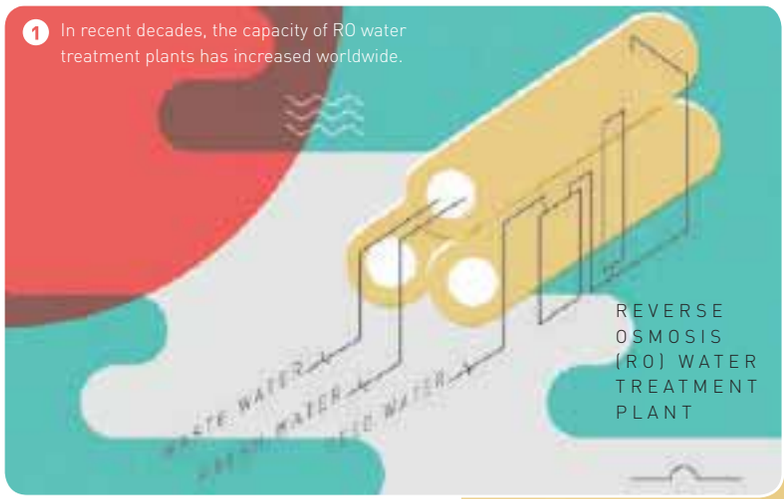
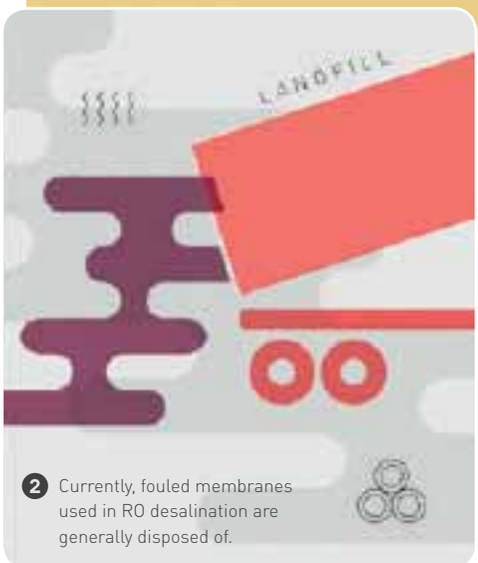
Recycling membranes

Dr Eloy García Calvo, **Raquel García Pacheco**, **Domingo Zarzo Martinez**, and **Dr Elena Campos Pozuelo** are involved with a project that aims to recycle used water treatment membranes. Here, they describe the simple transformation process that makes this possible and the challenges of competing with commercial alternatives



1 In recent decades, the capacity of RO water treatment plants has increased worldwide.



2 Currently, fouled membranes used in RO desalination are generally disposed of.

Can you summarise the key issues the LIFE-TRANSFOMEM project consortium seeks to address?

Energy consumption and membrane fouling represent major concerns in membrane technology, since they increase the costs associated with treated water. Due to the growth of reverse osmosis (RO) applications in industrial processes, economic but also environmental worries have increased demand for the recycling and reuse of fouled, end-of-life, thin-film composite RO membranes.

The main objective of the LIFE-TRANSFOMEM project is to demonstrate, at pilot scale, the viability of transforming end-of-life membranes into nanofiltration and ultrafiltration membranes using a simple, low energy surface modification technique based on polyamide chemical attack.

By what means does the team behind this project hope to achieve its goals? What are your proposed methodologies, with particular reference to the pilot study?

We will develop several actions in order to achieve our objectives. The first is membrane autopsy, which means opening the spiral-wound module of the membrane and extracting samples for qualitative and quantitative analysis. We will characterise end-of-life RO membranes from different industrial plants and with diverse fouling.

The next stage is transformation of RO membranes. We plan to recycle end-of-life membranes by chemical attack with sodium hypochlorite. Two methodologies will be trialled at pilot scale, both consisting of a direct recycling mode with no structural changes to the spiral-wound module.

We will then validate the transformed membranes in nanofiltration and ultrafiltration processes. Once the membrane has been transformed, it is necessary to evaluate its performance and lifespan. For this purpose, water pilot systems will be designed for treating sea, brackish and waste water. Finally comes economic assessment of the solutions: feasibility studies will be conducted in order to assess the national market dimension (availability of used RO membranes) and to evaluate the cost-benefit ratio of the recycling process.

