Brilliant Water Reuse in Brazil

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The need for advanced wastewater treatment and reuse is increasing in all parts of the world as the limited supply of freshwater rapidly is being depleted. This is especially true in the São Paulo region of Brazil, where there is a growing demand for high-quality potable and industrial processing water.

Membrane project curbs industrial use of freshwater

The Aquapolo Ambiental water reuse venture was created to address new regulations to restrict industrial use of potable water in São Paulo. Aquapolo is the largest wastewater reuse project in the Southern Hemisphere and the fifth largest of its kind in the world. Upon completion, this groundbreaking facility will free up enough drinking water to continuously supply a population of 350,000 inhabitants, with the potential capacity to reach 600,000.

Membrane bioreactor (MBR) design has been identified as the most cost-effective solution to upgrade the existing wastewater treatment plant to meet São Paulo's pressing demand for industrial reuse wastewater. The new Aquapolo facility will employ Koch Membrane Systems' innovative Puron MBR technology and MegaMagnum reverse osmosis (RO) membranes.

Construction commenced in April 2010, and the water treatment portion of the project is following an aggressive schedule for startup in November 2011.

Public & Private Sectors Join Forces

The state of São Paulo, with close to 41 million people, is the world's seventh most populous urban area, and is considered the economic, financial and technical hub of Brazil. The region contains nearly one-fourth of the country's population but less than 2% of its water.

Drinking water resources are becoming increasingly scarce in São Paulo. The state government, recognizing the importance of safeguarding drinking water for the region's inhabitants, recently issued new regulations to restrict the industrial use of potable water. These legal updates have forced factories to look for ways to reuse their wastewater or obtain recycled water from another source.

Aquapolo Ambiental was born from a unique business structuring and project financing arrangement known as a specific-purpose partnership (SPP) between Foz do Brasil, the engineering division of Odebrecht Group, and Sabesp, a Brazilian state-owned utility that provides water and sewage services for residential, commercial and industrial use in the municipalities of the state of São Paulo.

The SPP signed a 15-year finance contract with the Brazilian Development Bank, a federal public company that provides long-term financing for private infrastructure projects that contribute to the development of the country, such as water and sewer systems. To build this project, the SPP will rely on the expertise of the Brazilian engineering and construction firm Construtora Norberto Odebrecht, working under a three-year engineering, procurement and construction contract.

The new treatment plant will be built on the grounds of the ABC Sewage Treatment Plant (ABC STP) of Sabesp, located on the boundary between São Paulo and São Caetano do Sul counties. Effluent from the ABC STP will be treated and pumped to the Mauá Petrochemical Complex and sold to other factories in the region for use in industrial processes. The initial 2012/2014 phase will produce 56,160 cu meters per day (650 L/sec) of reuse water, eventually reaching a capacity of 86,400 cu meters per day. Sixty-five percent of the plant output has been sold under a 34-year contract to Quattor, a petrochemical company located within the Mauá petrochemical complex—Aquapolo's target market. Other potential users are companies located along the 10-mile steel pipeline being built to carry water to the complex.

Feasibility Study Evaluates Reuse Options

Several critical discharge parameters of the current ABC STP operation seriously compromised the ability to reuse the existing effluent, including chemical oxygen demand (COD), biochemical oxygen demand, suspended solids, ammonium, total phosphorus and conductivity. The facility was built in the 1990s and has an installed capacity of 3,000 L/sec, but it operates at 50% of its design capacity.

Koch Membrane Systems conducted a comprehensive feasibility study to identify the most cost-effective strategy for upgrading the existing plant infrastructure. This study evaluated the amount of high-quality water needed for reuse, which parts of the existing wastewater treatment structure could be used in the upgraded facility, alternative system configurations and the capital and operating costs of each configuration.

RO typically is the technology of choice for producing the quality of water needed for industrial reuse. In the case of the ABC STP facility, an evaluation of the current effluent quality and future water reuse targets determined that it was not possible to solely add RO directly after secondary clarifiers to meet reuse quality parameters.

The poor performance of the secondary clarifiers, suffering regularly from bulking sludge, was a major potential threat for any RO solution. Another point to address was the high ammonia level still present in the secondary effluent from the plant. While RO remained an essential part of the treatment process

Table 1. Water Quality

Parameters	Unit	Effluent of ABC STP	Reuse Water Required
Average Flow	Lps	1600	650
Temperature	°C	15 - 30	15 - 30
BOD	mg/L	20 - 60	10
COD	mg/L	50 - 120	20
TSS	mg/L	40 - 100	2
Ammonia Nitrogen	mg/L	20	1
Total Phosphorous	mg/L	5	0.5
pH	-	5.0 - 9.0	6.5 - 7.5
Total Iron	mg/L	2	0.3
Sulphide	mg/L	1	0.1
Turbidity	NTU	50	1
Conductivity	µs/cm²	650 - 1500	720
Total Hardness	mg/L	100	100
Aluminium	mg/L	0.5	0.2
Phenol	mg/L	0.2	0.1
Copper	mg/L	0.2	0.01
Surface Active Agents	mg/L	5.1	1
Free Chlorine	mg/L	-	1

Table 2. Design Differences

Parameter	Units	Rebuild System 1	Rebuild System 2	Rebuild System 3	TMBR
Pretreatment					
Coarse Screen	-	Existing	Existing	Existing	Existing
Sand & Fat Removal	-	Existing	Existing	Existing	Existing
Primary Clarification		Existing	Converted to DN	Existing	Existing
Fine Screens (2 mm)	-	New - after primary clarifier	New - before primary clarifier	New - after primary clarifier	New - after secondary clarifier
MBR Design					
Volume DN	%	0	19%	19%	6%
Volume N	%	74%	74%	56%	17%
Volume Membrane	%	7%	7%	7%	10%
Total System Volume	%	81%	100%	81%	33%

to reduce total dissolved solids and make the water clean enough for reuse, the RO system needed to be coupled with an effective pretreatment system.

