Case study factsheet

Rosignano Solvay (CS2)

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Project AquaSPICE

Rosignano , **Italy**

Description

The Rosignano Solvay case study focuses on enhancing water sustainability at one of Italy's largest industrial sites, where Solvay produces chemicals such as sodium carbonate, sodium bicarbonate, peracetic acid, and hydrogen peroxide. The initiative builds upon an existing public-private partnership with Consorzio ARETUSA, which has been optimizing the regional water cycle for over 15 years by reclaiming and reusing approximately 3 million cubic meters of urban wastewater annually. AquaSPICE aims to further reduce freshwater intake by treating wastewater from peroxide and peracetic acid production through a pilot system named WAPEREUSE. This system integrates chemical pre-treatment, filtration, biological denitrification, and advanced oxidation processes to bring the treated water to a quality suitable for reuse in cooling systems. Additionally, digital solutions for real-time monitoring and water treatment optimization have been implemented to enhance operational efficiency. The ultimate goal is to validate the pilot's technical and economic feasibility for full-scale deployment, ensuring a more sustainable and circular water management approach at the site.

This pilot implementation is part of Rosignano Solvay's commitment to implementing a sustainability practice in its industrial operations. You can also refer to the Rosignano case study from ULTIMATE project.

Best practices

- Pre-Implementation Characterisation & Modular Design:
  Before construction, conduct thorough influent characterization to understand variability in COD, Nitrates, pH, and specific industrial contaminants. Design treatment trains in a modular format (e.g., containerised units) to allow phased implementation, ease of transport, and adaptability to evolving site needs. Ensure that physical layout facilitates access for maintenance, sampling, and sensor calibration.
- Sequential Treatment Integration:
  Combine biological and physico-chemical processes to balance treatment efficiency and operational resilience. Begin with pH neutralisation to condition the feed for downstream biological activity and AOP filtration with ferric hydroxide materials to remove residual of H_2O_2. Use biological oxidation and denitrification for bulk organics and nitrogen removal, followed by an optional polishing treatment (GAC, IEX) to target residual contaminants. Each stage should be designed to protect and enhance the next.
- Real-Time Monitoring & Automated Control:
  Install UV254 and DO sensors for continuous monitoring of key parameters such as organic load and aeration efficiency. Integrate these with a PLC or SCADA system to automate dosing, aeration, and backwashing cycles. Ensure real-time monitoring are in place for deviations from setpoints to allow rapid operator intervention.
- Preventive Maintenance & Cleaning Routines:
  Develop maintenance protocols for membrane systems, including scheduled backwashing and periodic chemical cleaning (e.g., with NaOCl or citric acid). Monitor transmembrane pressure and flux trends to detect early signs of fouling. Keep spare parts and cleaning reagents on-site to minimize downtime.
- Operator Training & SOPs:
  Train operators in both manual and automated system operation, with particular focus on biological reactor management, chemical dosing, and interpretation of sensor data. Standard Operating Procedures (SOPs) should be documented for all treatment stages, covering startup, shutdown, emergency response, and troubleshooting.

Technology performance and best practices

The most effective treatment sequence combined the following units:
Neutralisation → AOP filtration using ferric hidroxide material → Biological Treatment (MBR in intermittent aeartion) → GAC/IEX Polishing

The achievements, in numerical terms, of the case study were:

- COD Removal:
  Ranged between 40% and 85% depending on influent quality.
- Nitrate Removal:
  Complete nitrate elimination was achieved in most cycles after dosing with external carbon sources (glycerol), demonstrating efficient denitrification.
- pH Stabilization:
  Influent pH (originally 2–3) was successfully neutralized to 6.8, ideal for biological treatment.
- Reagent Consumption:
  - NaOH (neutralisation): ~1.7 L/m³
  - External carbon (denitrification): ~1.2 L/m³
  - Acid (cleaning/adjustment): ~0.1 L/m³
- Energy Consumption:
  Estimated at ~50 kWh/m³ of treated water, primarily due to aeration, and membrane operations.

Synergistic benefits

1. Integration with ARETUSA Reclamation Plant:
   The WAPEREUSE pilot system was designed to work in synergy with the existing ARETUSA Water Reclamation Plant, which has been reclaiming municipal wastewater for industrial reuse for over 15 years. By treating industrial peroxide and peracetic acid wastewater to meet discharge standards, the pilot enables further treatment within ARETUSA, expanding the available volume of reclaimed water for cooling processes at the Solvay plant. This public-private partnership model optimizes regional water resources and strengthens industrial-municipal cooperation.
2. Enhanced Digital Monitoring & Process Optimization:
   The implementation of real-time monitoring sensors and digital process control tools improved treatment efficiency and operational reliability. By continuously tracking pH, nitrate levels, COD, and biological oxidation efficiency, operators could optimize chemical dosing, aeration, and filtration parameters in real time. Additionally, the integration of real-time monitoring helped prevent process failures and ensured that treated water met reuse quality standards.
3. Reduction of Chemical Dependency & Environmental Impact:
   By leveraging biological denitrification as a primary treatment step, the system reduced the need for chemical dosing compared to conventional physico-chemical treatments (e.g; RO, fenton process). The optimized use of pH adjustment chemicals (NaOH) and external carbon sources ensured efficient performance with lower environmental impact and operational costs.

