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R&D+i

Innovation to take care of the planet

2024 ACTIVITY REPORT

Index

Innovation to take care of the planet

The water sector is facing an imminent tightening of legal requirements, with the approval of the revision of the European Wastewater Treatment Directive (5 November 2024), the new European Regulation on Water Reuse 2020/741 and its transposition through the Royal Decree 1085/2024 (22 October), and the Drinking Water Directive (EU) 2020/2184, which came into force on 12 January 2023.

Considering this demanding **regulatory scenario,** innovation is essential to ensure the sustainability of facilities and services throughout the end-to-end water cycle. To meet the new requirements and address climate, technological, digital, and social challenges, Aqualia's open innovation is a key driver that engages both internal staff and external stakeholders.

At Aqualia, we have long acknowledged the importance of innovation in addressing the main challenges of our time and we have internalised this throughout the organisation. Our Innovation and Technology Department (ITD) works—in collaboration with others both inside and outside the company—to spot opportunities, develop innovative solutions, and implement and transfer knowledge.

The transfer of R&D+i knowledge from Aqualia to production is also an essential part of our sustainability strategy. To this end, the Innovation and Technology Department works alongside production and engineering teams in adapting plants and implementing alternative solutions for water sourcing, as well as for eco-efficiency and smart water management throughout the end-to-end water cycle.

6,260,473 €
investment in R&D

3
new R&D projects initiated in 2024, including the development of innovative solutions to care for the planet[1]

6
new R&D processes applied at facilities managed by the company[2]

23
projects undertaken by the Innovation and Technology Department (ITD)

48
universities and
29
resarch centres we collaborate with

24
active patents

[1] The new R&D+i projects initiated in 2024, which include the development of innovative solutions for combating climate change, correspond to the LIFE Salteau projects in Denia and Tenerife, IDIWater in the Canary Islands, and HE United Circles in Salamanca.

[2] The new implementations of R&D+i processes applied in company-managed facilities correspond to AnMBR + ELAN, ANPHORA®, ELSAR®, Advanced Thickener Control (I4U), Aquavite® Recovery, and tertiary reuse with UF + RO membranes.

R&D+i Strategy: innovation and cooperation in the face of challenges

Our R&D+i strategy focuses on identifying opportunities and developing and implementing innovative solutions to address the environmental, social, technological, and legislative challenges associated with the management of the end-to-end water cycle. Internal and external collaboration is key to the effective transfer of knowledge that drives innovation at Aqualia and its contribution to sustainable development.

This vision is built around two pillars that are deployed throughout the end-to-end water cycle: **eco-efficiency** and **sustainability.**

ECO-EFFICIENCY

Following the principles of the circular economy with efficient management of natural resources and the recovery of raw materials.

Objectives

- Develop advanced technologies that optimise the use of renewable resources.
- Avoiding the generation of waste in the company's processes and services.
- Search for solutions that allow growth in all water markets in accordance with eco-efficiency requirements.

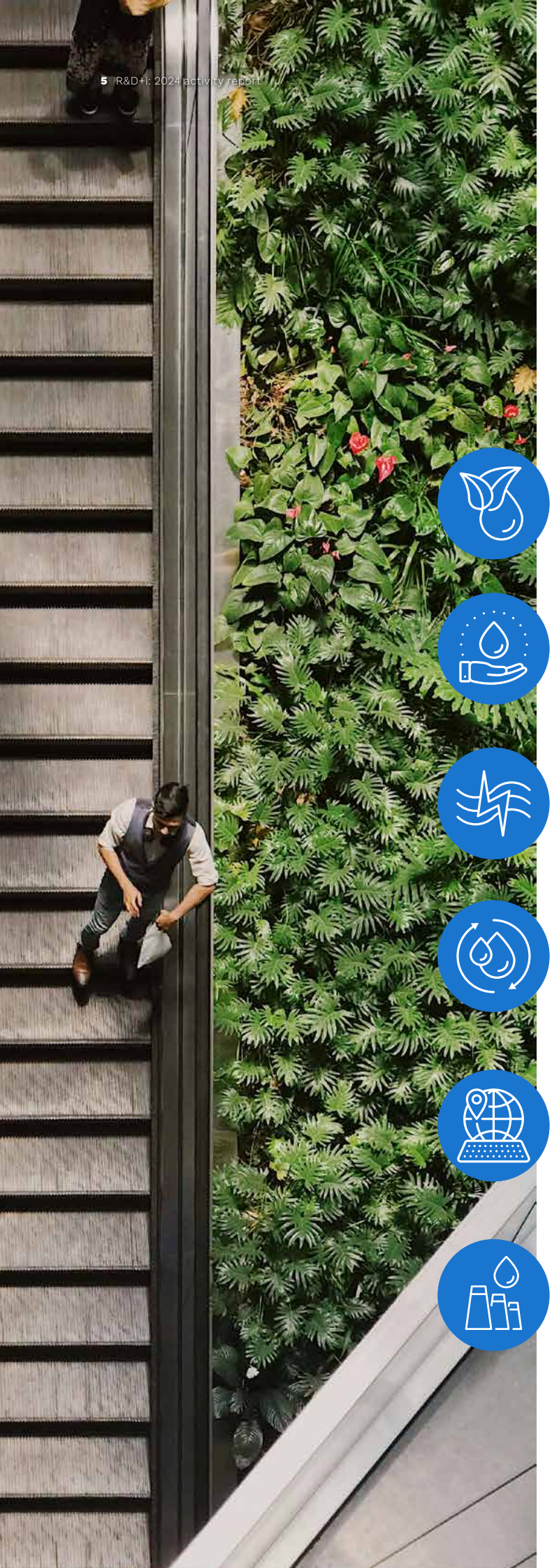
SUSTAINABILITY

Minimising energy consumption, avoiding pollution in an just social environment and protecting the climate and nature.

