Factsheet – UF & NF with RO regenerated membranes

AUTHORS: A. Casadellà, A. Serra, Zurita, A., S. Casas

DATE: 26/02/2021

VERSION: V7

Disclaimer

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°776541.

UF & NF with RO regenerated membranes

Unique selling points:

- ✓ Tailor made rejection yields (e.g. > 80% of emerging pollutants/priority substances; > 99% of microorganisms;
  > 95% of salts).
- ✓ Reuse of a waste (end-of-life RO membranes) that is regenerated (regenerated RO membranes) and can be used in the water cycle.
- ✓ To produce a regenerated water with enough quality to be reused.

Description of the technology

Ultrafiltration (UF) and **nanofiltration** (NF) are membrane filtration processes whose purpose is to remove mainly suspended solids and organic matter and divalent ions from liquid effluents, respectively. They normally work at pressures of 1-5 bar (UF) (Jafarinejad, 2017) and 5-20 bar (NF) (Charcosset, 2012) and present zero or low monovalent ions rejection, respectively.

In general terms, UF process is able to efficiently **separate colloidal particles, viruses and bacteria** (Spivakov and Shkinev 2005), but has low salt rejection (Calabrò and Basile 2011). On the other hand, NF not only enables the **separation of even smaller organic molecules, but also of inorganic salts**. However, it is to note that NF membranes have low rejection of monovalent ions, high rejection of divalent ions and higher permeabilities compared to RO membranes (Wu *et al.,* 2017).

As a function of the oxidation degree, **regenerated end-of-life** reverse osmosis (RO) membranes can operate as UF and NF modules. By this way, a waste can **be reused** in the water cycle, incrementing their lifetime.

In the NextGen project, a pilot plant located in the wastewater treatment plant (WWTP) of Tossa de Mar is integrated by an UF module coupled successively to a NF one, both fitted with regenerated RO membranes.

The flowrate capacity production of the pilot plant is of 2 m^3/h.

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Flow scheme of the technology

Simplified scheme diagram of the process.

