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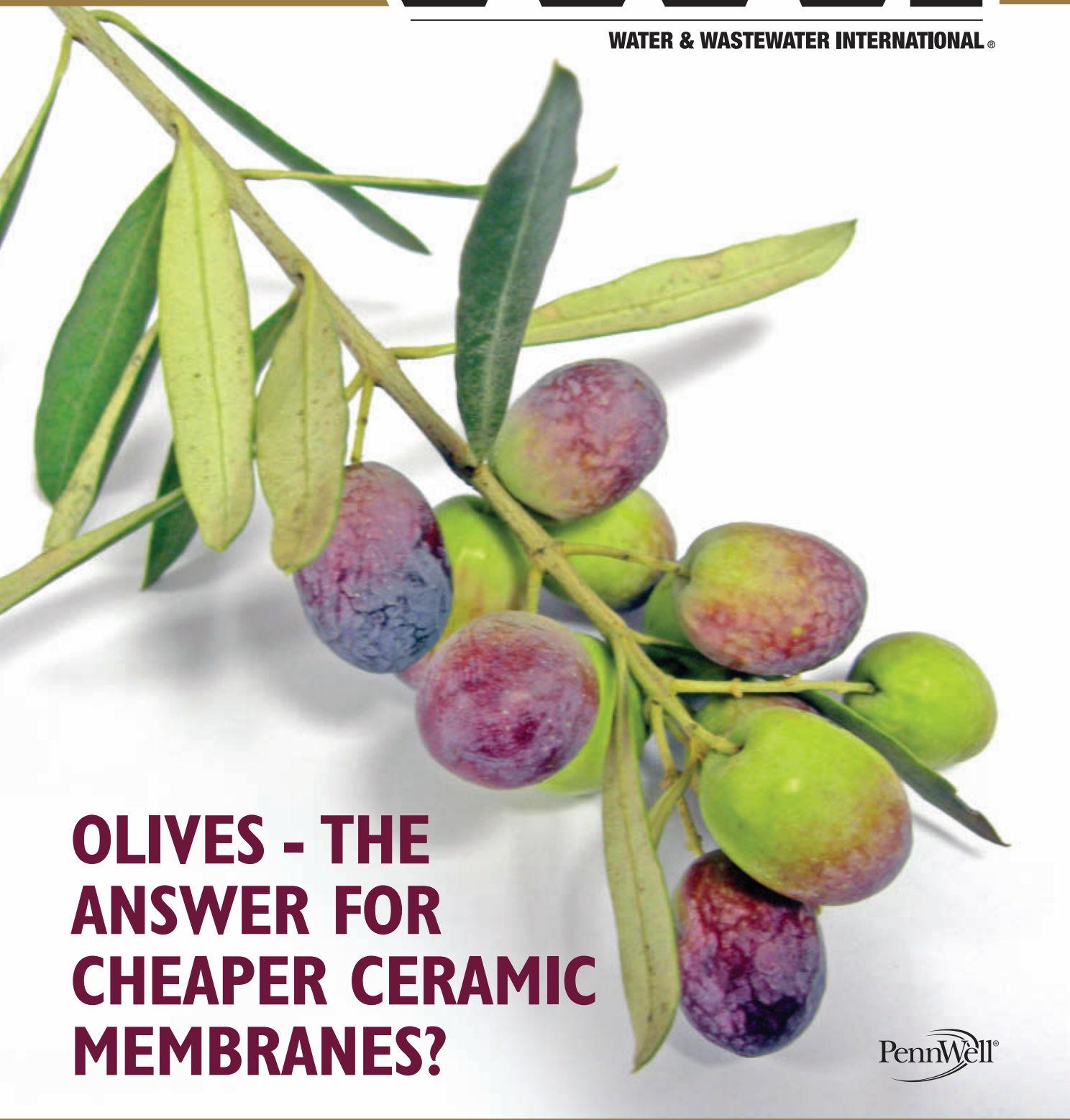

OLIVES - THE ANSWER FOR CHEAPER CERAMIC MEMBRANES?