Requirements and conditions

1. Complex Water Composition & Treatment Challenges:
   The industrial wastewater from peroxide and peracetic acid production contains high levels of Total Organic Carbon (TOC), Chemical Oxygen Demand (COD), nitrates, sulfates, phosphates, and hydrogen peroxide. The organic fraction includes phthalic acids, other organic acids, alcohols, and aromatic compounds, while metals originate from stainless and carbon steel infrastructure. The high variability in water composition required a tailored treatment approach to ensure successful reuse.
2. pH Adjustments & Chemical Pre-Treatment:
   Due to an initial low pH (2-3) in the wastewater, pH neutralization was required before biological treatment. This was achieved by dosing soda (NaOH) to reach a pH of 6.8, making the water suitable for further processing. This additional treatment step added chemical consumption costs and required careful monitoring to avoid overcorrection.
3. Regulatory & Permitting Requirements:
   Although no new permits were required for the pilot, strict industrial and environmental regulations had to be followed to ensure that treated water met quality standards for reuse in cooling systems. Ensuring compliance with municipal discharge regulations was also necessary, as any effluent exceeding allowable limits could not be directed to the ARETUSA reclamation plant for further treatment.
4. Integration with Existing Water Reuse Infrastructure:
   The pilot plant was designed to complement the existing ARETUSA Water Reclamation Plant, which has been treating municipal wastewater for reuse in Solvay's industrial operations for over 15 years. Particularly, the treatment train was optimized to reach at least a wastewater quality suitable for discharge in sewer network, from where the wastewater can enter ARETUSA facility to be treated for reuse.
5. Operational & Energy Demands:
   The WAPEREUSE pilot system required high energy inputs, particularly for aeration of the biological process and membrane filtration. Particularly, biological treatment with denitrification required precise oxygen control to maintain optimal microbial activity and minimize energy costs. Reagent consumption included 1.2 L/m^3 of external carbon, 1.7 L/m^3 of soda, and 0.1 L/m^3 of acid, with an estimated energy consumption of 50 kWh/m^3 of treated water under pilot-scale operational conditions.

Key lessons

- Value of Integrated Multi-Stage Treatment:
  A key lesson from the pilot was that optimized biological treatment with a simple physical-chemical treatment to adjust pH of water was successful to treat efficiently a complex industrial wastewater for reuse. However, experimental tests underlined the importance of modular design and process flexibility when dealing with high-variability industrial streams.
- Importance of Influent Characterization & Pre-Treatment:
  Influent variability in terms of pH, COD, and residual oxidants significantly impacted downstream treatment stability. Early pH neutralisation proved essential to protect biological and membrane systems. The pilot emphasized the need for detailed and continuous influent monitoring to adapt treatment strategies dynamically and safeguard overall system performance.
- Digital Monitoring Enables Real-Time Control:
  Real-time sensing technologies like UV254 absorbance, DO, Redox and nitrates monitoring were critical for maintaining stable biological operation and optimizing chemical

dosing. The pilot demonstrated that digital monitoring not only improves process control but also reduces energy and reagent usage over time. Investment in sensor integration early on can prevent operational bottlenecks and enable data-driven decision-making.

- Modularity Supports Scalability & Replicability:
The containerised nature of the WAPEREUSE system allowed flexible deployment and quick transfer between the university site and the Solvay plant. This setup showed clear potential for replication in other industrial contexts, especially where space, permitting, or integration with existing infrastructure pose constraints.

Lessons learned from technology operation

- Operator Training & Technical Competence:
The WAPEREUSE system required skilled personnel familiar with both biological and physico-chemical processes. Operating the biologiacl reactor, managing chemical dosing, and interpreting real-time sensor data demanded a multidisciplinary understanding. Lessons learned highlight the importance of cross-training staff on integrated systems and ensuring familiarity with digital monitoring interfaces to avoid misinterpretation of surrogate parameters.
- Maintenance Demands & Fouling Management:
Membrane systems (used for solid-liquid separation) were prone to fouling, especially during periods of inconsistent influent quality. Regular backwashing and chemical cleaning protocols were essential to maintain performance. The pilot revealed that establishing preventive maintenance schedules based on real-time pressure and flow data significantly reduced unscheduled downtimes and prolonged membrane lifespan.
- Technological Risks & Downtime Avoidance:
Unstable influent pH and chemical carry-over posed risks to both biological activity and downstream components. Early-stage neutralisation and automated control helped mitigate these risks. The use of UV254 and DO sensors enabled early detection of performance deviations, allowing proactive intervention and energy saving. One key lesson was that even short-term lapses in dosing accuracy or aeration control could reduce significantly treatment efficiency and increase treatment costs, emphasizing the need for robust fail-safes and alarm systems.
- Data-Driven Troubleshooting & System Resilience:
Real-time data acquisition proved invaluable for diagnosing process anomalies and fine-tuning operations. When sensor readings indicated organic overload or insufficient oxidation, quick adjustments to intermittent aeration cycles or chemical inputs minimized disruption. The experience showed that system resilience improves significantly when operators can act on immediate performance feedback, reducing reliance on delayed lab analyses.

Applied technology

- **Water recovery technologies for water reuse**

Publications and references

- Process innovations and circular strategies for closing the water loop in a process industry

  Efthalia Karkou [a,**], Athanasios Angelis-Dimakis [b,*], Marco Parlapiano [c], Nikolaos Savvakis [a], Owais Siddique [b], Antonia Vyrkou [b], Massimiliano Sgroi [c], Francesco Fatone [c], George Arampatzis [a]

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Related tags

Ultrafiltration | Water reuse | Advanced Oxidation Processes | Biological treatment | Denitrification Process | Industrial Water Treatment | Wastewater Recycling | Cooling Water Reuse | Sequencing Batch Reactor | Ozonation | Digital Water Monitoring | Sustainable Water Management

Contact data

Involved organisation

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