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STUDIES REGARDING SURFACE WATER TREATMENT USING A MICROFILTRATION-ULTRAFILTRATION PILOT PLANT

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Abstract

In this paper the results of surface water treatment process for drinking purpose are presented, using the microfiltration-ultrafiltration process. The experimental studies were carried out using a microfiltration-ultrafiltration pilot plant and raw water from Bega River, Timisoara as feed. To assess process performance, the water quality, *e.g.*, turbidity, total coliforms and hardness parameters were determined for two different operating regimes subjected to filtration time. A good efficiency of turbidity removal was achieved, the residual values being situated below the maximum allowable value admitted by drinking water regulation. The presence of total coliforms in treated water imposed the necessity of a final disinfection step, after applying microfiltration-ultrafiltration process.

Keywords: surface water, pilot plant, microfiltration, ultrafiltration

1. Introduction

Water resources are becoming increasingly scarce in many areas of the world due to development, and increased demand (Pearce, 2008).

In the present, at European level, the drinking water treatment technology requires new and innovative processes, based on the raw water quality and flows.

Among innovative technology, microfiltration-ultrafiltration process have been remarked, because no chemical agents are used, constant producing of treated water with high quality and simple automation of process (Ghayeni et al., 1996; Readon et al., 2005).

While membrane separation process have been widely used to recover valuable products from complex mixtures, only recently have membrane technologies emerged as viable for drinking water production and for wastewater treatment (Musteret and Teodosiu, 2007; Taniguchi et al., 2003).

Ultrafiltration process applied to water treatment has become a more attractive technology worldwide to produce drinking water (Sheng-ji et al, 2007). Ultrafiltration process uses a finely porous membrane to separate water and microsolutes from macromolecular and colloids (with diameters between 0.001 and 0.1 μ m). Microfiltration process refers to filtration process that use porous membranes to separate suspended particles with diameters between 0.1 to 10 μm. Thus, microfiltration membranes fall between ultrafiltration membranes and conventional filters (Baker et al., 2004).

Ultrafiltration (UF) and microfiltration (MF) process are theoretically the best pre-treatment upstream reverse osmosis, removing from the feed water most of the potential elements responsible of desalinating membranes fouling such as particles, turbidity, bacteria and large molecular weight organic maters (Bonnelye et al., 2008).

Membrane technologies were used in many applications of water treatment. (Durman et al., 2001; Gille and Czolkoss, 2005; Jarusutthirak and Amy, 2001; Lipp et al., 1998; Panglisch et al., 1997; Pansglisch et al., 1998; Podaru et al., 2008; Reissman and Uhl, 2006; Sayed et al., 2007).

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In Timisoara City, 66 % of water for drinking use is originated from surface water. The actual drinking water treatment plant uses the classical technology consisted of coagulation, decantation, filtration and disinfection.

The present study was carried out for surface water treatment plant, from Timisoara City, using the microfiltration and ultrafiltration process. To evaluate the process performance, influent (raw water) and effluent (permeate) quality, expressed by turbidity, total coliforms and total hardness was determined.

2. Experimental

2.1. Pilot plant

Fig.1 presents the technological scheme of a microfiltration-ultrafiltration pilot plant (microfiltration-ultrafiltration module, SCED-06-006, PIASA firm, Engineering and Trading S.A., Spania), used for the treatment of surface water, from Bega River, Timisoara. In Fig. 2 it is shown the image of microfiltration-ultrafiltration pilot plant.
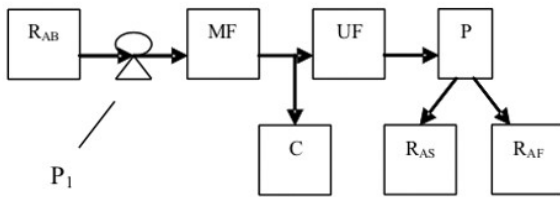

Fig.1. Technological scheme of microfiltration-ultrafiltration pilot plant

Fig.2. The image of microfiltration-ultrafiltration pilot plant

Pilot plant was provided with a principal screen (PLC) that offers access to all running processes and operated in automatic and continuous regime. Two different operation situations subjected

to filtration process duration until membrane cleaning, *i.e.*, T_1 = 30 minutes, T_2 = 90 minutes were used. In addition, the aspects related to membrane fouling were followed.