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Waste to value: Chamotte (from fired tile scrap) and marble dust are being used to help bring down manufacturing costs

CRACKING THE CERAMIC CAPEX CONUNDRUM

While higher costs have prevented widespread use for durable ceramic technology, a European funded project in Spain aims to tackle this by producing membranes from industrial waste and raw materials from the tile industry.

By William Steel

The Recycled Membrane Bioreactor project (REMEB) is working under a three-year framework to develop, validate and commercialise a low-cost membrane bioreactor (MBR) featuring sustainable ceramic membranes.

REMEB has a total budget of €2.3 million and is being supported through the Horizon 2020 research and innovation initiative where it has received financing via a €1.8 million grant from the European Commission. The project — which began last September and is set to conclude August 2018 — is being undertaken by a consortium of eleven partners; public and private players spread through seven countries.

Ceramic membranes are of course not new, but they remain prohibitively expensive for many settings — limiting their use to niche, largely industrial, applications and bolstering the business case for choosing polymeric membranes, which dominate the membrane market. This is an unfortunate circumstance considering the numerous advantages of ceramic membranes, notably their resilience to chemicals and lifetime robustness.

Seeking to overcome barriers imposed by expense, what sets REMEB apart from conventional ceramics is the materials it intends to utilise in production of membranes.

WASTE TO VALUE

Speaking to WWi magazine, Elena Zuriaga, REMEB technical coordinator, and researcher at FACSA (the Spanish company leading REMEB and one of the largest operators of drinking water and wastewater facilities in Spain) says: "Conventional ceramic membranes — made from oxide materials such as alumina, zirconia, or titania — are very expensive. It's not only that materials

» THE GOAL IS TO **REDUCE CAPITAL** COSTS THROUGH A CERAMIC DESIGN **FEATURING CHEAP,** ABUNDANT MATERIALS **AND EASILY REPRODUCIBLE,** LOW-COST MANUFACTURING **METHODS.**

▲ Testing times: Validation of the REMEB MBR technology will take place at the Aledo municipal WWTP, in the region of Murcia, Spain

are expensive; the manufacturing process is also very costly."

"Because of this, their use is limited predominantly to industrial wastewater treatments where high investment and capital costs are not so great a problem. But that cost barrier is a problem in other cases where we would like to see ceramic-based solutions implemented."

In particular, REMEB hope to foster greater use of ceramics in municipal facilities.

"As an alternative," she says, "in order to achieve ceramic membranes with lower cost than the commercial ceramic ones, and [which are] more sustainable, we are using agricultural and industrial wastes, together with raw materials typically used in the ceramic tile industry, instead of metal oxides."

Describing how waste materials are featuring in REMEB's plan, Zuriaga says: "Olive oil (orujillo) wastes are used as pore formers. Chamotte (from fired tile scrap) and marble dust have been used together with the typical raw materials employed in the ceramic tile industry (basically clay, quartz and feldspar)."

"At the moment we are working at pilot scale to test different compositions of wastes and raw materials in order to achieve the most suitable plasticity, mechanical resistance and porosity. The advantage of these recycled materials is their widespread availability in the Mediterranean region and low cost," says Zuriaga.

A low-cost ceramic membrane, optimised for MBRs, of the sort REMEB promises to deliver would be well received by the water treatment market and MBR operators and would, as Zuriaga says, "enable ceramic-based wastewater treatment solutions – and their many advantages – to reach a far wider range of applications."

THE EXPANDING MBR MARKET

A core technology of the water treatment and reuse industry, there's a large and expanding market for MBRs: with some 4.2 million m^3/day of large-scale (greater than 30,000 m^3/day) MBR capacity installed worldwide according to Bluefield Research, and typical worldwide market growth rates of up to 15%.

However, while MBR growth has been aided through declining costs of polymeric membranes, costs for ceramic membranes remain high.

Gang Xin, technical manager at BioWater Technology, a Norwegian water treatment technology company partnered on REMEB, tells WWi, "We're starting to see ceramic membranes becoming more popular and taking over a larger market share. There's a critical obstacle though — the cost of membranes."

