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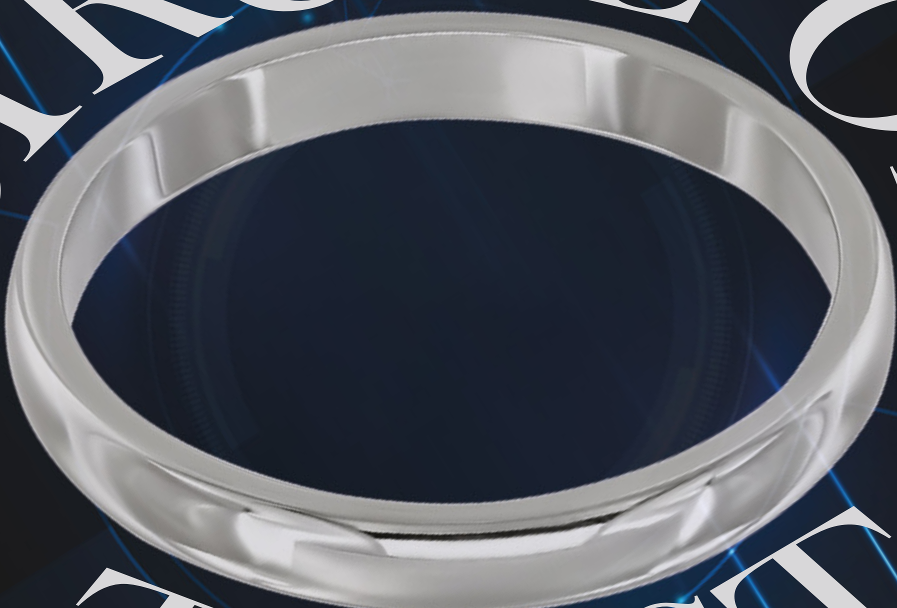
CIRCLE OF TRUST



EMBED ETHICAL CULTURE, EMBRACE PRO… BEHAVIOUR

PLUS SMARTER WATER USE / CHOC OF AGES / FU… LOW MEASUREMENT

Food & Water:
Using water smarter

Amanda Jasi reports on a project that aims to introduce circular symbiotic arrangements between industry and water service providers

WATER is vital to life, serving industry, agriculture, and the public. But clean water scarcity is a major problem facing the world currently, with strain on the system expected to continue growing. This makes improving efficiency and protecting groundwater increasingly important.

Industry is a major water user, accounting for about 40% of water abstraction in Europe. *The Chemical Engineer* spoke with researchers involved in the Horizon 2020 funded project *Ultimate*, which aims to catalyse water smart industrial symbiosis (WSIS). Project coordinator Gerard van den Berg said this would create economic value and increased sustainability by introducing circular symbiotic arrangements between industry and water service providers. Van den Berg is a Team Manager at water research institute KWR, which leads the project.

According to van den Berg, *Ultimate* is one of the first projects to focus on WSIS. It comprises nine case studies in "four of the most relevant industrial sectors in Europe" –(petro)chemicals, biotechnology, agro-food, and beverages – "showcasing the potential for achieving water smart symbiosis while contributing to economic growth".

While emphasis is on water, by turning wastewater into a resource, the project is also expected to achieve extraction and exploitation of energy and materials. Several of the studies include work in energy and/or materials.

Van den Berg said that circular economy aims to reduce resource depletion, environmental degradation, and potentially increased competition for scarce resources including water and embedded compounds.

"It is widely recognised that water, due to its natural origin and involvement in several processes, plays a central role in achieving these goals. We feel that transformation of the traditional linear production-consumption-disposal chains to circular water systems is key to the success."