Objectives

- Development of cutting-edge technologies that promote the sustainability of the company whilst protecting the environment and biodiversity.
- Improved energy efficiency in the company's solutions and services.
- Revaluation of by-products from the end-to-end water cycle.

Aqualia's innovation work lines are supported by the United Nations Sustainable Development Goals (SDGs), where particular emphasis is placed on affordable and high-quality water supply and sanitation services (SDG 6), optimised energy balance (SDG 7), as well as responsible production and consumption (SDG 12) without affecting the climate (SDG 13).



Lines of work

Following European policies as a roadmap, we work and develop solutions across six areas of action with multiple projects.

Sustainable water treatment

These solutions based on nature offer low-cost options with excellent performance in line with European regulations on treatment of urban wastewater.

Alternative resources: Reuse, water treatment and desalination

Faced with the problem of water stress, purification and reuse of wastewater adapted to the size of the population and the water quality required by regulations.

Sustainability and energy efficiency

Harnessing wastewater as an energy source and exploring other renewable alterntives, such as transformation of organic matter into bioenergy (biomethane, hydrogen) in WWTPs.

Circular economy, eco and bio-factories

Solutions for the use of waste and transformation of WWTPs into eco and bio-factories that minimise consumption of energy and reagents, reduce waste production, and generate new products.

Digital developments

Advanced technology to improve water cycle management: Internet of Things, interconnection of multiple sensors, data analysis, AI. This combination of elements allows for early problem detection, rapid response, and process optimisation.

Industrial water

Industrial activity must be increasingly sustainable: we provide solutions so that our industrial clients can adapt the use of water in their processes and optimise the treatment of their effluents.

Sustainable water treatment

The updated version of the **Urban Wastewater Treatment Directive (UWWTD)** extends the wastewater obligation to towns and villages with more than 1,000 inhabitants and requires integrated storm water management. It also lowers the discharge limits, increases nutrient recovery, and sets its sights on achieving a neutral energy balance by 2040. In tandem, it requires higher quality sludge for subsequent reuse, addressing the removal of microcontaminants and microplastics.

Conventional solutions fall short of these expectations, and in small plants, conventional technologies such as extended aeration require costly investment and maintenance. Conversely, nature-based solutions (mainly lagoons and peat filters) offer low-cost options that demonstrate strong performance. At larger plants, the solutions are also based on aerobic technologies, which consume energy and produce worthless sludge, whereas there are alternatives that reduce the size, improve efficiency, and minimise energy consumption and waste production through the concept of extended producer responsibility (EPR).

Along these lines, we have been working to adapt our treatment technologies to plant scale to minimise energy consumption and waste production. In this way, we are helping to improve aerobic and anaerobic treatment and reduce sludge production by recovering nutrients to obtain valuable resources, such as fertilisers.

KEY ACTIONS IN 2024

INTEXT HUB

Project for the treatment of wastewater in small population centers

Challenge: Addressing the challenges of sustainable treatment in small towns and villages.

At the **INTEXT Hub,** the issue of wastewater treatment in small population centers, which sometimes lack adequate facilities, is tackled in a direct and innovative addressed. The INTEXT platform assists in decision-making regarding wastewater treatment systems for both small municipalities with no pre-treatment system and those requiring improvement of existing systems.

The approach focuses on developing enhanced or intensified extensive solutions and/or combining extensive and intensive technologies. The core objectives of INTEX are:

- Reduction of maintenance and investment costs for solutions in small urban agglomerations.

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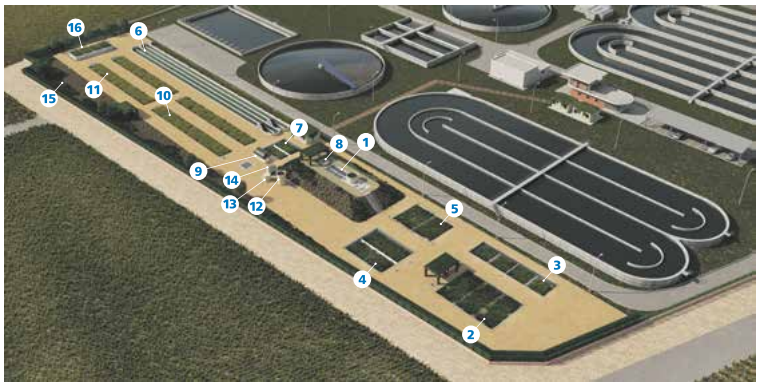
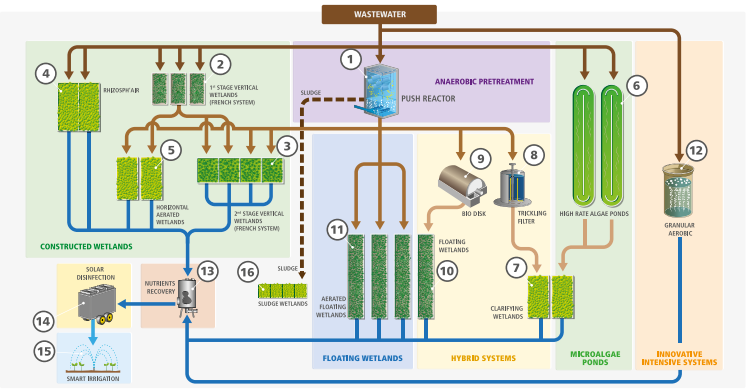
INTEXT