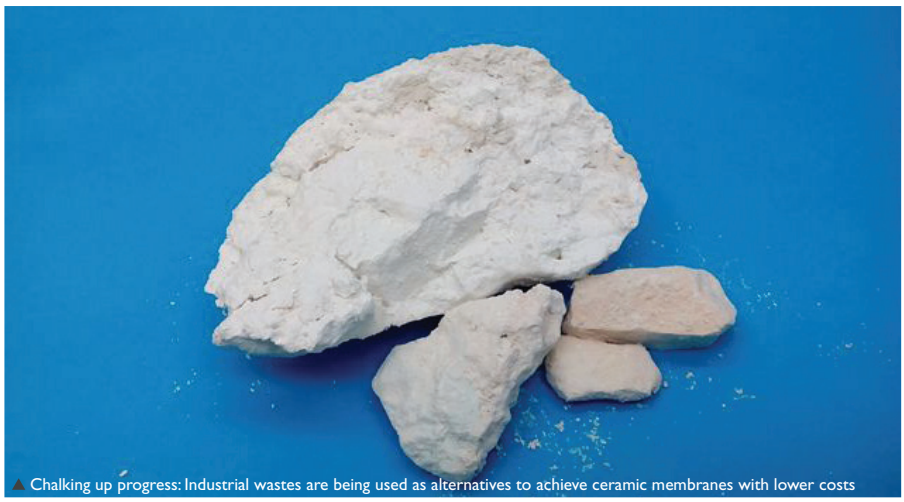
Xin continues: "If you look at the life-cycle analysis of ceramic membranes, these might be close to polymer membranes over a twenty-year time span in both capital (CAPEX) and operating (OPEX) costs. But because companies tend to focus on capital costs when deciding on what product or solution to invest in or choose, polymers are usually favoured."

"Therefore, if we're able to significantly lower capital costs of ceramic membranes we might be able to enable greater use of ceramic membranes within the market."

The goal, Xin explains, is therefore to reduce capital costs through a ceramic design featuring cheap, abundant materials and easily reproducible, low-cost manufacturing methods.

Reduced OPEX costs would then follow naturally, owing to attributes of ceramic membranes, as Zuriaga highlights: "Ceramic membranes demonstrate greater resilience in ways that are useful in the context of

▲ Pressing on: Olive oil (orujillo) wastes are used as pore formers in the process



▲ Chalking up progress: Industrial wastes are being used as alternatives to achieve ceramic membranes with lower costs

membrane operation and maintenance."

"The main advantage," Zuriaga says, "is that they have better chemical, thermal and mechanical properties than polymeric ones; making it possible to operate them under severe conditions."

MAINTENANCE REDUCTION

This robustness is evident in their being highly resistant to fouling, high temperatures, acids, solvents and bases, and their ability to operate at high pressures. Ultimately, these characteristics mean ceramic membranes require less maintenance and carry lower operational costs over longer lifespans than polymerics.

Elaborating on a particular important aspect of MBR operations, Xin says: "Ceramic membranes are more durable against the types of chemicals featuring in periodic chemical cleaning that all membranes must undergo. Polymers are quite resilient, but their lifetime capability is typically three to five years — after this, membrane cassettes must be replaced – adding expense, and increasing OPEX. In contrast, ceramic membranes, even with more frequent level of contact with those chemicals, can see lifetimes of ten years or more. The difference here is significant."

Precisely how low REMEB can push costs for the ceramic membrane is unclear at this time: "In our initial proposals we stated the aim to reduce costs [compared to conventional ceramics] by at least 30%; but the final cost reduction will depend on combined reductions in cost of raw materials and cost of manufacture," says Zuriaga.

"For sure we expect to produce membranes cheaper than conventional ceramic membranes, but we also hope to be cost-competitive with polymeric membranes — that's key."

Altogether with these savings, Zuriaga estimates "the cost of the REMEB MBR may be between 2.5 and 3.5 times less than MBRs with conventional ceramic membranes."

PILOT-SCALE MANUFACTURING

Remarking on the consortium's diversity, Zuriaga says "it's a real strength for the project as it brings in a great deal of expertise from multiple disciplines, and knowledge of varying market conditions, which is especially important to a project like REMEB where we're considering global applications."

