ELIMINATION OF EMERGING POLLUTANTS WITH MEMBRANE PROCESSES: A REVIEW

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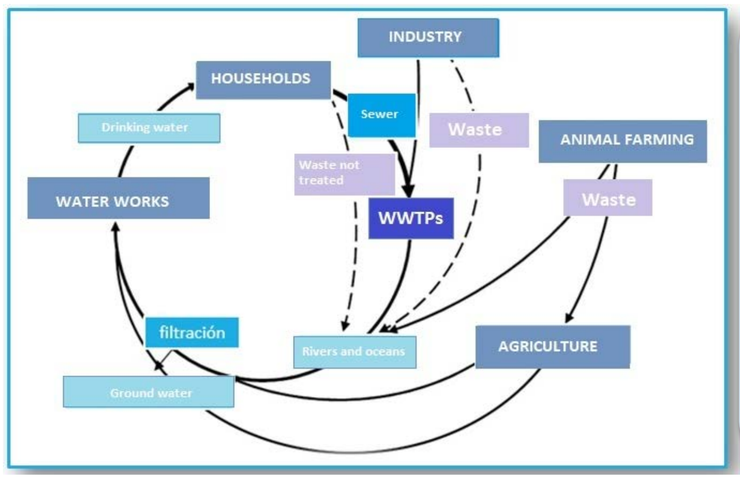
INTRODUCTION

Population growth and economic development have contributed to the deterioration of water resources. (Barceló & López de Alda, 2008). Production of chemicals has increased because of the development of resources and available technology, which in turn has led to an increase in the number of chemical compounds considered hazardous to the environment. (Bolong et all, 2008). This group of contaminants is comprised of a wide variety of products, such as personal care products, pharmaceuticals or surfactants. (Petrovic et all, 2003). Drugs and particularly antibiotics are of all emerging pollutants, which generated greater concern and study in recent years. The presence of these unregulated microcontaminants in surface water is mainly due to the inability to remove them in wastewater treatment plants by conventional methods, requiring the development of other types of treatment methods (Andreozzi et all, 2003).

OBJECTIVE

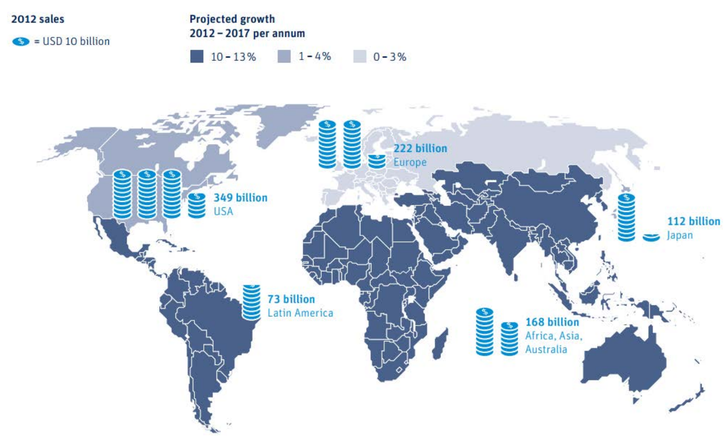
The main objective of this work is the evaluation of membrane technologies as a method of emerging pollutants elimination present in water matrices.

GRAPHICALLY STATE OF ART



Emerging pollutants

- Flame retardants
- Pesticides
- Drugs
- Hormones
- Pharmaceutical and personal care products
- Lifestyle compounds



Volume of sales and estimated growth of the pharmaceutical market. (IMS Health, 2015)

Betalactamics	•Amoxicillin •Ampicillin
Macrolides	•Erythromycin •Azithromycin
Tetracyclines	•Tetracycline •Oxytetracycline
Sulfonamides	•Sulfamethoxazole •Sulfadiazine
Fluoroquinolones	•Ciprofloxacin •Norfloxacin