What are the main challenges associated with this process, and how will you seek to overcome them?

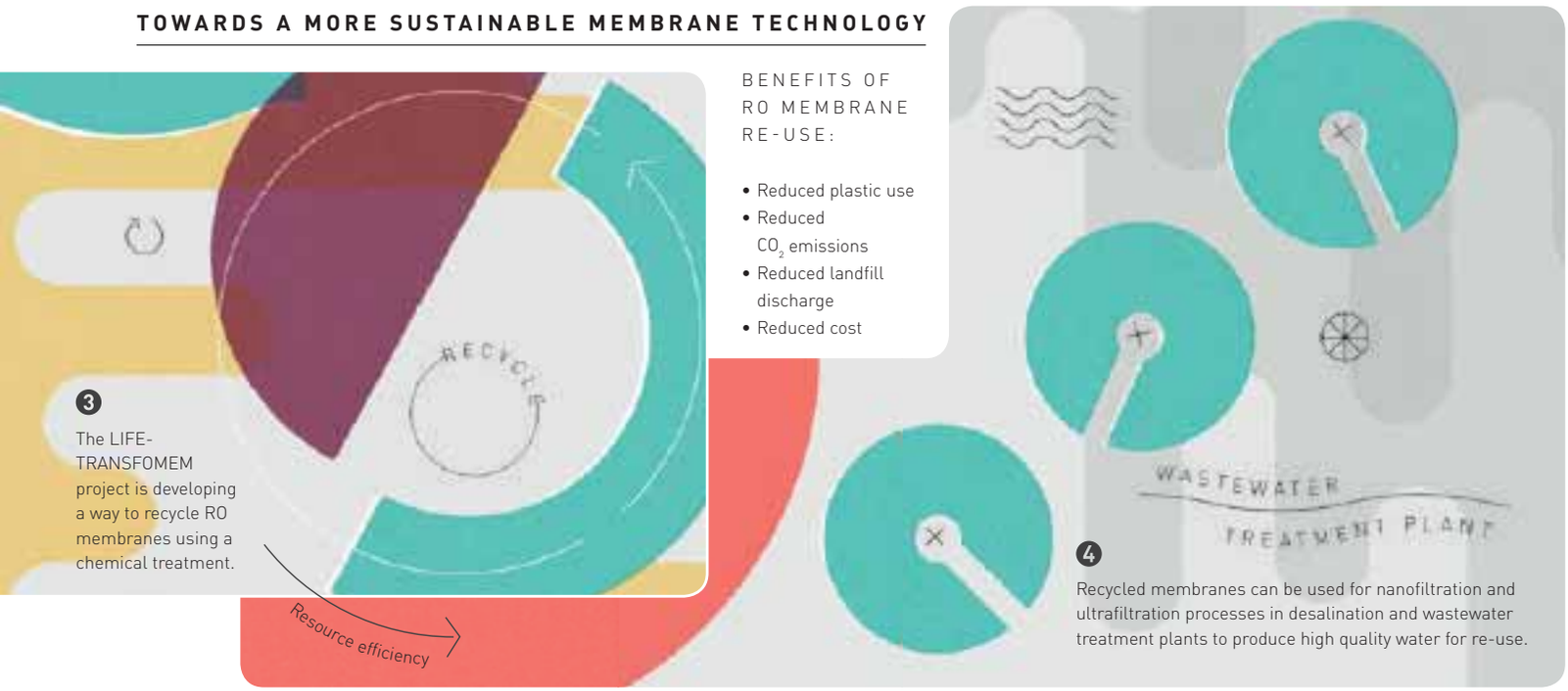
There are two challenges that will determine whether or not this project is successful. The first is to provide recycling solutions to end-of-life RO membranes, despite their type of fouling and commercial brand. At the very least we hope to identify which cases are the best in which to apply the transformation process. Secondly, the recycled membranes must be able to compete with commercial membranes in terms of cost, effectiveness, durability, energy requirements and maintenance.

How are the consortium's activities to be monitored in order to ensure its timely success?