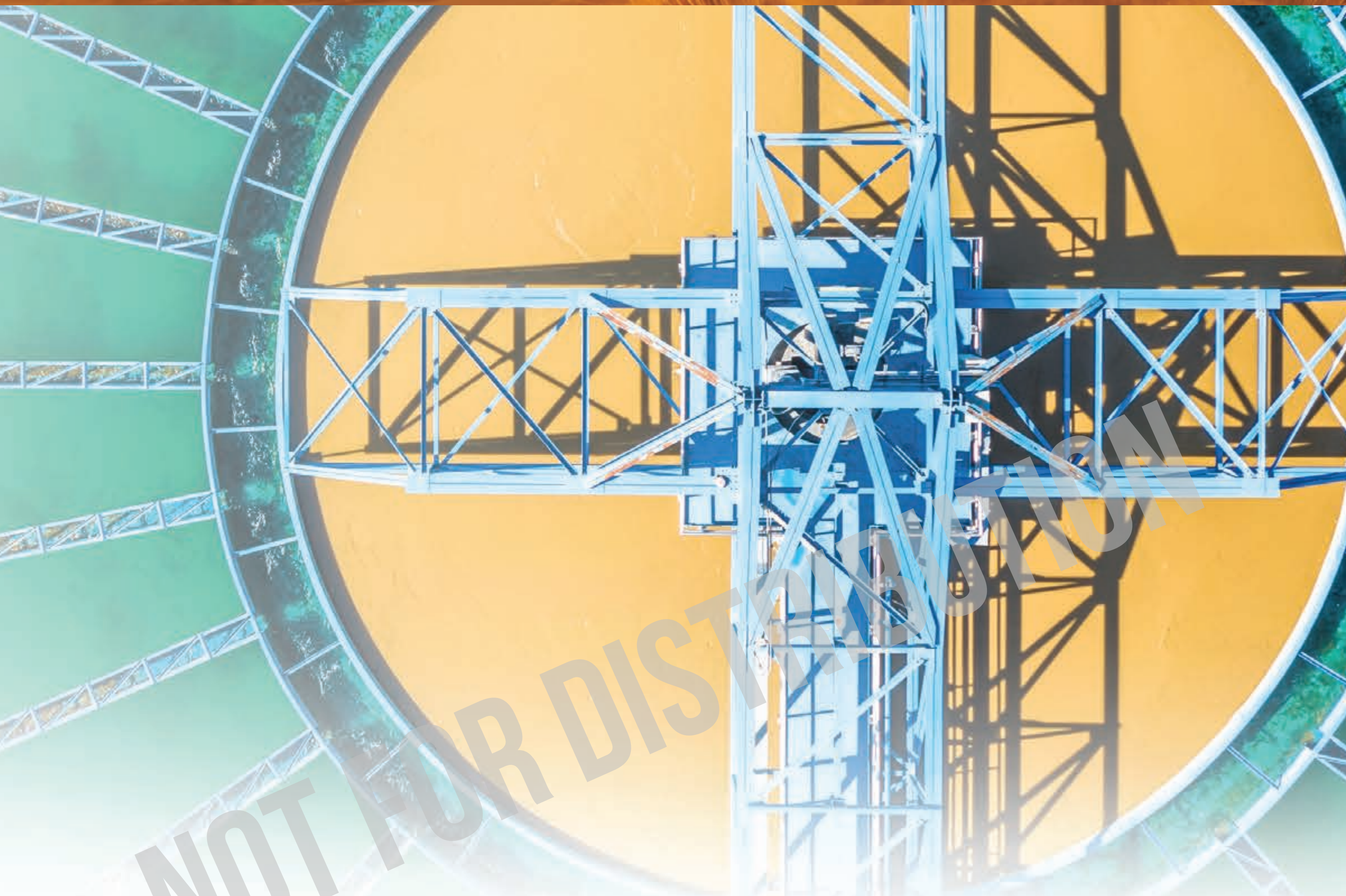
> **Transformation of the traditional linear production-consumption-disposal chains to circular water systems is key to the success**

CUTTING THE SALT

A case study based in Rosignano, Italy builds on the existing Aretusa collaboration which supplies Solvay's Italian chemical production business with about 3m m^3/y reclaimed wastewater for industrial use, primarily for cooling towers. This collaboration has saved about 40m m^3 of water for drinking purposes since supply began.

The Aretusa plant is for tertiary treatment and receives water that has been through conventional wastewater plants in Cecina and Rosignano. Under *Ultimate*, the Italian project aims to maximise recovery by solving the issue of high salinity flux which hinders reuse at Solvay. This can result from seawater and other salty water intrusion into the sewer system enroute to Aretusa.

Study leader Francesco Fatone explained that the standards for the salinity of wastewater that can be reused at Solvay are high (EC<2,000 µS/cm). Fatone is also Professor of Chemical and Environmental Engineering at Università Politecnica delle Marche, Italy, a partner in the study. He said that though high salinity can be treated using reverse osmosis to achieve the quality required,



this would increase energy consumption and produce brine. This makes it economically and environmentally unsustainable.

Fatone said the study team aims to develop a smart equalisation system. This would involve monitoring salinity in the sewer collection system to understand at source the areas leading to high salinity in the wastewater, and to try to separate high salinity flux from lower salinity flux. Smart equalisation would allow high salinity flux to be discharged into the sea or local river, while lower salinity flux is kept for treatment at Aretusa.

A digital platform would provide this data to allow smart equalisation to be operated, and to allow real-time monitoring of water quality. Fatone said currently, monitoring relies on sampling and analysis, and there is no digital solution to support water reuse. The project is working to develop such a platform. Fatone said that "ideally, [there] will be this digital twin...and this digital twin will include the control system of the smart equalisation."