Tecnologías innovadoras híbridas Intensivas-Extensivas para la recuperación de recursos de las aguas residuales en pequeñas poblaciones

Innovative hybrid INTensive-EXTensive technologies for resource recovery from wastewater in small communities



Planta demostrativa continental
Continental demo site



1 Reactor PUSH / PUSH reactor

Sistema francés / French system:

2 Humedales verticales 1ª etapa / 1st stage vertical wetlands

3 Humedales verticales 2ª etapa / 2nd stage vertical wetlands

4 Rhizosph'air

5 Humedales horizontales aireados / Horizontal aerated wetlads

6 Lagunas microalgas / Microalgae ponds (HRAPs)

7 Humedales clarificadores / Clarifying wetlands

8 Filtro percolador / Trickling filter

9 Biodisco / Biodisk (RBC)

10 Humedales flotantes / Floating wetlands

11 Humedales flotantes aireados / Aerated floating wetlands

12 Aerobio granular / Granular aerobic

13 Recuperación de nutrientes / Nutrients recovery

14 Desinfección solar / Solar disinfection

15 Riego inteligente / Smart irrigation

16 Humedales fangos / Sludge wetlands

Con la contribución del Instrumento Financiero LIFE de la Unión Europea LIFE19 ENV/ES/001233
With the contribution of the LIFE financial instrument of the European Union
LIFE19 ENV/ES/001233

Coordinador / Coordinator: aqualia

aimen TECHNOLOGY CENTRE · AUTARCON · AARHUS UNIVERSITY · FUNDACIÓN PÚBLICA ANDALUZA CENTRO DE I+D+i EN TECNOLOGÍAS DEL AGUA · FIN Future Intelligence TELVENT INTERNATIONAL COMPANY · projar Group · SYNTEA

Con la colaboración de / Hosted by: Excmo. Ayuntamiento de Talavera de la Reina

- Reduction of the area required per equivalent inhabitant (EI) (<1m²/EI).
- Improvement of effluent quality, especially nutrient removal (nitrogen and phosphorus).
- Disinfection and reuse of water for small populations.
- Development of a decision support system (DSS) for the correct solution of the INTEXT Hub implemented at the Talavera de la Reina WWTP, which features 16 innovative hybrid wastewater treatment technologies for small populations. The following treatment trains are included:

  . Upflow anaerobic sludge blanket (UASB) pretreatment with PUSH® pulsed feeding.

  . Vertical constructed wetlands for the treatment of raw wastewater, pretreated water, sludge treatment, or secondary effluent clarification.

  . Horizontal constructed wetlands with forced aeration.

  . Microalgae lagoons.

  . Biofilm systems (trickling filter, biofilter).

  . Floating wetlands.

  . Granular aerobic system.

  . Nutrient recovery systems, solar disinfection, smart irrigation.

The INTEXT platform provides support to users who need to make decisions regarding the technological selection of wastewater treatment systems for both small populations without prior treatment and those requiring improvement of existing systems. The following parameters are incorporated into the DSS tool in a straightforward manner to assist users in decision-making:

- Available area
- Inflow rate / Pollutant load
- Flow and load variations
- Climate
- CapEx vs OpEx
- Water reuse
- Discharge limits (nitrogen, phosphorus in sensitive areas)

Alternative resources: reuse, water treatment and desalination

In the current scenario of water stress, the use of non-conventional water sources is essential. Regulation (EU) 2020/741 on the reuse of wastewater ensures the same levels of quality and risk control for reclaimed water across all EU countries. In Spain, Royal Decree 1085/2024 on water reuse establishes a new legal regime governing the use of reclaimed water. As regards drinking water, Directive (EU) 2020/2184 and Royal Decree 3/2023 in Spain set the technical and health criteria due to increasing concerns over public health and the threat of emerging contaminants. They call for a modernisation of much of the drinking water treatment processes in Europe to address new limits on endocrine disruptors, pharmaceuticals, and microplastics.

These new regulations require the development of innovative wastewater treatment and water reclamation solutions. For each objective, we provide customized solutions, so we can achieve sustainability from every angle: technical, economic, environmental, and social.

The new standards prioritize the **measurement and removal of emerging contaminants and microplastics,** as well as the development of risk management strategies and diagnostic tools. These tools will ultimately allow us to pick an optimal mix of technologies for each situation, while also assessing the feasibility of upgrading existing plants to meet the new requirements.

