions from water hardness salts with sodium ions, and is carried out in ion exchangers. Ion exchangers are devices filled with special ion exchange masses that exchange ions. Calcium and magnesium ions from water bind to the ion exchange mass, and an equivalent amount of sodium ions is released from the mass. Of course, this replacement cannot last indefinitely and is limited by the amount of sodium ions in the ion exchange mass of the ion exchanger, which means that calcium and magnesium salts are converted into an equivalent amount of sodium salts by softening [1,8]. The resulting sodium salts are extremely soluble in water and do not form scale. Sodium bicarbonate resulting from carbonate hardness is known as baking soda.

### Devices used in water softening

1.) The specialized container intended for the preparation of the scavenger regeneration solution is shown in Fig. 1. The solution preparation process begins with the use of water from the scavenger, to which 100 kg of tableted salt is added. During every third regeneration, 10 kg of previously dissolved sodium hydroxide (NaOH) in 30 kg of demineralized water is added to the solutionthe (vessel should be filled in a ratio of 1/3 salt and 2/3 water).

***Fig. 1.*** *Preparation of regeneration agent for scavenger*

2.) The pre-sand filter has the role of keeping any dissolved substances from the raw water (organic substances) on it. The role is played by a 25 µm filter cloth. The replacement of the filter cloth is done when the pressure of the feed water, that is, as soon as there is a difference in the pressure at the inlet compared to the outlet (of 1 bar).

3.) The sand filter is filled with different sand fractions whose role is to remove mechanical impurities from the water. Over time, the filter filling (sand) of the sand filter becomes clogged (dirty) with impurities from the water, so it is necessary to wash the sand filter. Filter washing is also done by a combination of co-current and counter-current washing with raw water. Rinsing must be done once a week, and if necessary, more often, when the production of demi water allows it. Rinsing is done first against the current, while it visually looks like the incoming water. The performed filter washing is recorded in the daily report of the plant for the production of demi water, steam and hot water. The length of sand filter flushing depends on both the amount of technical water that passed through it and its quality. Rinsing of the sand filter can also be done in situations where there is a difference in the pressure value at the exit and entry into the sand filter. After the sand filter, the purified water from mechanical impurities goes to the ion exchange column.

***Fig. 2.*** *Pre-sand filter, sand filter and scavengers*

4.) The scavenger serves to soften water and contains ion exchange filters (softeners), which consist of an ion exchange column filled with a certain amount of ion exchange mass. Currently, resinexa TPS4500 type ion exchange resin is used. The resin removes dissolved organic matter from the feed water. When the mass is saturated, by passing the table salt solution and the NaOH solution, it is converted back into an active form and the resin is ready for softening a certain amount of water (Fig. 2). Regeneration of each scavenger is done once per shift with NaCl solution, and every third regeneration is done with NaCl and NaOH solutions.

In Beohemija DOO, for the production of liquid detergents, softened water is needed 24 hours a day, without interruption, so in that case automatic duplex softeners-scavengers are used. These are two devices connected in parallel, while one is working, the other is being regenerated, when the working device is saturated, the automation switches the already regenerated device into the working phase, with this distribution it is achieved that one device is always ready for work. All stages of regeneration can be time-adjusted and adapted to a certain capacity of the device.

In the working phase, water flows through the control valve, flows around the central pipe, passes through the ion exchange mass and enters the central pipe through the lower nozzle, from where it is drained to the place of consumption. The working capacity of the softener is about 100 m³ of water, which depends on the amount of ion exchange mass and the hardness of the feed water. After the capacity is exhausted, the softener regenerates and becomes ready for water treatment again.

It is important to note that about 10% of the produced demineralized water is used for the regeneration process. Before reverse osmosis, antiscalant is automatically added to the softened water, and analysis of the softened water is performed once per shift, including the measurement of conductivity (1100-1250 μS/cm) and pH value (7.4-7.9). $KMnO_4$ consumption is monitored daily, mostly in the first shift. Also, a chlorine remover is added before reverse osmosis. All results are recorded in the daily report of the plant for the production of demi water, steam and hot water. This complex process ensures continuous availability of high-quality demineralized water, which is crucial for efficient production and plant maintenance (Fig. 3). Scavenger regeneration is programmed to last 144 minutes.

