Water reuse after treatment of industrial wastewater from the peroxide and peracetic acid production

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The increasing need for water efficiency and pollution reduction in industrial processes compels the adoption of safe and sustainable engineering solutions for environmental protection. In line with the European Union's Circular Economy Action Plan, the H2020 AquaSPICE project tested the WAPEREUSE pilot plant for the treatment and reuse of industrial wastewater generated by hydrogen peroxide and peracetic acid production at the Solvay plant in Rosignano. The treated water was evaluated for reuse based on three possible value chain options for wastewater valorization: (1) discharge into the municipal sewer system, followed by treatment first at the Rosignano municipal wastewater treatment and then at the ARETUSA water reclamation facility using advanced treatments; (2) delivery to the ARETUSA water reclamation plant for subsequent reuse at Solvay, and (3) direct internal reuse at Solvay's chemical production site, meeting discharge limits of Chemical Oxygen Demand (COD) < 100 mg O_2/L and nitrate (NO_3^-) < 20 mg N/L. The pilot plant treated up to 1 m^3/d of industrial wastewater through high-load biological denitrification and oxidation in a membrane bioreactor (MBR). This system offered a sustainable alternative to conventional energy-intensive processes, such as Advanced Oxidation Processes (AOP) and/or Reverse Osmosis (RO) [1], which are typically required to remove recalcitrant COD from industrial effluents to meet discharge limits. Unlike AOPs, which rely on chemical oxidants (e.g., ozone, UV/H_2O_2), this method enhances COD removal through optimized microbial activity. Furthermore, real-time data from sensors measuring UV absorbance at 254 nm (as a surrogate for COD), NO_3^-, redox potential, and dissolved oxygen in the MBR were transmitted to a programmable logic controller (PLC) to automate and optimize process conditions.

After initial tests focused on biomass acclimatization and optimization of operational parameters, stable performance was achieved. As a trade-off between COD degradation kinetics and nitrate removal efficiency, both the denitrification and oxidation cycles were set to 8 hours. Under these conditions, with an influent NO_3^- concentration of 251 ± 71 mg N/L, the observed NO_3^- removal rate was 11.5 mg N/(L · h), achieved with an external carbon dosage of 1.4 L per denitrification cycle. The weighted average effluent NO_3^- concentrations remained below 20 mg N/L, satisfying Solvay's internal reuse threshold. Regarding COD, the influent concentration of 251 ± 71 mg O_2/L was reduced during the 8-hour oxidation cycles to an average of 65 ± 32 mg O_2/L, meeting internal reuse discharge limits.

Therefore, the WAPEREUSE pilot demonstrated that digitally enhanced MBR treatment systems can ensure sustainable industrial water reuse by achieving stringent discharge limits without employing energy or chemical intensive treatments.

Keywords: *circular economy, wastewater reuse, industrial symbiosis, membrane bioreactors, nitrate removal, sustainable engineering*

[1] Foglia A, J. González-Camejo, S. Radini, Sgroi M, Li K, A.L. Eusebi, et al. Transforming wastewater treatment plants into reclaimed water facilities in water-unbalanced regions. An overview of possibilities and recommendations focusing on the Italian case. 2023 Apr 1;410:137264–4.