Aquaporin Inside®

Increase industrial water sustainability and value wastewater for its potential

Be at the forefront of sustainable water use while reducing CAPEX and OPEX

Many industries are massive water consumers and polluters, often in areas where water is already in short supply. From chemical, semiconductor and automotive producers to the distillery, textile, pharmaceutical and power industries, factories are under increasing pressure from both society and governments, who are demanding more sustainable production.

Stringent regulation on the use and reuse of water in many industries is a growing trend, and some countries have even implemented regulations that require Zero Liquid Discharge (ZLD).

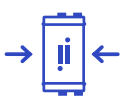
It is a tough balancing act for factory owners to use less water, reuse more water, use less chemicals, recover valuables and minimize liquid waste – all while running a profitable business – especially as tightening regulations typically entail costly investments in complicated cleaning processes and land.

At Aquaporin, we make it possible for factory owners to comply with regulations while also lowering capital and operating expenses. By using Aquaporin Inside® Forward Osmosis membranes in your effluent treatment, you can minimize the steps needed to fulfill treatment and reuse requirements. This will help you:

MINIMIZE YOUR WASTE

REUSE MORE WATER WITH BETTER QUALITY

SIMPLIFY YOUR EFFLUENT TREATMENT



OPTIMIZE YOUR LAND USE

RECOVER VALUABLES

IMPROVE LOGISTICS

Industries across the world are heavily using and polluting water

- Industrial wastewater often has a complex composition, with many toxic chemicals and low biodegradability **requiring a sequence of treatment technologies** (biological and chemical).
- Globally, **80% of wastewater flows back into the ecosystem without being treated or reused**, contributing to approximately 1.8 billion people using drinking water contaminated with feces.
- **Industrial water consumption is responsible for 22% of global water use.** It is expected that in rapidly industrializing countries, this proportion could increase by a factor of five in the next 10-20 years.
- **90% of the approximately 6.2 billion liters of industrial wastewater generated every day across India is untreated when it is discharged.** The Ganga River alone receives around 1.3 billion liters of raw sewage and 250 million liters of industrial effluent daily.

Use forward osmosis to overcome effluent treatment challenges

Aquaporin Inside® Forward Osmosis (FO) enables the efficient extraction of water, removing challenging contaminants, reducing effluent volume and concentrating valuables.

In the textile industry, FO can result in wastewater volumes that are 50 times lower, reaching water recovery up to 98 %. It can also triple dye and salt concentration, retaining them with minimal loss (close to 100 % dye retention). When dewatering high chemical oxygen demand (COD) wastewater, it is possible to achieve high COD rejection and a threefold reduction in Multi Effect Evaporator (MEE) condensate volume (65 % water recovery).

In the semiconductor industry, it is possible to make wastewater volume up to 14 times lower, achieving complete rejection of copper and fluoride and at least 87 % rejection of boron. Moreover, 93 % of the water can be recycled. Within the pharmaceutical industry, FO has been proven to save an absolute minimum of 30 % of the water in vaccine production. These are just some examples of what FO can achieve.

How does forward osmosis work?

FO is a water separation process in which a semipermeable membrane is used to separate water from dissolved solutes. It uses natural energy in the form of osmotic pressure to transport water through the membrane, while retaining the dissolved solutes on the other side. This improves efficiency without increasing energy use.

In FO systems, a solution of lower solute concentration (known as the feed solution) flows on one side of the membrane, while a solution of higher solute concentration (the draw solution) flows on the other side. Osmosis induces water to flow from the feed solution through the membrane and into the draw solution. As the water moves through the membrane, the draw solution becomes diluted and the feed solution is concentrated (Figure 1).

The FO process can run without additional hydraulic pressure. The draw solution can consist of a simple salt/water mix or a substance specifically tailored for the application.