Along with reuse, **desalination** also helps to secure the world's water resources. More than 1,700 plants are up and running in Europe, with a nominal flow of 3,400 Mm^3/year, and an estimated overall annual growth rate of around 7 % since 2010. A key factor is clearly the optimisation of these processes, following the introduction of new materials and membranes to increase their performance and reduce energy consumption.

Aerial view of REUSA Hub.

KEY ACTIONS IN 2024

REUSA HUB

Platform for advanced urban wastewater regeneration and reuse

From right to left, ballasted clarification (CLARIFAST) and dissolved air and/or ozone flotation (DAFAST).

Challenge: Working on advanced urban wastewater regeneration and reuse.

Within the framework of the new legal requirements, the **REUSA Hub** targets advanced urban wastewater reclamation and reuse. It is a demonstration-scale platform located at the El Toyo WWTP (Almería, Spain), where the European projects **Life Phoenix and H2020 Rewaise** are currently being developed.

The REUSA platform was initially created with the ambition to develop innovative and sustainable solutions at a semi-industrial scale to produce reuse-quality water for agriculture, in accordance with the new requirements of RD 741/2020. Today, this objective has been surpassed, having validated all its technologies and their combinations to produce Class A agricultural irrigation water, the most restrictive of the regulation.

The REUSA Hub has gone even further, achieving the production of water of adequate quality for other uses contemplated in RD 1085/2024: urban, industrial, livestock, or sports. Additionally, different combinations of advanced oxidation processes have been developed to eliminate emerging contaminants and microplastics, future quaternary treatments contemplated in the draft European Urban Wastewater Treatment Directive.

The **main objectives** pursued by the REUSA platform are:

- Develop innovative urban wastewater regeneration solutions for small, medium, and large treatment plants, adjusting solutions to each specific case, based on population size, water quality, and economic capacity. Tailored solutions are developed for each population size to achieve total sustainability, which translates into technical, economic, and environmental viability.
- Low-cost solutions to ensure reuse, especially in the agricultural sector, where price plays a crucial role in acceptance.
- Quantify and eliminate emerging contaminants through advanced oxidation processes. The REUSA platform, therefore, includes quaternary treatments, which are again ahead of the new treatment directive currently under negotiation.
- Quantify and eliminate microplastics through advanced filtration processes.
- Diagnose existing tertiary systems in the Spanish province of Almería for optimisation, to meet new quality requirements for agricultural use, and assess the feasibility of upgrading existing plants to meet new requirements.

From right to left, skid of continuous and semi-continuous wash filters; and disinfection container with UV, O_3, and H_2O_2.

- Develop a diagnostic tool that will allow for the selection of the best combination of technologies for each case, also mapping the tertiary treatments of existing treatment plants both nationally and internationally.

The REUSA Hub platform features **16 innovative technologies**—six of which happen to be developments from our Innovation and Technology Deparment— running on a semi-industrial scale, with a treatment capacity ranging from 10 to 50 m^3/h, and which can be applied at various types of WWTPs. These technologies pre-treat water before it undergoes secondary treatment, with the aim of maximising the quality of water. This improvement significantly reduces the amount of disinfectant required during later stages of the process. This is important because the disinfection dose is a key factor in meeting the relevant water quality standards.

Among these technologies, most are in the patent phase or already patented, such as:

- Ballasted clarification with particulate activated carbon (CLARIFAST), equipment in patent protection phase.
- Dissolved air and/or ozone flotation (DAFAST), equipment in patent protection phase.
- Continuous wash filter (PURASAND HR), European patent EP4344761.
- Double-stage continuous wash filter (PURASER).
- Semi-continuous wash filter with biologically activated carbon (PURABAC).
- Fresnel solar concentrator, equipment in patent protection phase.
- Microalgae reactor combined with clarifying wetlands, as a solution for small populations.

Sustainability and energy efficiency

The UWWTD, in its latest version, sets out to achieve energy neutrality for WWTPs with an installed capacity of over 10,000 h-eq. It also proposes raising the contribution made by renewable sources to 100 % by 2040. In the end-to-end water cycle in its current state, the electricity used by pumping technology for the abstraction, supply and distribution of urban water stands at 0.5 kWh/m^3, very similar to the average specific consumption of WWTPs of 0.5 kWh/m^3, which together account for 2 % of Spain's annual consumption.

In our efforts to innovate, wastewater itself serves as an energy source capable of supplying the purification process, while also generating an energy surplus. We are making significant progress in developing technological alternatives such as anaerobic treatments and maximising the transformation of organic matter into bioenergy (biomethane and/or hydrogen). At the same time, we also busy optimising equipment and plant operation control through digital technologies. We are making renewable energies —such as solar and wind power— part of the process of maximising the production and use of energy at WWTPs.

We are also targeting energy recovery in waterfalls as part of the end-to-end water cycle and active pressure control.

Aerial view of the Linares (Jaén) WWTP and distribution of the incorporated innovative panels:
1) 8 vertical curved plates in settling tanks.
2) 8 conventional fixed plates.
3) 341 conventional fixed plates.
4) 200 retractable plates.