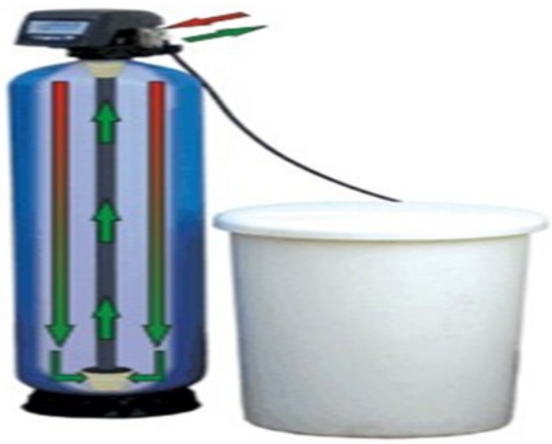

***Fig. 3.*** *Scavenger work phase*

The phase of countercurrent washing of the ion exchange mass is a key step in the process of regeneration of ion exchange columns. During this stage, the water is diverted through the central pipe to the bottom of the column, from where it passes through the ion exchange mass upwards and finally drains into the sewer from the top of the column. The goal of this phase is multiple. First, it enables efficient washing of mechanical impurities that have arrived with the feed water (Fig. 4.).


***Fig. 4.*** *Countercurrent rinsing phase*

Reagent entrainment phase is shown in Fig. 5. In this phase, a solution of sodium chloride (table salt) and NaOH is passed through the device, whereby the ion exchange mass is regenerated and converted back into an active form. The salt solution is drawn in from the salt container via an injector built into the control valve. For one regeneration, 100 kg of tableted salt is consumed, and for every third regeneration, 10 kg of NaOH is added.


***Fig. 5.*** Reagent loading phase

The slow wash phase is a continuation of the reagent draw phase. In this phase, water is drawn in directly from the sand filter (Fig. 6.)


***Fig. 6.*** Slow rinse phase

During the fast flushing phase, the flow of water through the device is the same as during the working phase, with the fact that the output water is not directed to the output connection, but to the sewage system. Which column is in operation and which is being regenerated, the regeneration time, as well as the amount of NaOH consumption, are entered by the operators in the daily report. At the end of the regeneration process, a certain amount of water is returned to the brine (approximately 500 l), to which salt and, if necessary, sodium hydroxide are added later, and the solution is ready for the next regeneration.

5.) Reverse osmosis system, shown in Fig. 7. Water flows over the surface of the membrane under high pressure, water molecules pass through the membrane and are collected in the permeate collector that separates it [5,6]. Molecules of dissolved salts are concentrated in the part of the water that flows over the surface of the membrane and that part is taken out of the module as a concentrate, which is rejected 5-6 $m^3/h$) and the flow of the concentrate $5 m^3/h$ which is entered in the days report once in a shift. Demineralized water automatically goes into receiving vessels, each of 25 $m^3$. Analysis of demineralized water is performed once per shift and entered in the daily report. When the permeate flow drops below $5 m^3/h$, it is necessary to rinse the membranes according to the instructions[7].
The basic element of the reverse osmosis device is the so-called RO module. The RO module consists of a reverse osmosis membrane (RO membrane) placed in its housing. Currently, membranes manufactured by TORAY type TMG20-400C are in use. The membrane is made of special materials through which small molecules can pass, while the passage of larger molecules is impossible.
6.) Demineralized water automatically goes into receiving vessels 7a and 7b, each with a volume of 25 $m^3$ (Fig. 8).

***Fig. 7.*** *Reverse osmosis system*


***Fig. 8.*** *Acceptance court for demineralized water*

## MATERIAL AND METHODS

The material was demineralized water from parts of the plant: scavenger and reverse osmosis and from receiving vessels. Control of the microbiological correctness of demineralized water was carried out in the microbiological laboratory of Beohemija DOO in Zrenjanin, according to the Rulebook on methods for determining the pH value and the amount of toxic metals and non-metals in personal hygiene products, care and beautification of the face and body and for determining the microbiological correctness of these products (Official Gazette of the SFRJ No. 46/83) [9]. The procedure for taking samples of demineralized water was carried out in accordance with the Rulebook on the method of taking samples and methods for laboratory analysis of drinking water (Official Gazette of the SFRJ No. 33/87) [10].

## RESULTS AND DISCUSSION

The results of microbiological analysis of demineralized water from both scavengers, reverse osmosis systems, under UV lamps and receiving vessels are shown in Table1.