Concentrations in wastewater

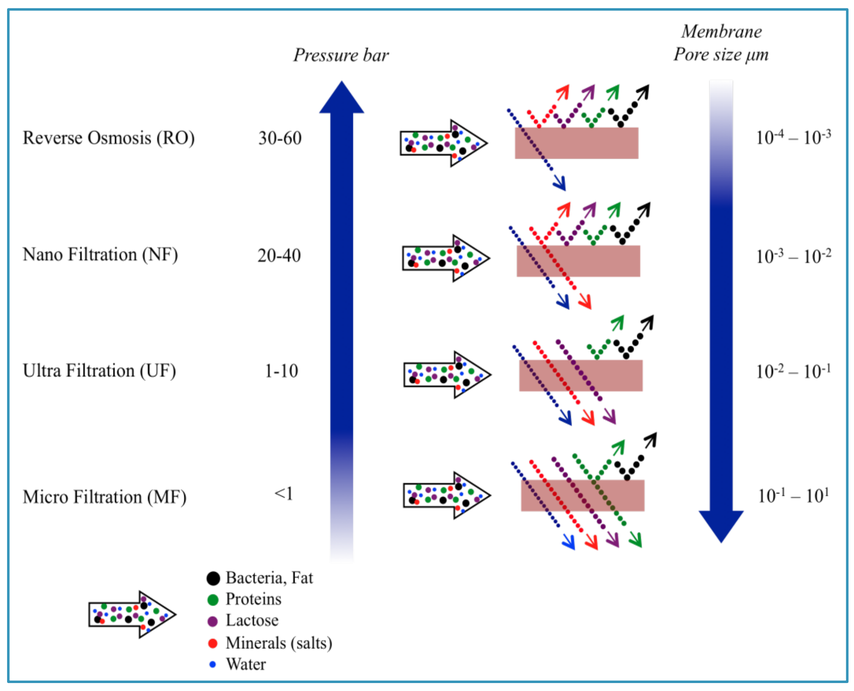
- Australia & China: Clarithromycin (6.5 µg/l) and Ciprofloxacin (4.6 µg/l)
- Europe: Erythromycin-H2O (2.5 µg/l) and Sulfamethoxazole (1.7 µg/l)
- Spain: Ciprofloxacin (13.6 µg/l) and Ofloxacin (5.3 µg/l)
- Gran Canaria: Ciprofloxacin (20.3 µg/l) and Levofloxacin (14.2 µg/l)

Toxicity and risks

An Australian study revealed resistance of bacterial strains to antibiotics such as ciprofloxacin and sulfamethoxazole, among others.

Another study revealed the toxicity of ciprofloxacin in the microalgae Selenastrum capricornutum.

In Italy a mixture of drugs including the antibiotics ciprofloxacin and sulfamethoxazole inhibited the growth of human embryonic cells.



MEMBRANE TECHNOLOGIES FOR THE ELIMINATION OF EMERGING POLLUTANTS

RO

Type of pollutant	Matrix	Operating conditions	Rejection percentages	References
Drugs of abuse and caffeine	Wastewater (0,63-4106 ng/l)	Membranes: LE, BW30 & XFR (Dow FilmTec). T (°C): 17-29; pH: 7,1-7,4	LE (47 - >98) BW30 (57 - >98); XFR (47 - >98)	(Boleda et all, 2010)
Pharmaceutical products	Ground water (8,7-2548 ng/l)	Two parallel operations, with 40 membrane modules in the first and 20 in the second. Each module contains 6 membranes BW30LE-440 (Dow) T (°C): 17; pH: 5,6-6,1	(50 - >95)	(Radjenovic et all, 2008)
Pharmaceutical products and endocrine disruptors	Milli-Q water (100 µg/l)	Membranes: XLE (Dow FilmTec) y SC-3100 (Toray). T (°C): 20; pH: 7	XLE (57 - 91); SC-3100 (0 - 85)	(Kimura et all, 2004)
Antibiotics	Synthetic waste water (10 mg/l)	Membranes: XLE y HR95PP (Dow FilmTec) y TFC-S (Koch Membrane Systems) T (°C): 25 pH: 7,4-7,5	XLE (97,2 - 100) HR95PP (96,8 - 100) TFC-S (100)	(Kosutic et all, 2007)
Antibiotics	Wastewater (89,5-810 µg/l)	Membrane: XLE (Dow FilmTec) T (°C): 25; pH: 5,98-6,82	(>99)	(Dolar et all, 2009)
Pharmaceutical products, pesticides and flame retardants	Suface water (38-1143 ng/l)	8 SW 30-4040 membrane modules (Dow FilmTec) T (°C): > 0 – 49; pH: 5-9	(>98,9 - >99)	(Heberer et all, 2002)
Pharmaceutical products and endocrine disruptors	Surface, Milli-Q and wastewater (0,72-2,07 µg/l)	Membrane: X20 (TriSep) T (°C): 21±1; Surface water pH: 8,0-8,1 Mili-Q water pH: 7; Wastewater pH: 7,9	Surface.: (82,1-100) Mili-Q(91,5-100);WW(96,2-100)	(Comerton et all, 2008)