KEY ACTIONS IN 2024

PHOTOVOLTAIC AND WIND ENERGY INNOVATION

Installation of innovative solutions for obtaining photovoltaic and wind energy at the Linares WWTP

Challenge: Efficient storage solutions to ensure a constant energy supply.

Within the framework of our ambitious renewable energy plan, in 2024 we validated several new renewable electricity production solutions by adding innovative solar panels to our existing facilities at the Linares WWTP (Jaén, Spain). These panels allow us to increase daily production during those hours of the day that experience the most sunshine, especially in months with lower irradiation.

One of the main challenges is the intermittency of these sources: for example, solar energy is only available during the day, and wind energy depends on wind speed. The storage of electricity generated from renewable sources presents both significant challenges and promising opportunities. Additionally, current storage capacity is limited and often costly, highlighting the need for technological innovations and economies of scale to make them more accessible.

On the other hand, there are notable opportunities around storage solutions, such as batteries, which can revolutionise how we manage energy to improve efficiency and reduce costs. In the long term, the storage of electricity from renewable sources is key to a successful transition towards a cleaner, more sustainable energy system.

Beyond this action, we have developed a pilot experience at another WWTP located in Spain—in this case, Badajoz—to explore electric storage solutions through batteries promising greater energy efficiency and lower cost.

In this pilot experience implemented at this WWTP, the following conclusions have been reached regarding battery storage:

- **It allows for the shifting of energy** from one period to another, offering greater direct economic returns.
- **It enables adaptation to regulatory changes** that will require energy storage systems.
- **It allows for the adaptation of each integrated** water cycle WWTP's needs and the management of installation surpluses in future remunerated auxiliary services.
- By balancing installed power and the storage system, **economic performance, self-sufficiency, and savings in installations are optimised.**

Circular economy, eco and bio-factories

The **European Circular Economy Action Plan (EU CEAP)** champions the efficiency of industrial processes and the use of resources to avoid waste. Meanwhile, a new European law on critical and strategic raw materials is on the drawing board which will feature a zero-pollution action plan for air, water, and soil.

According to the National Sludge Register, around five million tonnes of sewage sludge are produced annually in Spain (assuming a dryness of 20 %), most of which ends up being used in agriculture (around 80 %), while the remainder ends up in landfill or is incinerated (roughly 4 %). The UWWTD directive requires sludge to be treated, recycled, and recovered in accordance with the hierarchy set out in the Waste Framework Directive.

The EU is set to establish a minimum recovery rate for phosphorus and advocates for the reuse of nutrients, including the revaluation of biosolids and their compounds with agronomic value (organic matter, nitrogen, phosphorus, potassium, calcium, magnesium, and other micronutrients) in agriculture. Aqualia has been working with the University of Santiago de Compostela since 2014 to precipitate phosphorus present in the runoff from the dewatering centrifuges and recover the struvite crystals. As a result, in 2024, we achieved **European Patent EP3112320A1** (Method and system for the crystallisation of struvite for recovering phosphates in wastewater).

The first industrial-scale struvite reactor was built at the Guillarei WWTP in Spain, and in recent years another plant was commissioned —also in Spain—at the Guadalete WWTP, to supply a fertiliser, Aquavite®, to Fertiberia factories.

Many innovation projects seek to develop alternative solutions to conventional WWTPs to transform them into bio- or eco-factories, minimising energy and reagent consumption and avoiding waste production. It also happens to be a way of creating opportunities to generate bioproducts through resource recovery: biofertilisers, biostimulants, biopesticides, biochar, vegetable charcoal, ectoine, or unicellular protein, among others.

Additionally, sludge management at WWTPs addresses hygienisation and stabilisation treatments, its material and energy recovery, along with its biomethanisation and co-digestion.

Sludge drying using a solar system.

KEY ACTIONS IN 2024

END-TO-END WATER CYCLE INNOVATION CENTRE AT THE SALAMANCA WWTP

Coordinates national and international activities to develop innovative solutions

On the left, sludge dried using a solar system. On the right, End-to-end Water Cycle Innovation Centre at the Salamanca WWTP.

Challenge: In 2024, the End-to-end Water Cycle Innovation Centre, located at the WWTP in the Spanish city of Salamanca, celebrated its first anniversary. This centre is developing innovative solutions to address the current and future challenges of a sustainable end-to-end water cycle, deliver quality drinking water, and provide a decarbonised wastewater management system to unlock the true value of water. The centre also oversees national and international activities.

During 2024, several activities were carried out, including:

- Water treatment and supply management **for human consumption** include monitoring and reservoir management, such as those implemented at the Fuentesclaras reservoir (Ávila, Spain). Regarding the potabilisation process, it is worth mentioning the tests carried out with advanced sensors to continuously measure and record chlorine concentrations at the Salamanca DWTP. In terms of distribution and leak detection, it is noteworthy that the city of Salamanca was a pioneer in intelligent network management with the active pressure management system that was launched a few years ago.

- **Sanitation and treatment** to increase process efficiency and reduce energy consumption at WWTPs. One of the work lines with the most progress in 2024 is the recovery of treatment sludge. These actions include:

. Co-digestion: Joint digestion of sludge generated at the facilities with other biowaste from local industries, allowing for biogas production.

. Stabilisation and hygienisation of sludge for its use as agricultural amendment and recovery of degraded soils.