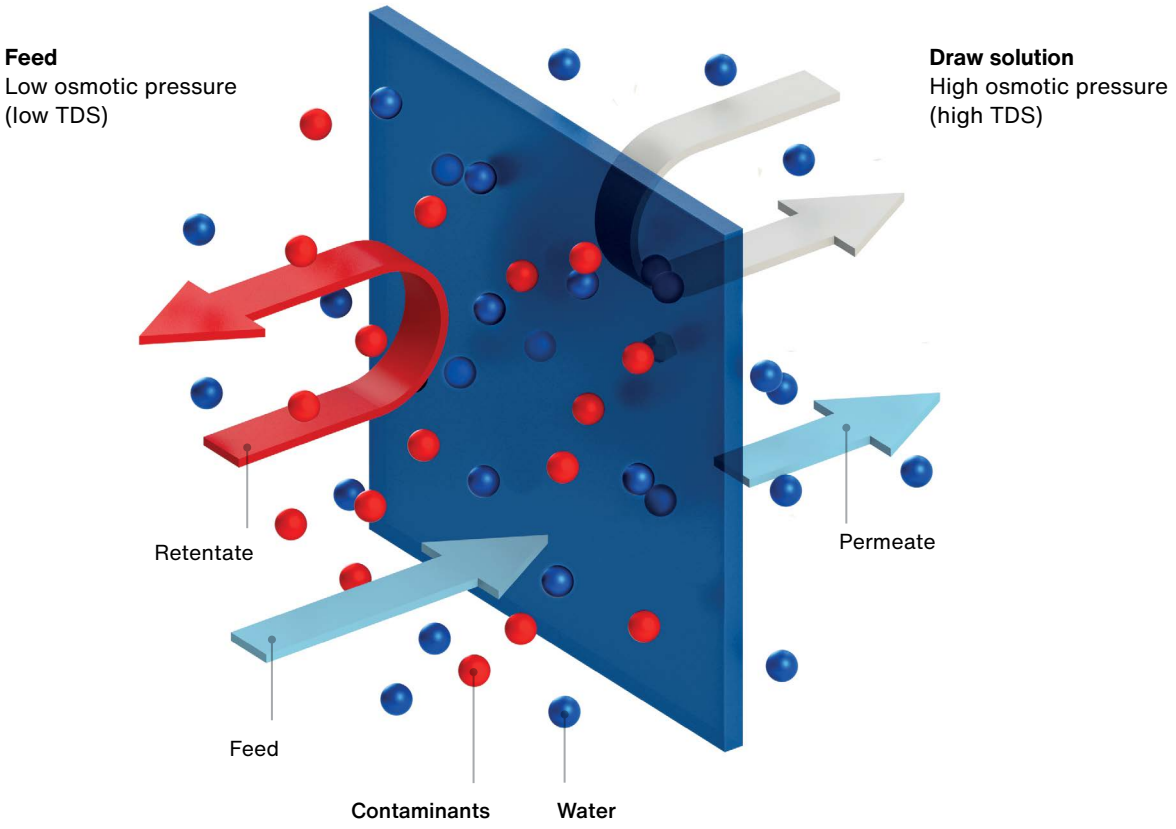


Figure 1: Principle of forward osmosis

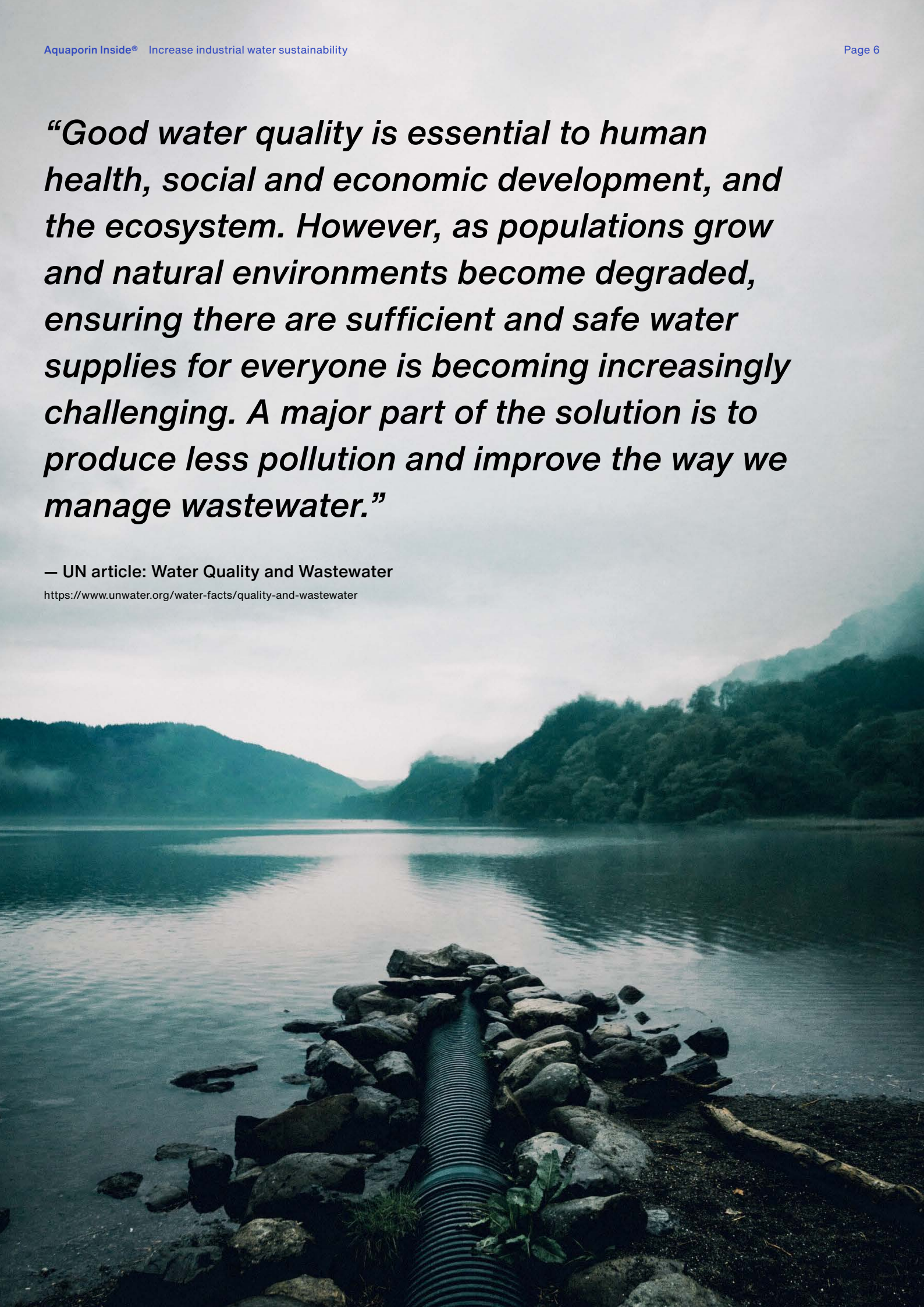
With forward osmosis you can

- **Minimize waste** by effluent volume and sludge reduction to save costs related to disposal or evaporation/crystallization in Zero or Minimal Liquid Discharge systems
- **Reuse more water** with better quality by treating streams with difficult contaminants and high BOD/COD/TOC – where other technologies fail
- **Optimize land use** through simpler and more efficient treatment
- **Simplify treatment** through fewer and faster process steps by partly/fully replacing primary, secondary and tertiary treatment – including chemical and biological treatments – to lower CAPEX/OPEX
- **Retain valuables** such as dyes, salts, nutrients and metals by extracting water from the feed solution
- **Improve logistics** by minimizing waste volume to reduce disposal costs

“Good water quality is essential to human health, social and economic development, and the ecosystem. However, as populations grow and natural environments become degraded, ensuring there are sufficient and safe water supplies for everyone is becoming increasingly challenging. A major part of the solution is to produce less pollution and improve the way we manage wastewater.”

— UN article: Water Quality and Wastewater

https://www.unwater.org/water-facts/quality-and-wastewater



Aquaporins, the world's most efficient water conductors

In FO processes, the characteristics of the membrane are key. Aquaporin Inside® FO membranes use aquaporin proteins – the proteins responsible for transporting water in all living cells – to filter water. Aquaporins are 100 % selective to water molecules, which ensures our FO membranes are highly efficient at rejecting chemicals, minerals and other contaminants. They minimize reverse salt flux and have extremely high rejection, which means the recovered water is of a very high quality.

These innovative membranes are packed into our Aquaporin Inside® Hollow Fiber FO modules, which are compact, light weighted and easy to install.