NF

Type of pollutant	Matrix	Operating conditions	Rejection percentages (%)	References
Pharmaceutical products, endocrine disruptors, preservatives, and sunscreens	Deionized water (20 µg/l)	Membrane: HL (Desal, Osmonics, GE Water Process Tech) T(°C): 25±2; pH: 6,5	(40 - >97)	(Wang et all, 2015)
Pharmaceutical products, endocrine disruptors	Surface, Milli-Q and wastewater (0,72-2,07 µg/l)	Membranes: NF270 (Dow Filmtec) and TS80(TriSep) T(°C): 21±1; Surface pH: 8,0-8,1; Mili-Q pH: 7; Wastewater pH: 7,9	NF270: Surf(0-93) Milli-Q(1,3-68,8) WW(8,2-92,9) TS80: Surf(66,3-100) Milli-Q(0-94,6); WW(76,7-100)	(Comerton et all, 2008)
Pharmaceutical products, endocrine disruptors and pesticides	Fresh water (8-17 µg/l)	Membranes: NF200 and NF90 (Dow FilmTec) T(°C): 20; pH: 7	NF200 (23-90) NF90 (47-97)	(Yangali-Quintanilla et all, 2011)
Antibiotics	Wastewater (89,5-810 µg/l)	Membranes: NF90 (Dow FilmTec) and HL (Desal, Osmonics) T(°C): 25; pH: 5,98-6,82	NF90 (>99) HL (65,45 - >99)	(Dolar et all, 2009)
Pharmaceutical products	Groundwater (8.7-2548 ng/l)	Two operations, 31 and 15 membrane modules respectively. Each module contains 6 membranes NF90-400 T(°C): 17; pH: 5.6-6.1	(30% - >95%)	(Radjenovic et all, 2008)

MBR

Type of pollutant	Matrix	Operating conditions	Rejection percentages (%)	References
Pharmaceutical products, polycyclic fragrances and endocrine disruptors	Wastewater (26-6840ng/l)	Ultrafiltration membrane on the outside of the bioreactor. 1st Test: T(°C): 22,2; SRT (days): 10; HRT (hours): 0,5 2nd Test: T(°C): 27,2; SRT (days): 27; HRT (hours): 1,2 3rd Test: T(°C): 5,5; SRT (days):55; HRT (hours): 4	1st Test: (0 - 98,5) 2nd Test: (0 - 99,4) 3rd Test: (0 - 97,9)	(Clara et all, 2005)
Pharmaceutical and personal care products, endocrine disruptors, pesticides, industrial products and sunscreens.	Synthetic waste water (5 µg/ l)	An external microfiltration membrane is used. T (°C): 26 ± 0.2; SRT (days): 88; HRT (hours): 26	(27% - >95%)	(Wijekoon et all, 2013)
Pharmaceutical products and polycyclic fragrances	Synthetic wastewater (10-20 µg/l)	Zenon ZW-10 submerged ultrafiltration membrane. T(°C): 18-24; SRT (days): 72; HRT (hours): 12	(10% - 98%)	(Reif et all, 2008)
Pharmaceutical products	Wastewater (35-22,500 ng/l)	submerged microfiltration membrane, with an effective porosity comparable to an UF membrane, T (°C): 20 ± 2; SRT (days): 3; HRT (hours): 14	(47,3% - 99,8%)	(Radjenovic et all, 2007)

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