. Cleaning and enrichment of biogas. The new processes implemented at a demonstration scale have allowed progress in obtaining high-quality biomethane, including the most restrictive standards for its injection into the grid.

. Dry phase digestion for medium-sized urban agglomerations. The department has developed the first anaerobic reactor with high solids concentration. Technology to provide solutions to the vast majority of WWTPs managed by Aqualia (medium-sized extended aeration).

. Solar sludge drying at the Bohumin WWTP, in collaboration with SmVaK in the Czech Republic, which increases dryness from 25 % to 91 %, significantly improving microbiological quality for subsequent use. This plant began its journey in Chiclana de la Frontera in 2012, where the solar dryer was optimised by coupling solar collectors, which had the function of air heating. This allows for greater system efficiency by significantly increasing the temperature inside the solar dryer.

Digital developments

Cutting-edge tools have revolutionised the management of the water cycle and energy consumption by optimising processes through technologies such as the Internet of Things (IoT), which can be used to connect up multiple sensors. Meanwhile, data analysis and artificial intelligence monitor water and energy systems in realtime, enabling the early detection of problems and ensuring a quick and efficient response.

Decision support systems (DSS) are crucial in this context, as they are able to integrate data from various sources and use advanced algorithms to provide accurate recommendations. In water management, these systems are able to forecast future demand, optimise distribution, and ensure that resources are used efficiently. When it comes to energy consumption, DSS is able to identify usage patterns, suggest cost-saving measures, and manage the load more effectively, thus reducing consumption and related costs.

At Aqualia, we design our own systems, which incorporate the knowledge of thousands of professionals, thus providing value and branding and setting ourselves apart from the competition, as an added value in the service we provide to all the municipalities in which we operate.

KEY ACTIONS IN 2024

LIFE RESEAU

Development of proprietary granular technology to treat water volumes in a smaller space, implemented at the Moaña WWTP

Challenge: Develop sustainable treatment solutions.

The Innovation and Technology Department (ITD) has been working for around ten years on the development of its granular water line. Aerobic granules are clusters of microorganisms that have a significantly higher sedimentation capacity than flocs in AS systems (speeds of > 8.0 m/h compared to 0.5 – 1.0 m/h). Being a compact technology, it can treat certain water volumes using less space.

- The stratification of different microbial populations within the granule allows biological processes to occur simultaneously (organic matter removal, nitrification, denitrification, and phosphorus assimilation), something that in conventional systems is done in different reactor zones or at different times in the same reactor.
- Increase in both the plant's treatment capacity and energy savings, as these clusters of microorganisms can treat larger flows in shorter periods.
- The excellent sedimentation capacity of the granules eliminates the need for sedimentation tanks, saving a process step and economising land use, as well as saving on pumping and recirculation. Thus, it is estimated that a plant based on granular biomass requires 75 % less surface area and has 30 % lower energy requirements compared to a conventional AS process, achieving equal or superior effluent quality.

These advantages make this technology attractive for the construction of new sewage treatment plants, as it requires less extension than conventional technology and also reduces civil engineering costs. It is also a useful option for plants already in operation that need to increase their

treatment capacity (higher volumes or more stringent requirements for organic matter or nutrient removal, as indeed required under the new Wastewater Directive), making small adaptations to already built reactors.

Within the wider framework of the **LIFE RESEAU** innovation project, we designed, built, and started up two 450 m^3 reactors at the Moaña WWTP (Pontevedra, Spain), in which the treatment capacity per reactor Surface area was increased by 400 % to reach 2,000 m^3/d of wastewater.

Additionally, as part of the **REWAISE** and **RESEAU** projects, the following work lines have been developed within the framework of digitalisation in Moaña:

- Assessment of the network's digitalisation status (GIS), determination of catchment areas, and identification of critical monitoring points.
- Development of models (e.g., in SWMM) to evaluate network dynamics, both in dry weather and precipitation scenarios.
- Installation of appropriate sensors at strategic points for monitoring flows, levels, relief points, and wastewater quality parameters. Additionally, they will serve for model calibration and prediction of derived parameters not available in real-time.
- Integration of data into SCADA supervision platforms.
- Control of flows and quantification of the resistance and response capacity of sanitation networks using models, understanding network dynamics to detect infiltration and/or relief areas that may cause flooding.
- Integration into an intelligent network of machine learning/artificial intelligence models based on information collected in previous phases to allow predictions of flow and water quality in the network, the number of reliefs and their impact on receiving environments, as well as assisting in decision-making for WWTP operation.

IT developments have also been applied to water abstraction processes to prevent algae blooms as well as in potabilization trihalomethanes (THM) removal and reagent dosing optimisation. In desalination, algorithms have been used to optimise the electrical consumption of desalination plants in national and international facilities. Similarly, numerical optimisation methods and mathematical modelling have been applied to minimise the energy consumption of the sewer system or aeration processes in wastewater treatment.

Granular reactors of the LIFE RESEAU project at the Moaña WWTP.

Industrial water

Water plays a key role in industry and at Aqualia we work hard to ensure that our industrial clients achieve their sustainability and innovation objectives and improve to adapt both process water and effluents to prevailing regulations. To make this happen, we have developed solutions aimed at optimising the treatment of industrial wastewater in the agri-food, mining, and chemical sectors to achieve reuse and reduce the water footprint.