Raw water passed through microfilter (MF – spiraled cartrige filter CA-0804-04 model, 50 microns) with a 200 L/h flow, and then passed through a tangential ultrafiltration membrane (UF - TRIHIGH Hallow Fiber type, CLN4000So model (30-50 Kdalton). The feed flow was achieved with P1 pump (PRINZE pump, CK 50 III 220/380 V model, with 600 L/h capacity)

A permeate (P) and a concentrate (C) results as a product of pilot plant. Part of permeate, P (filtered water) was accumulated in washing water tank (R_{AS}), fitted with a float bowl, and the rest was stored in filtered water tank (R_{AF}).

Filtration operation was controlled by a security system that controls the differential pressure between the inlet and outlet of the ultrafiltration module. The objective of this operation is to avoid the membrane fouling by colloid accumulation on its surface, and was operating in automatic mode, at different range time. Membrane cleaning consisted of three steps e.g. air drainage, pressurization (air, with 1 bar pressure) and backwashing (with filtered water).

2.2. Analytical methods

To assess the process efficiency, analyses of inffluent (raw water, AB) and effluent (permeate, P) were carried out. Turbidity (T) (HATCH 2100 N Turbidimeter, Made in Germany), total coliforms (CT) (SR 3001-91), respective total hardness (SR 3026-76) parameters were analyzed.

3. Results and discussions

3.1. Operating conditions

3.1.1. Membrane cleaning after 30 minutes of filtration process operation

Turbidity is a principal physical characteristic of water and an expression of the optical property that causes light to be scattered and absorbed by particles and molecules rather than transmitted in straight lines through a water sample. It is caused by suspended matter or impurities that interfere with the clarity of the water (EPA Guidance, 1999). Minimum, average and maximum values for 104 numbers of turbidity determinations for raw water (T_{AB}) and permeate (T_P), respective removal efficiency (E_T) are presented in Table 1.

Table 1. T_{AB} and T_P values, respective E_T (membrane cleaning after 30 minutes of filtration process operation)

Value	T_{AB} [NTU]	T_P [NTU]	E_T[%]
Minimum	3.55	0.10	67.48
Average	8.68	0.51	93.64
Maximum	19.30	2.14	98.00

In Fig. 3 it is shown the evolution of T_{AB}, T_P parameters, respective E_T during operating microfiltration-ultrafiltration process.
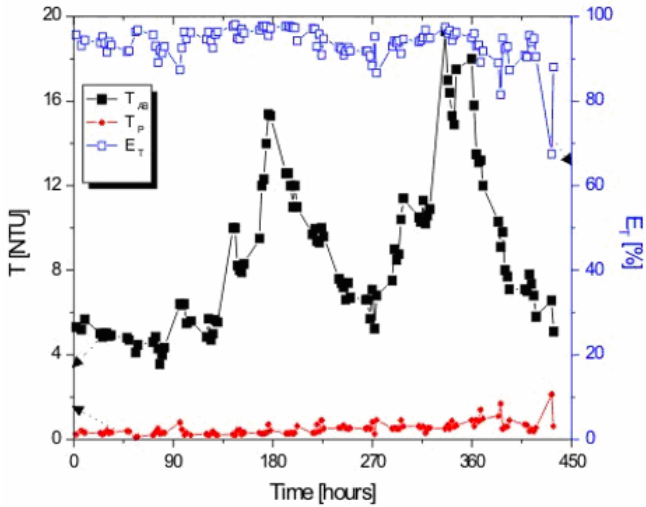

Fig.3. The evolution of T_{AB}, T_P and E_T during microfiltration-ultrafiltration process with membrane cleaning after 30 minutes of filtration process operation

It can be noticed that the T_P values varied between 0.10 and 2.14 NTU, which are below maximum allowable value required by drinking water regulation, of 5 NTU (Law 311, 2004). Good efficiency of turbidity removal was achieved, ranged between 67.48 and 89.00 %.