The consortium involves a symbiosis between a public research centre and private companies. Its activities are continuously monitored in order to guarantee the achievement of the planned objectives, thus maintaining scientific quality and quantity, which is in line with our time estimates. We often revise the schedule by comparing what we planned to do with what has been achieved. All of the project actions have a person responsible for developing them, and they are in continuous contact with the technical lead and coordinator of the project. Communication between all members of the project is essential. We also report on a regular basis to the European Commission (EC) to evaluate our progress, as well as delivering an annual formal report.

Will this project increase social awareness of recycling natural resources?

We have designed dissemination activities for the general public and also for specific groups, such as students of water management resources. Although the basic concept is the same, we alter our activities for each group. When addressing more informed people, we will conduct visits to the pilot plant and IMDEA Agua laboratory. For the general public, we participate in science communication events like 'Science Week' and 'Researcher Night'. In all of these dissemination activities, people can observe an end-of-life membrane and understand how they are made at a laboratory scale, how they work and how we transform and test them.



BENEFITS OF RO MEMBRANE RE-USE:

- Reduced plastic use
- Reduced CO_2 emissions
- Reduced landfill discharge
- Reduced cost

3 The LIFE-TRANSFOMEM project is developing a way to recycle RO membranes using a chemical treatment.

4 Recycled membranes can be used for nanofiltration and ultrafiltration processes in desalination and wastewater treatment plants to produce high quality water for re-use.

From waste to resource

A collaboration between the research centre IMDEA Agua and water treatment companies Valoriza Agua and Sadyt, the **LIFE-TRANSFOMEM** project is recycling reverse osmosis membranes to make water treatment processes more sustainable

RECYCLING IS A key tenet of sustainable living. While most are by now familiar with recycling glass, paper and plastic, there are many further kinds of waste material that can be turned into new products – including the membranes used in water treatment processes.

Reverse osmosis (RO) technology is used in many industrial processes to purify water. In these applications, water is passed through semipermeable membranes in order to remove a wide range of particles, including bacteria. However, RO membranes usually have a maximum lifespan of five years – depending on the water quality that they are treating – after which time they become 'fouled'; compromising the industrial process, and are therefore disposed of.

The disposing of fouled membranes is wasteful, environmentally damaging and costly; and furthermore it directly conflicts with EU goals to achieve a crosscontinental recycling society. In an effort to bring water management in line with sustainable efforts elsewhere in industry, the LIFE-TRANSFOMEM project aims to recycle end-of-life RO membranes by transforming them into ultrafiltration and nanofiltration membranes, which can then be used to turn wastewater into reclaimed water that can be reused.

The project consortium includes IMDEA Agua, a public institute based in Madrid, Spain, that conducts advanced research on water; as well as Sadyt (Sociedad Anónima Depuración y Tratamientos) and Valoriza Agua, both of which belong to the global Sacyr group. Together, the three teams aim to make membrane-based water treatment processes more sustainable by increasing their durability and reducing their associated costs – both environmentally and economically.

CHEMICAL ATTACK

The LIFE-TRANSFOMEM team will take end-of-life RO membranes from desalination plants and treat them for re-use in lower pressure filtration processes. In order to achieve this, the researchers will apply a chemical treatment to the membranes. "IMDEA Agua has been working on this for over three years. In this time we have identified the specific parameters that will enable us to achieve the transformation of RO membranes into nanofiltration and ultrafiltration membranes," explains the team. The transformation process involves 'chemical attack' by sodium hypochlorite, which modifies the main polymer structure of RO membranes responsible for separating molecules.

Two different types of transformation will be trialled. In the first, called passive transformation, the membrane will be immersed in a sodium hypochlorite solution and left for a period of time. The second mode, active transformation, forces the solution to circulate in the membrane. This aggressive form of transformation is more effective but, unlike passive transformation, it requires an input of energy.

DIRECT APPLICATION

The resultant membranes, which will have remarkably increased permeability, will be put to use as nanofiltration membranes to treat brackish and sea water in desalination plants,

FILTRATION PROCESSES: AN OVERVIEW

Reverse osmosis, nanofiltration and ultrafiltration are all pressure-driven processes involving a membrane. The main difference between them is the size of the pores in their membranes, which determines the compounds that can pass through the semi-permeable barrier. Reverse osmosis membranes are dense (with no pores), will let virtually nothing but water through, and operate at high pressure; while nanofiltration and ultrafiltration have nanopores (nanofiltration has the smallest) and operate at lower pressures.