A wide breadth of expertise is also necessary given the scope of REMEB's activities, which extend from market analysis to complete product design, manufacture, testing, and replication.

The wide geographic base of support is also supporting the project's considering how other resources may be suitable as base-materials for a ceramic membrane: "It would be possible to find an alternative organic material to orujillo [which is being used as a pore former] — to this end, other organic wastes will be tested" says Zuriaga.

Presently, pilot-scale manufacturing of ceramic membranes is taking place at three REMEB partner ceramic-based research centres — ITC-UJI (Spain), Centro Ceramico (Italy), and SAM (Turkey) — using waste resources convenient in each region. Further afield, the Antonio Nariño University in Columbia will undertake analysis of the applicability of the REMEB MBR in view of circumstances in South America.

ITC-UJI are also currently collaborating with a ceramic tile manufacturing company to re-tool and adapt their manufacturing process to what's required for the REMEB membrane.

Zuriaga says: "This is a new product for them to manufacture, so there's a lot of information to share about the material properties we need to see in the membrane." But Zuriaga is confident that alongside an effective ceramic membrane, REMEB's outcomes could open doors to a new area of operations for ceramic manufacturers.

TECHNOLOGY VALIDATION

The REMEB ceramic membrane will be designed with application into existing MBRs, featuring polymeric membranes, in mind — allowing operators to readily switch to a ceramic solution. That being the case, BioWater Technology believes that facilitating access to

▲ Marble dust, with raw materials in the ceramic tile industry (clay, quartz and feldspar) is being used as an alternative

▲ Teamwork: Everyone involved in delivering the REMEB project, led by Spanish water company FACSA

ceramic membranes will have positive consequences beyond improving MBR operation and maintenance.

Xin notes, "There are certain applications that only ceramic membranes can fulfil. For instance, high temperatures, extreme pH levels, high oil or fat levels."

Moreover, ceramic membranes represent a key enabler to the use of some technologies. One example is seen in how, or more specifically where, membranes may be incorporated into MBR systems.

Like many MBRs, BioWater's Continuous Flow Intermittent Cleaning (CFIC) system — a next-generation biofilm technology — can take a side-stream setup, with membranes installed outside of the bioreactor.

In an alternative CFIC or MBR configuration, however, membranes may be placed within the biofilm reactor, alongside carriers. There is a problem here though: "Understandably, people may worry about bringing a plastic carrier into direct contact with a membrane — as there's a risk of damaging the membrane. This risk is very real for polymer-based membranes, which are quite delicate."

"But with ceramic-based membranes, the material is far more durable — this situation creates a very good opportunity to integrate the two processes; in other words, it makes it more feasible to incorporate membranes into the biological reactor."

Enabling more MBR systems to have carriers and membranes combined in the same tank would be an excellent development according to Xin, who says that as well as reducing a system's footprint, "Membrane and carriers [working] together in the same bioreactor can improve membrane performance in water reuse installations and significantly reduce energy inputs compared to conventional MBR processes."

Precisely how well REMEB's ceramic MBR performs remains to be seen. In this regard, REMEB look toward preparations taking place at the Aledo municipal WWTP, in Region of Murcia, Spain; where the validation of the REMEB MBR will take place. As the Aledo WWTP already hosts a polymeric MBR, it provides an ideal testing ground for REMEB and its comparative assessment against polymer membranes.

All things considered, Xin is optimistic over the future of ceramic membranes: "It's too early to say what proportion of the market ceramic membranes might take over. But considering the broader membrane market, there's significant potential here. We will have a better sense of this with completion of the business plan; so around early spring 2018."

William Steel is a freelance correspondent for WWi magazine.

Disclosure: The REMEB project is funded by the Horizon 2020 programme (reference 641998), under the framework of the call H2020-WATER-2014-two stage and the topic Water-1a-2014, which promotes projects and initiatives for research, technological development and innovation. The project bears the focus 'Climate action, environment, resource efficiency and raw materials', and has identified societal challenges in Europe in relation to security, climate change and environmentally friendly production methods, among others.