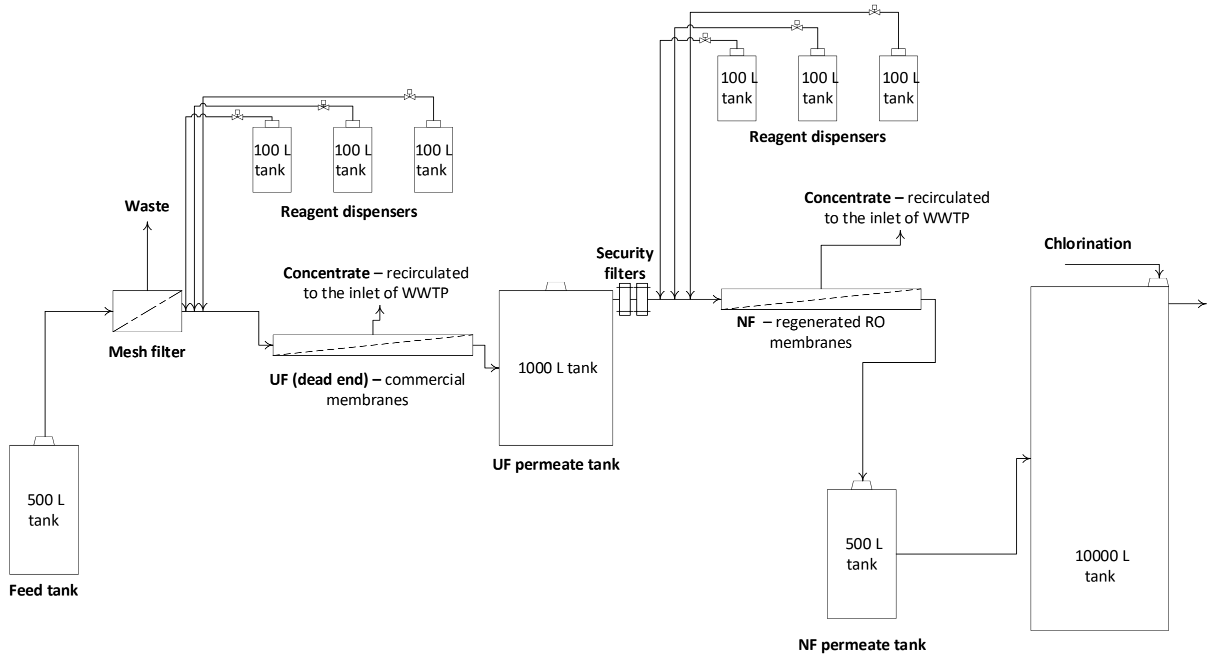

Figure 1. Simplified P&ID of the NextGen pilot plant.

Pictures of the technology

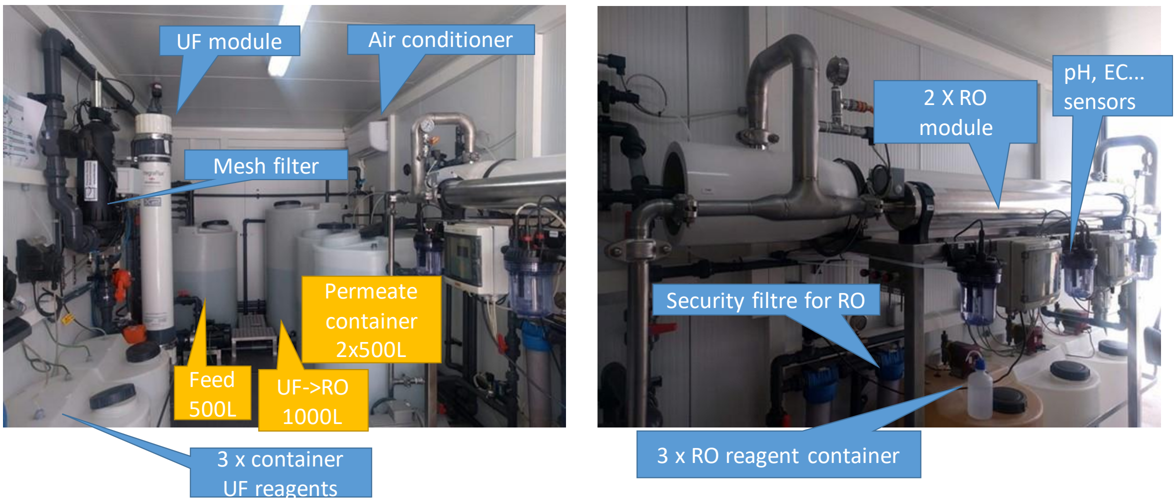

Figure 2. Images of the pilot plant equipment.

Synergetic effects and motivation for the implementation of the technology

- ✓ **Establishment of a circular economy concept (by the reuse of membranes).**

The valorisation of the RO end-of-life membranes is a key aspect to establish the circular economy practices in the water cycle.

By this way, a waste (RO end-of-life membranes) can be regenerated (through an oxidation step) and later can be reused in the NF or UF modules as a function of oxidation degree. Therefore, this practice increases the circularity in the water process.

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✓ **Reduction of the emerging/priority pollutants that reach aquatic systems.**

By removing emerging/priority pollutants from the wastewater treatment plants (WWTP) effluents, NextGen will contribute to **avoiding that certain organic substances reach aquatic systems** thus preventing certain effects on the fauna related to endocrine disrupting process as well as protecting the flora. Furthermore, high quality water can be suitable to recharge the aquifers and, consequently, to be used **for indirect potable reuse (IPR)**.

✓ **Reduction of the drinking water consumption destined to private garden irrigation.**

UF & NF processes fitted with regenerated RO membranes will produce a regenerated effluent the quality of which allowing to use it for the private garden irrigation. This fact will contribute to **reduce the quantity of drinking water consumed** for this application, therefore improving the availability of this resource.