The presence of total coliform bacteria in water within the distribution system (but not in water leaving the treatment plant) indicates that the distribution system may be vulnerable to contamination or may simply be experiencing bacterial re-growth (Health Canada, 2006). Minimum, average and maximum values for 13 numbers of total coliforms determinations for raw water (CT_{AB}) and permeate (CT_P), respective the removal efficiency (E_{CT}) are presented in Table 2.

Table 2. CT_{AB}, CT_P, respective E_{CT} values (membrane cleaning after 30 minutes of filtration process operation)

Value	CT_{AB} [no./100cmc]	CT_P [no./100cmc]	E_{CT} [%]
Minimum	3480.00	130.00	53.76
Average	27278.46	2100.92	89.87
Maximum	91800.00	16090.00	99.63

The dynamics of the parameters, CT_{AB}, CT_P respective E_{CT}, during operating microfiltration-ultrafiltration process, is shown in Fig. 4.

Even if the good efficiency for CT removal was achieved (53.76 and 99.63 %), however the presence of CT in effluent (3480.00 ÷ 91800.00 no./100 cmc), no Romanian regulation requirements were met. In addition, the total hardness parameter was checked. The values of total hardness for raw water (influent) and permeate (effluent) were similarly and ranged from 4.40 to 5.20 German hardness degree.
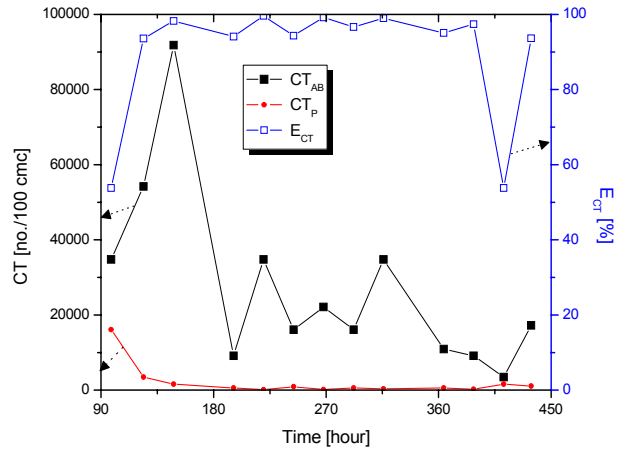

Fig.4. The dynamics of CT_{AB}, CT_P and E_{CT} during microfiltration-ultrafiltration process (membrane cleaning after 30 minutes of filtration process operation).

These results demonstrate that the microfiltration-ultrafiltration process application did not affected the water hardness, desired aspect, because of drinking water regulation requirements (minimum 5 German hardness degree).

3.1.2. Membrane cleaning after 90 minutes of filtration process operation

Table 3 gathered the minimum, average and maximum values of a number of 54 determination for T_{AB}, T_P, respective E_T.

Table 3. T_{AB}, T_P, respective E_T values (membrane cleaning after 90 minutes of filtration process operation)

Value	T_{AB} [NTU]	T_P [NTU]	E_T[%]
Minimum	3.00	0.53	57.80
Average	6.42	1.20	80.76
Maximum	16.20	3.70	87.25

In Fig.5 shows the evolution of T_{AB}, T_P parameters, respective E_T during operating microfiltration-ultrafiltration process.

From Fig.5, could be observed that T_P values ranged between 0.53 and 3.70 NTU, also below maximum allowable value of 5 NTU. Under these working conditions, E_T ranged between 57.80 and 87.25 %.

The minimum, average and maximum values for 5 determinations of total coliforms - CT_{AB}, CT_P, and E_{CT} are presented in Table 4.

In Fig. 6 it is shown the variation of CT_{AB}, CT_P and E_{CT} parameters during operating microfiltration-ultrafiltration process.

Under these operation condition, CT ranged between 542.00 and 3480.00 no./100 cmc, and the removal efficiency between 35.79 and 95.03 %.