Towards this the team has so far installed sensors in the sewer system and validated the models that will provide data for the digital twin of the sewer system and the smart equalisation. Control logics for smart equalisation have also been developed.

The understanding on final water quality offered by data collection could aid a matchmaking platform to further reclaimed water use, that would allow the quality of water leaving Aretusa to be matched with an intended use. While industry would be prioritised, the platform could enable other sectors such as agriculture, to benefit from reclaimed water that is not needed by industry, or which does not meet the standards for use within industry. Fatone highlights that water quality required for industrial reuse is sometimes higher than for other uses, such as irrigation.

Another aspect of the study is looking at the potential to reuse byproducts from local industry or products that do not meet required specification – including hydrochar resulting from treatment of sewage sludge – in water treatment. Hydrochar and biochar can be activated chemically or thermally to act as an alternative to activated carbon, which is

used in wastewater treatment to reduce chemical oxygen demand (COD, ie organic matter). The team is investigating the sustainability of the activation process for the alternative compared to conventional carbon.

The alternative will be tested in a 10 m^3/h pilot plant adsorption system that is operable and is now being tested with conventional activated carbon to establish a baseline. A current challenge facing the study is finding a plant capable of industrial-scale activation of hydrochar.

> **Circular solutions introduce additional complexity such as variable quality and quantity of the water streams and reco very, reuse of energy, valuable nutrients and materials**

GREENER GREENHOUSES

In the Netherlands, a project is focused on improving water efficiency in horticulture. The Netherlands is one of the world's largest exporters of fresh vegetables, cut flowers, and ornamental plants.

Joep van den Broeke said that while the Dutch greenhouse sector is already a world leader in water efficiency, increasing pressures stimulate the need for reuse, including "ever strict legislation concerning emission of pesticides and nutrients through wastewater". Additionally, water supply is under pressure as the rainwater and desalinated groundwater the sector relies on are being threated by climate change and rising sea levels.

"Closing the cycle through reuse is…considered essential for the continued existence of the horticulture industry", said van den Broeke. He leads the Netherlands study and is a Senior Researcher and Project Manager at KWR.

Towards closing the loop, a study focus is using selective electrodialysis to remove sodium and retain nutrients beneficial to plants in reclaimed water. Van den Broeke said electrodialysis is "a membrane-based process involving transport of ions through semipermeable membranes using an applied electric field…The application of current causes the ions to move from the feed into the brine". While it is a mature technology and is used for desalination in various applications, selective electrodialysis required for the described application is still under development.

The study is using commercially-available monovalent-ion-selective membranes to try to achieve rejection of sodium, while keeping nitrogen (primarily nitrate), phosphorus (primarily phosphate) and potassium within the water stream. The process first has to be validated at lab scale and will later be tested in a 40 m^3/h pilot that is currently under construction.

Electrodialysis would be combined with treatment steps already present at the pilot site, as well as steps that will be installed, such as UV disinfection to remove pathogens.

The study is also investigating combining a geothermal plant with high-temperature aquifer thermal energy storage (HT-ATES) to supply energy. Van den Broeke explained that in such a system, groundwater in an aquifer is pumped from one well and its temperature is increased using a heat exchanger and residual heat from the geothermal plant. The water is stored in a second well. In winter, the stored heat energy is recovered by reversing the process. Hot water from the second well is pumped up and heat is extracted with the heat exchanger and supplied to the greenhouses.

Under *Ultimate*, the Netherlands team will undertake a feasibility study which will include all preparatory work required to make an investment decision.

SYMBOLISING SUCCESS

Van den Berg said: "The success of *Ultimate* will be symbolised by the transformation from linear to circular systems contributing to a more competitive industry, building on cross synergies with water service providers. This requires, though, upscaling of *Ultimate* pilots to full-scale applications and transfer of practical experiences and expertise to different industries and regions, in and beyond Europe, while systematically addressing technological, digital, socio-economic, governance and business systems interdependencies. Key to the success of *Ultimate* is the cooperation between researchers, engineers, and customers."

Acknowledging that regulatory frameworks may present barriers for industries to explore and invest in new technologies, van den Berg also noted that the project is being carried out in close connection with policymakers. This is "to ensure that the latest insights and experiences may be included in new policy and guidance documents".

Van den Broeke highlighted the role of chemical and process engineers.

He said: "The successful upscaling of *Ultimate* circular technologies requires a change from linear to circular thinking by engineers and customers. Circular solutions introduce additional complexity such as variable quality and quantity of the water streams and recovery, reuse of energy, valuable nutrients and materials. This requires innovations from process and chemical engineers involved in design and transfer of industrial symbiotic systems." ■