1. **Simple scale-up from lab to full-scale plant**
2. **Simple to install – no pressure vessels required**
3. **High operational stability and flexibility**
4. **Optimal land use via flexible and compact module design**

How to apply Aquaporin Inside® FO membranes in your effluent treatment

By integrating a FO system that uses Aquaporin Inside® FO membranes in your effluent treatment, you can achieve Minimum or Zero Liquid Discharge and so meet wastewater treatment regulations – while also reducing costs and land use.

For effluent treatment plants with ZLD (Figure 2), the ultrafiltration (UF), nanofiltration (NF) or reverse osmosis (RO) stages can be fully or partly replaced by an FO system (option 1-2). FO can also be added after RO (option 3) to further reduce the volume sent to the evaporator and so reduce the energy requirements for evaporation.

Moreover, FO minimizes the volumes of difficult streams that need to be disposed of, reducing the waste load and transportation costs to waste management facilities. Additionally, due to its proven high rejection of compounds, FO can recover valuables from wastewater streams, such as dyes, salts, nutrients and metals, with minimal loss.

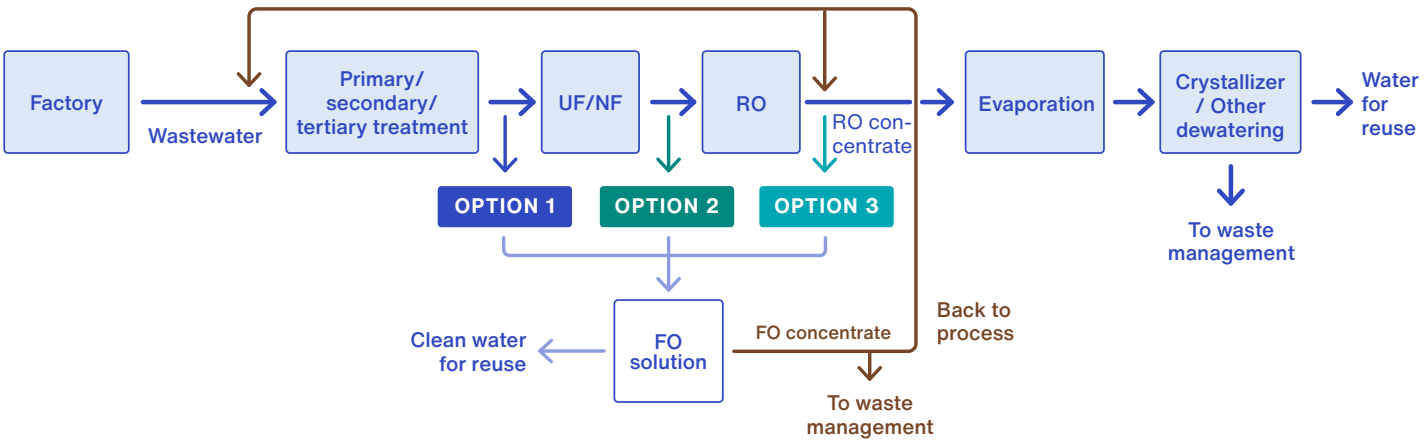


Figure 2: Schematic flow diagram of effluent treatment plant with Minimal or Zero Liquid Discharge, showing where forward osmosis can be utilized in the process (Option 1-3).

How to get started with your forward osmosis solution

Wastewater streams can vary significantly from one application to another. Therefore, there is no one standard fit for all applications. Each case must be evaluated carefully to ensure a tailored solution for your exact needs. That's why we are here to assist and advise you, from initial ideation and feasibility testing through to full-scale operation.

PHASE 1 →

Desk evaluation

Evaluate feed stream and operating conditions to ensure technology match

Define treatment targets and initial cost range

PHASE 2 →

Feasibility screening

Application test:

- Concentration trial to determine flux expectations, maximum level of wastewater concentration and the rejection of the main contaminants

Material compatibility test:

- Trial to verify membrane chemical compatibility with the wastewater

Note: Depending on the results from the feasibility screening additional tests may be recommended prior to piloting

AQUAPORIN LABS OR ONSITE

PHASE 3 →

FO solution pilot

Pilot-scale, continuous operation of FO solution, including draw regeneration

Validate:

– Water quality

– Energy consumption

– Cleaning needs

ONSITE

We must reuse wastewater

Water is a limited resource. The sustainable use of water and reuse of wastewater is urgently needed. By incorporating Aquaporin Inside® FO membranes into your effluent treatment, you will get:

Features

- High rejection of contaminants
- High efficiency
- High water recovery
- High retention of valuables
- Compact design
- Flexible solution
- Water treated using natural aquaporins

Benefits

- Minimize your waste
- Reuse more water with better quality
- Simplify your effluent treatment
- Optimize your land use
- Recover chemicals
- Improve logistics

Outcome

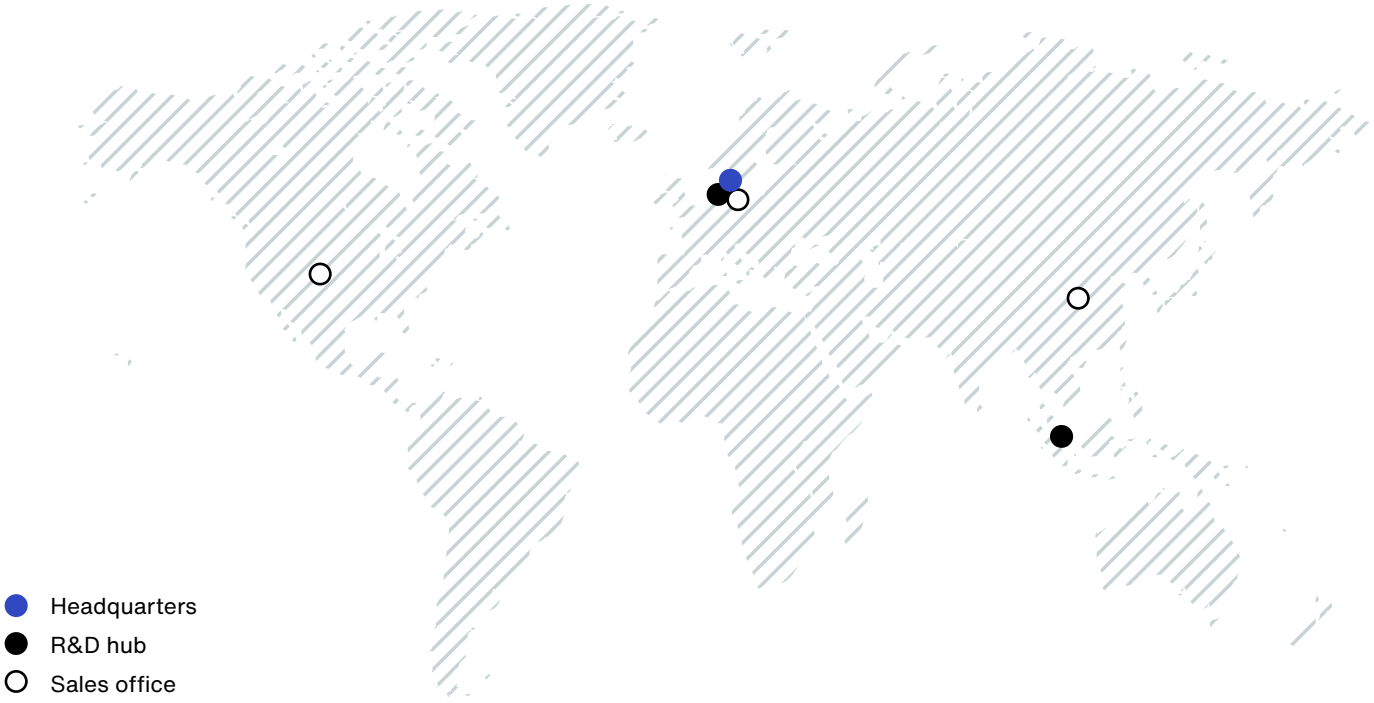
- Sustainable production & increased profitability
- Quick response to regulatory requirements
- Greater transparency towards customers, markets and end consumers
- Improved brand image thanks to environmentally conscious use of water

About Aquaporin

Aquaporin is a global water technology company headquartered in Denmark. We are dedicated to revolutionizing water purification, by merging biotechnological techniques and state-of-the-art engineering. We are the only company that incorporates aquaporins into water purification membranes

We are working with customers to develop more sustainable methods of dealing with wastewater streams – giving them a tangible way to improve their sustainability performance and connect with today's sustainability focused consumers, while also driving costs down.

For more information go to aquaporin.com



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