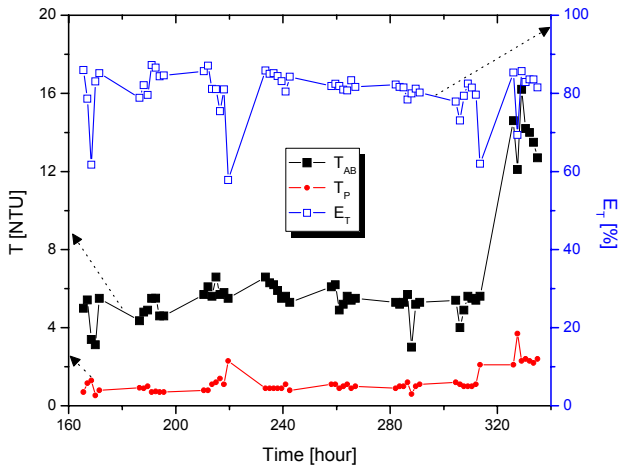Regarding water hardness, no reduction was achieved.

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Fig.5 The evolution of T_{AB}, T_P parameters, respective E_T (membrane cleaning after 90 minutes of filtration process operation)

Table 4. CT_{AB}, CT_P, respective E_{CT} values (membrane cleaning after 90 minutes of filtration process operation)

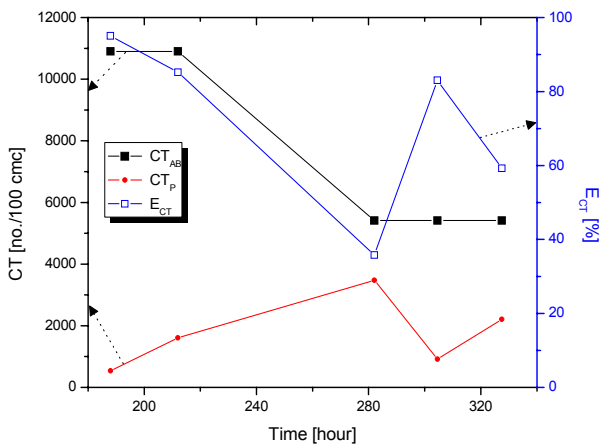| *Value*	CT_{AB} [nr./100cmc]	CT_P [nr./100cmc]	E_{CT} [%]
Minimum	5420.00	542.00	35.79
Average	7612.00	1751.80	71.67
Maximum	10900.00	3480.00	95.03

Fig. 6. Variation of CT_{AB}, CT_P, E_{CT} during microfiltration-ultrafiltration process (membrane cleaning after 90 minutes of filtration process operation)

6. Conclusions

The studies were performed on a microfiltration-ultrafiltration pilot plant in order to test the performance during the treatment of surface water for drinking purposes, from Bega River, Timisoara, Romania,.

By applying the microfiltration-ultrafiltration process, a good physical-chemical quality of drinking water results, in agreement with Romanian Drinking

Water Regulation (Law 311, 2004). Therefore, a good removal efficiency of turbidity was achieved.

For the filtration process where the duration until membrane cleaning can be T_1=30 minutes, E_T ranged between 67.48 and 89.00 %, while it can reach 57.80 and 87.25 %, when the duration until membrane cleaning becomes T_2=90 minutes.

The results regarding total hardness of the water shown that, by applying microfiltration-ultrafiltration process, the values of this parameter were almost unchanged.

The requirements of drinking water regulation subjected to the microbiological quality were not achieved, although good removal efficiency was obtained. Total coliforms removal efficiency ranged between 53.76 and 99.63 %, for operating time of 30 minutes of microfiltration-ultrafiltration process, respective between 35.79 and 95.03 %, for operating time of 90 minutes.

For both operating regimes no membrane fouling occurred significantly.

Based on these results, it can be concluded that the water quality can meet the imposed request from the physical-chemical point of view by using microfiltration-ultrafiltration pilot plant for surface water treatment for drinking water proposal, but the total coliforms presence in the pilot plant effluent imposes to insert a final disinfection step.