- Along these lines, we have been working towards various technologies, including: Anaerobic membrane reactors, which have been undergoing tests since 2014 at the Ecoparc in Barcelona, at the Citroën factory in Vigo, and currently for treating pig slurry in Xinzo de Limia.
- The advanced upflow reactor featuring the patented PUSH® technology.
- The ELAN® reactor, with has several references in the industrial sector, notably its industrial-scale implementation at the Heineken plant in Seville.

A byproduct generated in many industries is brine, which is also abundant in seawater desalination. These effluents, resulting from mineral separation, must be managed appropriately. With this in mind, we are looking to use them as a source of critical and strategic raw materials for separating critical minerals such as magnesium.

KEY ACTIONS IN 2024

ELSAR® TECHNOLOGY AT THE MAHOU SAN MIGUEL BREWERY IN LLEIDA

Bioelectrostimulated reactor that optimises the treatment process and allows for the extraction of energy and resources from industrial wastewater

Challenge: Minimise water consumption and maximise the utilisation of wastewater streams to obtain energy and resources.

At the Lleida factory belonging to the Mahou San Miguel brewery group, we set up the world's largest bioelectrostimulated reactor to treat its industrial wastewater. This technology, developed and patented by Aqualia in partnership with the University of Alcalá, has been christened ELSAR® and offers significant

advantages over other systems on the market: aside from the outstanding quality of the water it treats, it also manages to increase the production of bioenergy (biomethane and hydrogen) while achieving energy savings, flexibility, and stability.

The ELSAR® system is designed to meet the needs of 80 % of the food and beverage factories operating within the country. It achieves high levels of circularity when managing industrial water associated with the manufacturing processes of Mahou San Miguel Group's products and the organic load is used to obtain biofuels. The European ULTIMATE project has supported the latest scale-up of ELSAR®, although the earlier development of technology stems from previous projects such as ADVISOR, ANSWER, and ITACA.

Projects carried out in 2024

Acronym	Name	Start	End	Location	Lines of work					
					Sustainable water treatment	Alternative resources: reuse, water treatment and sustainable desalination	Sustainability and energy efficiency	Circular economy, eco and bio-factories	Industrial waters	Digital developments
BBI B-FERST	Bio-based FERtilising products as the best practice for agricultural management Sustainability	2019	2024	Jerez de Frontera	●			●		
BBI DEEP PURPLE	Conversion of diluted mixed urban bio-wastes into sustainable materials and products in flexible purple photo biorefineries	2019	2024	Linares / Badajoz	●			●		
LIFE INTEXT	Innovative hybrid Intensive Extensive resource recovery from wastewater in small communities	2019	2024	Talavera de la Reina (INTEXT Hub)	●	●				
H2020 SEA4VALUE	Developing radical innovations to recover minerals and metals from seawater desalination brines	2020	2024	Denia (Desalination Innovation Centre) / Adeje (WAVE Centre)		●				
H2020 ULTIMATE	Industry water-utility symbiosis for a Smarter Water Society	2020	2024	Lleida			●		●	
LIFE ZERO WASTE WATER	Positive energy wastewater treatment plant for combined treatment of waste water and bio-waste in small populations	2020	2025	Almería	●		●			
LIFE INFUSION	Intensive treatment of waste effluents and conversion into useful sustainable outputs: biogas, nutrients and water	2020	2025	Gijón	●				●	
MISIONES ECLOSION	New materials, technologies, and processes for the generation, storage, transportation, and integration of renewable hydrogen and biomethane from bio-waste	2021	2025	Salamanca (Innovation Centre for the Integral Water Cycle) / Jerez de la Frontera			●	●		
MISIONES ZEPPELIN	Research into innovative and efficient green hydrogen production and storage technologies based on the circular economy	2021	2025	Algeciras			●	●		
H2020 REWAISE	Resilient Water Innovation for Smart Economy	2020	2025	Moaña / Almería (REUSA Hub) / Denia (Desalination Innovation Centre) / Adeje (WAVE Centre) / Oviedo / Salamanca		●		●		●
LIFE PHOENIX	Innovative cost-effective multibarrier treatments for reusing water for agricultural irrigation	2020	2025	Almería (REUSA Hub)	●	●				
H2020 NICE	Innovative and enhanced nature-based solutions for sustainable urban water cycle	2021	2025	Talavera de la Reina (INTEXT Hub) / Madrid	●	●				
LIFE RESEAU	Resilience enhancement in the urban water sector	2021	2025	Moaña	●					●
UMI AQUATIM	Joint research unit: sustainable future of the circular, efficient, and resilient water cycle	2022	2025	Santiago de Compostela	●		●			●
HE D4RUNOFF	Smart implementation of adaptive hybrid solutions in sewage networks for preventing and managing diffuse pollution from urban water runoff	2022	2026	Santander	●					●
HE CHEERS	Producing novel non-plant biomass feedstocks and bio-based products through upcycling and the cascading use of brewery side-streams	2022	2026	Lleida				●	●	
HE NINFA	Taking action to prevent and mitigate pollution of groundwater bodies	2022	2026	Los Alcázares		●				●
HE RESURGENCE	Industrial water circularity: reuse, resource recovery and energy efficiency for greener digitized processes	2023	2027	Algeciras				●	●	
LIFE SALTEAU	Sustainable drinking and irrigation water production from saline alternative water resources	2024	2028	Denia (Desalination Innovation Centre) / Adeje (WAVE Centre)		●				
INTERREG GESTEAUR	Sustainable and digital water management in rural areas of the SUDOE region	2024	2027	Tiñosillos / Fontiveros / Nogales				●		●
HE CIRSEAU	Building a water smart economy and society	2024	2026	Madrid						●
UNITED CIRCLES	Interconnected efforts from feasibility to finance for industrial-urban symbiosis driven by circularity hubs	2024	2028	Salamanca (Innovation Centre for the Integral Water Cycle)		●		●		
INTERREG IDIWATER	DESAL + LIVING LAB MAC	2024	2026	Adeje (WAVE Centre)		●				