***Table 1.*** *The results of microbiological analysis of demineralized water*

| **Designation of the sample** | **Total number of aerobic mesophilic microorganisms Max 1000/g/ml** | ***Escherichia coli*** **negative in 1g/ml** | ***Pseudomonas aeruginosa*** **negative in 1g/ml** |
|---|---|---|---|
| RS-9A | 0 | 0 | 0 |
| RS-5B | 0 | 0 | 0 |
| Under a UV lamp | 0 | 0 | 0 |
| After Reverse Osmosis | 0 | 0 | 0 |
| Scavengers | >100 | 0 | 0 |
| RS-9A | 0 | 0 | 0 |
| Under a UV lamp | 0 | 0 | 0 |
| After Reverse Osmosis | 0 | 0 | 0 |
| RS-9A | 0 | 0 | 0 |
| RS-7A | 0 | 0 | 0 |
| RS-5B | 0 | 0 | 0 |
| Under a UV lamp | 0 | 0 | 0 |
| RS-7A | 0 | 0 | 0 |
| RS-7B | 0 | 0 | 0 |
| Under a UV lamp | 0 | 0 | 0 |

Microbiological analysis of demineralized water in the Scavenger water purification system, on Nutrient Agar after 24 hours of incubation, showed the growth of colonies of microorganisms, but within the permitted limits (Fig. 9). Growth of *E. Coli* was not present as determined by the presence of gas in Durchmann's tubes in brilliant green lactose bile broth after 24h, growth of *P. aeruginosa* was also not detected.

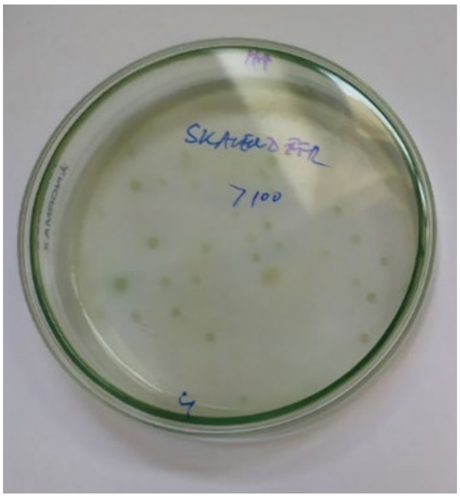

***Fig. 9.*** *Total number of aerobic mesophilic microorganisms on Nutrient Agar after 24h*

In the microbiological analysis of demineralized water, leachate from the column, receiving tank RS - 5B, for receiving tank RS - 9A and after reverse osmosis, the total number of aerobic mesophilic microorganisms on Nutrient Agar after 24 hours of incubation showed no growth (Fig. 10).

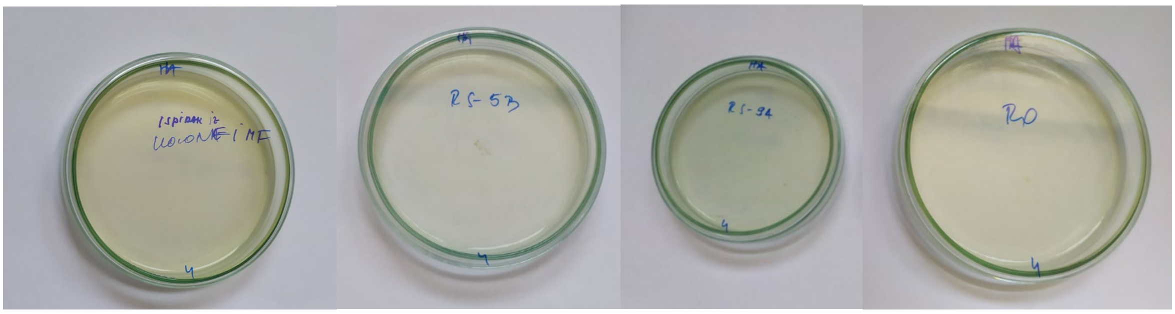

***Fig. 10.*** *Total number of aerobic mesophilic microorganisms on Nutrient Agar after 24h*

## CONCLUSION

Demineralized water is the basic raw material for the production of household chemicals and as such occupies an important place in the production process itself, therefore it is clear that its microbiological quality is of crucial importance.
Microbiological analysis of the basic raw material of demineralized water obtained by the reverse osmosis method in Beohemija DOO, showed that it meets the requirements given in the valid legal regulations of the Republic of Serbia.

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