Requirements of the technology and operating conditions

A mesh filter must be incorporated at the beginning of the treatment to ensure that any coarse solid reaches the UF module.

Cleaning cycles of UF & NF processes should be performed periodically to ensure suitable operation.

The following table summarize the most appropriated values of several parameters for the conventional UF & NF processes (which would be different when working with regenerated RO membranes).

Table 1. Required specifications for the UF and NF systems.

UF				
Parameter	**Units**	**Min**	**Max**	**Reference**
Transmembrane pressure (TMP)	bar	**-**	**2.1**	DuPont, 2019
Temperature	ºC	**1**	**40**	DuPont, 2019
pH	upH	**2**	**11**	DuPont, 2019
Particle size	µm	**0.03**	**0.5**	Spivakov and Shkinev, 2005

NF				
Parameter	**Units**	**Min**	**Max**	**Reference**
Turbidity	NTU	**>1**	**>1**	NextGen D1.2
Pressure	atm	**5**	**50**	Cheremisinoff, 2001
Temperature	ºC	**1**	**45**	NextGen D1.2
pH	-	**2**	**11**	NextGen D1.2
SDI	-		**5**	Dupont, 2020
MFI0.45	-		**4**	Dupont, 2020
Oil and grease	mg/L		**0.1**	Dupont, 2020
TOC	mg/L		**3**	Dupont, 2020
COD	mg/L		**10**	Dupont, 2020
AOC	µg/L Ac-C		**10**	Dupont, 2020
BFR	pg/cm2 ATP		**5**	Dupont, 2020

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Free chlorine	mg/L		**0.1**	Dupont, 2020
Ferrous iron	mg/L		**4**	Dupont, 2020
Ferric iron	mg/L		**0.005**	Dupont, 2020
Manganese	mg/L		**0.005**	Dupont, 2020
Aluminium	mg/L		**0.005**	Dupont, 2020

Key performance indicators (KPIs)

The KPIs to be monitored during the UF and NF processes, specifically those related with Costa Brava case study are summarized in the following table.

Table 2. KPIs for the coupling of UF and NF processes fitted with RO regenerated membranes in the Costa Brava case study.

Parameter	Units	Min	Max	Reference
Water yield of the system	% regenerated water produced	**40**	**80**	NextGen, D1.2
Salt rejection yield	% salt removal	**80**	**> 97**	NextGen, D1.2
Global removal yield for several priority / emerging pollutants	% pollutants removal	**40**	**>99.9**	NextGen, D1.2
TSS and turbidity removal yield vs inlet flow to the system	%	**85**	**99**	NextGen, D1.2
[E. coli] final effluent	CFU/100mL	**<LOD**	**0**	Spanish legislation in water reuse (RD 1620/2007)
[Intestinal nematodes] final effluent	Egg/L	**<LOD**	**1**	
[Legionella spp.] final effluent	CFU/L	**<LOD**	**100**	
Electricity consumption	kWh/m^3 water	**Mean value: 2 kWh/m³**		Garcia-Ivars *et al.*, 2017
Flux related to transmembrane pressure	l m^{-2} h^{-1}/bar	**Mean Value: 13 LMH/bar**		Garcia-Ivars *et al.*, 2017

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Links to related topics and similar reference projects

UF & NF with regenerated RO membranes	Reference
NextGen	**Case study "Costa Brava" (NextGen)**
DEMOWARE	UF & NF with conventional membranes applied for IPR in the Port de la Selva (Costa Brava, Spain).
ZEROBRINE	Deliverable D4.2 Regeneration and performance of reverse osmosis membranes from desalination plants.
SUGGEREIX	Link to the emerging/priority substances analysed in water in the Costa Brava region.

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Outlook

Case study specific information will be provided, when the results of the other work packages are available:

- Lessons learned from the case study
- Outcome of the assessments
- Legal and regulatory information concerning the whole value chain concerning the technology
- Business opportunities

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