LIFE-TRANSFOMEM

TRANSFORMATION OF DISPOSED REVERSE OSMOSIS MEMBRANES INTO RECYCLED ULTRA- AND NANOFILTRATION MEMBRANES

OBJECTIVES

- To increase the sustainability of membrane-based water treatment processes by improving their durability and reducing their environmental cost
- To demonstrate an alternative to the disposal in landfills of exhausted reverse osmosis filtration membranes used in wastewater treatment

PARTNERS

Instituto IMDEA Agua • Sociedad Anónima Depuración y Tratamiento (Sadyt) • **Valoriza Agua**

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and as ultrafiltration membranes in a wastewater treatment plant. In total, three pilot plants will be used to trial the methodology: two membrane recycling plants (one for active and one for passive treatment), and a monitoring plant that will be used to check membrane quality before and after the recycling treatment, and to test membranes for wastewater reuse.

The team will also conduct a financial feasibility study, surveying the available market for recycled products. The knowledge gained regarding membrane recycling can feed back into research by being published in scientific journals and being incorporated into an academic master's programme in Hydrology and Hydric Resources Management from Alaclá (UAH) and Rey Juan Carlos (URJC) universities.

A POWERFUL DEMONSTRATION

The project, which began in June last year, has made good progress in the past 10 months. "The three partners have achieved a tight research partnership. This helped the project to start well and be coordinated smoothly," the collaborators enthuse. At present, Sadyt is busy collecting used membranes from a range of industrial water treatment plants, and is even beginning to design and construct the pilot systems. Meanwhile, the research arm of the project – IMDEA – is analysing the used membranes, and conducting preliminary experiments that will be critical to the future scaling up of the membrane transformation process.

The project, which is due to finish in June 2018, aims to create a pilot demonstration of the viability of transforming used RO membranes into ultrafiltration and nanofiltration membranes, using a simple and low energy surface modification technique. If they are successful, the researchers will be one step closer to finding an alternative to membrane disposal, which would change practices in many industries and in waste management.

Transforming used membranes into new ones would also have several positive environmental impacts – notably the reduction in landfill disposal, a decrease in the consumption of plastics and also in the CO_2 emissions associated with membrane production. Furthermore, it is expected that the recycled membranes will be much cheaper than current options, making them more desirable for water treatment.

In Spain, areas with under 2,000 inhabitants – nearly 6,000 of over 8,000 existing municipalities – have wastewater treatment rates of less than 50 per cent, and there is a lack of tertiary treatment facilities to treat this water. As a result, increasing the accessibility of the membrane module system would be particularly beneficial in this region. These recycled membranes could therefore be a cost-effective means of treating wastewater in small urban communities which, according to EUROSTAT, 40 per cent of Europeans currently live in.

ACADEMIC-INDUSTRY PARTNERSHIP

The LIFE-TRANSFOMEM consortium involves three key players, representing research and industry

IMDEA AGUA

IMDEA Agua is a research institute that focuses on issues of water management, working to improve public and private decision-making processes by emphasising the link between water, public services, the economy and institutions. It has several projects focused on membrane technology and water treatment.

IMDEA Agua coordinates the LIFE-TRANSFOMEM project and has developed the laboratory protocol used to transform discarded reverse osmosis membranes. It will operate the pilot plants and is responsible for the project's dissemination.

SADYT AND VALORIZA AGUA

Sadyt is a leading water treatment company and part of the Sacyr group. It specialises in desalination and is one of the top 10 companies in the world in this sector, with over 70 desalination plants across the globe and 1,700,000 m^3 of water treated daily.

Head of the Sacyr companies that operate in the water field, Valoriza Agua is involved in the design, engineering and maintenance of many types of water treatment plants. Its activities include desalination of brackish water and seawater, water re-use, and industrial water treatment.

It has designed and built over 100 plants and is a leading water technology company in Spain and across the globe, serving over 3 million people.

As part of the LIFE-TRANSFOMEM project, Sadyt and Valoriza Agua will collect end-of-life membranes, design and accommodate demonstrations of the technology, and participate in pilot plant experimentations. They will also contribute to disseminating the results of the project.

WWW.AGUA.IMDEA.ORG
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