

EcoRight® System Pilot Study

Granular Activated Carbon Membrane Bioreactor Advances Treatment Technology for Reuse of Refinery Wastewater

Water Solutions

Challenge

Saudi Aramco has adopted a policy of minimizing its extraction of groundwater and the use (and associated expense) of desalinated seawater for process water use. As an alternative, they are actively investigating sustainable methods and technologies that will allow wastewater reuse, either as cooling water makeup and/or boiler feed water. Typically, reverse osmosis treatment of biologically treated effluent is required for reuse, however this leads to excessive organic fouling of reverse osmosis membranes due to recalcitrant COD remaining in the treated effluent.

Saudi Aramco approached Siemens with the concept of jointly evaluating the use of granular activated carbon in a membrane bioreactor (MBR) to achieve an effluent quality suitable for wastewater reuse. This new technology - marketed and sold under the name EcoRight® - is a Siemens/Saudi Aramco joint technology development that relies on Siemens' Petro® MBR technology, modified to allow the aeration tank mixed liquor suspended solids (MLSS) to operate with suspended granular activated carbon (GAC). This unique technology offers significant advantages over

conventional biological treatment technologies, including conventional powdered activated carbon-assisted biological treatment technologies.

Solution - EcoRight® System Pilot Study

Siemens contracted with Saudi Aramco to perform a pilot study using the EcoRight® system to treat wastewater from a Saudi Aramco refinery. The pilot study scope included an evaluation of reverse osmosis (RO) filtration of the EcoRight® system effluent to determine if the EcoRight® system produced longer RO run times by

minimizing membrane fouling and reducing clean-in-place (CIP) requirements. Pilot plant operations began December 14, 2010, and were completed on October 27, 2011.

Results

The EcoRight® pilot unit was operated over a 319 day period and, even after extraordinary variable discharges of oil and grease and COD loading, and frequent power interruptions, EcoRight® system effluent complied with all discharge standards, indicating that this technology has the capacity to process upsets and quickly return to normal operating conditions.



EcoRight® pilot unit in operation at a Saudi Aramco Refinery

Pilot Study Results

Average Influent and Effluent Constituent Concentrations and Percent Reduction During the Post Acclimation Period ⁽¹⁾

Parameter	Feed	Effluent	% Reduction
COD, mg/l	475	89	81
BOD5, mg/l	140	3.8	97
TOC, mg/l	92	8.5	91
NH3-N, mg/l	16	0.7	96

(1) This data was collected during the period when the chiller was operating to reduce the activated sludge system temperature to below 32°C

The EcoRight® system successfully removed recalcitrant COD and Extracellular Polymeric Substances (EPS) that typically foul ultrafiltration (UF) and reverse osmosis (RO) membranes. This was demonstrated by nearly eight months of EcoRight® system operation, and more than two and one-half months of reverse osmosis operation without requiring CIP procedures.

No damage to the EcoRight® system membrane fibers was observed during the membrane autopsy conducted at the end of the study, indicating that:

- The screen system was effective at keeping the granular carbon in the aeration tank and preventing contact with the membrane fibers in the MOS tank.
- The ability to keep the granular carbon segregated from the membrane fibers increases membrane life over powdered carbon MBR systems by eliminating carbon-related membrane abrasion potential.
- Bio-regeneration of the granular activated carbon likely contributed to significantly reduced activated carbon consumption. Isotherm testing on carbon samples collected at the end of the pilot study showed adsorptive capacity remaining on the carbon. When compared to the amount of activated carbon required to remove the equivalent COD by carbon filtration, the EcoRight® system resulted in a minimum 10-fold reduction in granular carbon consumption, a potentially significant operation cost savings in a full-scale system.
- The EcoRight® system demonstrated a clear advantage over conventional MBR systems by removing foulants normally present in the wastewater, and consequently reducing the need for CIP procedures. In full-scale operations this translates to increased membrane life; reduced chemical costs; reduced downtime; reduced operator attention; and energy, labor and material cost savings.

Next Steps

The EcoRight® pilot unit has recently started treating process and sanitary wastewater at a Saudi Aramco Gas Plant. This pilot study is being undertaken with the following objectives:

- To establish the optimum effluent quality achievable using the EcoRight® system.
- To determine whether or not RO polishing of EcoRight® system effluent produces utility and boiler feed water quality.
- To develop an understanding of activated carbon bio-regeneration carbon life to achieve reuse-quality treated effluent.

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