New implementations of R&D processes applied in company-managed facilities

In 2024, six solutions developed by the Innovation and Technology Department (ITD) were applied in facilities managed by Aqualia:

- AnMBR + ELAN
- ANPHORA®
- ELSAR®
- Advanced thickener control (I4U)
- Aquavite® recovery
- Tertiary reuse with UF + RO membranes

Patents

In 2024, our patent families increased and our trademarks experienced further growth for yet another year, as summarized in the attached list.

	Type of protection	Short name	Granted on	Patent no.
1	National patent OEPM	Water distribution and washing system for filter	08/02/2005	ES2196949
	National patent OEPM	Anaerobic batch water purification system	06/05/2009	ES2300164
	National patent OEPM	Carbonation system	04/03/2015	ES2451579
	European patent EPO	Carbonation system	18/11/2015	EP2712917
2	National patent OEPM	Anammox ELAN process	10/09/2014	ES2466090
	European patent EPO	Anammox ELAN process	17/12/2014	EP2740713
	Trademark registration	ELAN®	08/06/2013	11256559
	Trademark registration	ELAN® UK	15/09/2022	UK00911265559
	European patent EPO	AQU-ELAN® (ELAN® in water line)	30/08/2023	EP3255016
	Trademark registration	AQU-ELAN®	19/06/2024	18986044
3	European patent EPO	Optimised Algae-HRAP	06/01/2016	EP2875724
4	European patent EPO	Fluidised bed MFCs	22/04/2020	EP2927196
	Trademark registration	ELSAR®	02/06/2021	18398327
5	European patent EPO	Influent distribution and Mixing Device for UASB Reactors PUSH	05/10/2016	EP3090408
	European patent EPO	PUSH Improvement	15/11/2023	EP4166514
6	European patent EPO	Biogas upgrading	29/03/2017	EP3061515
	International patent PCT	Biogas upgrading USA	27/02/2018	US9, 901, 864 B2
	International patent PCT	Biogas upgrading MEXICO	02/12/2021	388417
	Trademark registration	ABADBioenergy®	22/05/2017	16146151
7	European patent EPO	MDC (Microbial Desalination Cells MIDES)	26/08/2020	EP3336064
	International patent PCT	MDC USA	23/03/2021	US10,954,145
	International patent PCT	MDC MEXICO	02/12/2024	419316
8	European patent EPO	SAnMBR	20/05/2020	EP3225596
	International patent PCT	SAnMBR USA	03/03/2020	US10,577,266 B2
	International patent PCT	SAnMBR MEXICO	21/06/2022	393297
9	European patent EPO	ADVANSIST	10/07/2020	EP3546562
	Trademark registration	ANPHORA®	02/06/2021	18398329
	International patent PCT	ADVANSIST/ANPHORA® USA	03/09/2024	US12,077,737
	International patent PCT	ADVANSIST/ANPHORA® MEXICO	19/07/2024	415126
	International patent PCT	ADVANSIST/ANPHORA® COLOMBIA	27/03/2019	41631
10	European patent EPO	DARE	19/05/2021	EP3527538
11	European patent EPO	STRUVITE CRYSTALLIZATION	17/04/2024	EP3112320
12	European patent EPO	Purasand High Recovery	31/07/2024	EP4344761
13	European patent EPO	WETFAN	27/11/2024	EP4375242

In 2024, two new patents and several trademark registrations were filed for processes, with the new brand identity created for the processes resulting from Aqualia Innovation. Of the patent applications filed in previous years, two are still in the process of evaluation, as shown in the table of patents pending:

	Type of protection	Short name	Application date	Patent no.	Result
1	European patent EPO	Pressure reactor	19/10/2017	EP17382699.1	Under evaluation
2	European patent EPO	Ectoine production	03/03/2023	EP23382198.2	Under evaluation

Awards and accolades received in 2024

"Fernando Calvet Prats" Technology Transfer Award from the Royal Galician Academy of Sciences (RAGC) for the patent filed by Aqualia and the University of Santiago de Compostela (USC) enabling the extraction of struvite from wastewater.

Award for Research from the Social Council of the University of Valladolid under the **'Companies and Institutions'** category, which went to Aqualia and FCC Medio Ambiente for more than 20 years of commitment to research and innovation.

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