References

Baker R.W., 2004, *Membrane Technology and Applications*, Johm Wiley&Sons, Lth, 2nd Edition, 237, 275.

Bonnelye V., Guey L., Castillo J., (2008), UF/MF as RO pre-treatment : the real benefit, *Desalination,* **222,** 59-65.

Durman B., Bourbigot M.M., Pankratz T., (2001), Membrane as pretreatment to desalinization in wastewater reuse : operating experience in municipal and industrial sectors, *Desalination,* **138,** 83-90.

EPA, (1999), *Manual Turbidity Provisions*, EPA Guidance, April, 7.1-7.13, On line at: http://www.epa.gov/OGWDW/mdbp/pdf/turbidity/chap_07.pdf

Ghayeni S., Madaeni S., Fane, A.G. Schneider, R.P.*,* (1996), Aspect of microfiltration and reverse osmosis in municipal wastewater reuse, *Desalination,* **117**, 49-60.

Gille D., Czolkoss W., (2005), Ultrafiltration with multi-bore membranes as seawater pre-treatment, *Desalinisation,* **182,** 301-307.

Health Canada, (2006), *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Total Coliforms*, Otawa, Ontario, Canada, On line at: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/water-eau/coliforms-coliformes/coliforms-coliformes-eng.pdf

Jarusutthirak C., Amy G., (2001), Membrane filtration of effluents for reuse: effluent organic matter rejection and fouling; *Water Science and Technology,* **43,** 225-232.

Law 311, (2004), Romanian Drinking Water Law, 311/2004, published in Official Monitorl, Part I, No.. 582, 30/06/2004.

Lipp P., Baldauf G., Schick R., Elsenhans K., stable H.H., (1998), Integration of ultrafiltration to conventional drinking water treatment for better particle removal – efficiency and costs, *Desalination, 119,* 133-142.

Musteret C.P, Teodosiu C., (2007), Removal of persistent organic pollutants from textile wastewater by membrane processes, *Environmental Engineering and Management Journal*, **6***,* 175-187.

Panglisch S., Kiepke I., Dautzenberg W., Gimbel R., (1997), Optimization of operating and cleaning of membranes- Results on ultra and microfiltration pilot plant investigations to treat reservoir water, *Desalination,* **113,** 247-249.

Pansglisch S., Dautzenberg W., Kiepke O., Gimbel R., Gebel J., Kirsch A., Exner M., (1998), Ultra and microfiltration pilot plant investigations to treat reservoir water, *Desalination,* **119,** 277-288.

Pearce G.K., (2008), UF-MF pre-treatment to RO in seawater and wastewater reuse applications: a comparison of energy costs*, Desalination,* **222**, 66-73.

Podaru C., Danielescu C., Sonea D., Pacala A., Vlaicu I., Cosma C., Burtica G., Manea F., Orha C., (2008), A comparative Study of two groundwater treatment pilot plants, *Transaction on Ecology and the Environment*, **111**, 149-157.

Reardon R.D., Paranjape S.V., Foussereau X.J., DiGiano F.A., Aitken M.D., Kim J.H., Chang S. Cramer R*.,* (2005), Membrane treatment of secondary effluent for subsequent reuse*, Water Environment Research Foundation Report (01-CTS-6). IWA Publishing, London, UK*.

Reissman F.G., Uhl W., (2006), Ultrafiltration for the reuse of spent filter backwash water from drinking water treatment, *Desalination,* **198,** 225-235.

Sayed S., Tarek S., Dijkastra I., Moerman C., (2007), Optimum operation conditions of direct capillary nanofiltration for wastewater treatment, *Desalination,* **214,** 215-226.

Sheng-ji X., Ya-nan L., Xing L., Juan-juan Y., (2007), Drinking water production by ultrafiltration of Songhuajiang River with PAC adsorbtion, *Journal of Environmental Science,* **19**, 536-539.

Taniguchi M., Kilduff J.E., Belfort G., (2003), Modules and natural organic matter fouling during ultrafiltration, *Environmental Science Technology*, **37**, 1676 - 1683.