The engineers evaluated four potential scenarios to upgrade the existing biological treatment. All four options involved submerged MBR technology. Depending on raw water conductivity, which varies significantly seasonally, the water produced by the MBR could either be reused directly or blended with RO permeate to meet the conductivity target level.

The first three scenarios involved retrofitting existing concrete structures. The fourth option was to make use of the existing plant operation and infrastructure and use the effluent of the secondary clarifier as feedwater to the new MBR installation. It was clear that the nutrient-deficient design of the existing plant would be a challenge biologically, but also that it could be developed as a greenfield enhancement to the existing site operation without direct interaction with the site operation.

"Also, the choice for a greenfield solution will surely avoid many unknown risks derived from interfaces or adaptations on the existing structures," said Giancarlo Ronconi, Foz do Brasil project leader.

For this unique combination of existing conventional biological treatment with a new MBR system, the new MBR system was designated as a tertiary membrane bioreactor (TMBR).

Pilot Study Supports TMBR

The engineering team concluded that adding a TMBR system to the existing plant infrastructure was the best solution for the new Aquapolo facility. In total, the Aquapolo project will encompass the construction of a new pretreatment step, the installation of a chemical dosing system and the construction of a 700-L/sec TMBR utilizing 94,500 cu meters of membrane area. The TMBR offers lower operating costs, lower process risk, greenfield design and negligible interaction with current plant operations and equipment.

The TMBR is a polishing MBR process. It will treat water coming from the existing secondary clarifiers and further treat it in a newly built biological step using membranes as the final separation process. Some of the TMBR effluent will be treated further by RO membranes to meet conductivity goals for water reuse.

To validate the TMBR approach, a one-year pilot study was conducted to confirm the design parameters, optimize the system operation and evaluate operating costs. A standard MBR pilot plant was used to exactly simulate the TMBR design concept. The membrane modules used were Koch Membrane Systems hollow-fiber submerged ultrafiltration (UF) membranes. All flows were according to the feasibility design, and dissolved oxygen, pH and mixed liquor suspended solids (MLSS) were controlled closely.

The pilot was operated between 2 and 6 grams/L MLSS, and startup and daily plant operation was simulated. The feed flow was controlled to a fixed value, and all maintenance cleaning and downtime were reflected in the operational flux of the membranes. The pilot plant output was 775 L/hr net flow. The biological system design was simulated with a hydraulic retention time of approximately three hours and a sludge retention time of between 12 and 20 days.

"The main challenge during the pilot phase was the organic load variation, but by developing the adequate approach to those situations, the Aquapolo team streamlined the learning curve regarding the wastewater behavior on ABC STP," Ronconi said.

A number of operational tools were developed to stabilize the operation and improve the biomass quality. Up until seven months into the pilot study, primary feed occasionally was bypassed to the TMBR and occasional ethanol dosed to the TMBR. This proved useful to stabilize the biological system and, more importantly, to stabilize the nitrifier population and alkalinity balance. Next, ferric dosing was added. This had two advantages: First, the total residual phosphorus was precipitated out to meet the discharge criteria, and second, the biomass became marginally more flocculated and easier to control for the nutrient removal processes. Using these operational tools, the target COD of 20 mg/L was achieved.

The TMBR pilot demonstrated that the submerged membranes benefited from the optimized biological system. Average flux rates of greater than 25 L/cu meter/hr were achieved, and daily maintenance cleaning was found to enhance the UF performance. Recovery cleaning returned the UF membrane to the original process permeability.

A standard RO pilot also was used to simulate the RO design concept of the proposed full-scale system for 200 L/sec feedwater. The pilot trials were set up in three well defined phases, a simple batch mode, a modified batch mode and a continuous mode. The RO system was able to produce an excellent water quality. The final water quality for reuse was achieved through blending the TMBR permeate and the RO permeate.

Meeting Water Reuse Requirements

Koch Membrane Systems was chosen for the Aquapolo project for its ideal technical support and biological design, the availability of MBR and RO pilot plants, vast experience with water recycling projects and ability to meet an extremely accelerated delivery schedule. The scope of supply included 63 Puron PSH1500 membrane modules, two MegaMagnum MM9 RO units, system design and controls, and after-market support and service.

The Aquapolo facility will use the 1,500-cu-meter Puron module, which was designed specifically for large-scale MBR projects. Features such as an optimized permeate extraction manifold and air supply lines reduce the number of piping connections needed during installation. For additional flexibility, the new product line enables users to easily retrofit the advanced Puron technology into systems with comparably sized modules.

In addition to the Puron modules, MegaMagnum RO elements will complete the custom-designed system. Each of the MM9 systems chosen for Aquapolo has a flow capacity of 1.7 million gal per day and 6,500 cu meters per day. WWD

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