Innovative Engineering Design Provides Long Lasting Success for Mumbai International Airport Ltd. (MIAL) Wastewater Treatment Plant

By **Ajanta Sarkar** and **Fred Wiesler**

The Chhatrapati Shivaji International Airport – known as CSIA – is the gateway to Mumbai, India's financial capital and its most populous city. In 2006, Mumbai International Airport Pvt. Ltd., or MIAL – a joint venture between a GVK-led consortium and the Airports Authority of India – was awarded the mandate to modernize and upgrade the facility to a world-class airport.

As a part of the massive expansion plan for Chhatrapati Shivaji International Airport, a 10 million liters per day (MLD) wastewater recycle project was contracted in 2011 to cater to the growing requirements of the expanded airport.

Due to increasingly strict environmental regulations, the treatment of raw sewage wastewater is required before it is allowed to flow into the natural ecological system. As the airport has a lack of fresh water availability for its requirements, it needs to recycle and reuse the treated sewage water for its operations, such as toilet flushing, horticulture, and HVAC cooling makeup water. Approximately 4 MLD of the treated sewage water is used as HVAC cooling water, 3 MLD is used for flushing, and 3 MLD is used for horticultural and operational purposes.

Aquatech, a leader in water and wastewater treatment for industry and infrastructure, was awarded an EPC contract to supply a 10 MLD sewage treatment and recycle system on a complete turnkey basis for the new airport terminal. MIAL chose Aquatech due to its long and successful record in providing treatment systems for a variety of purposes. The MIAL wastewater treatment project had some key design and water quality challenges that Aquatech successfully overcame through an innovative process and system design.

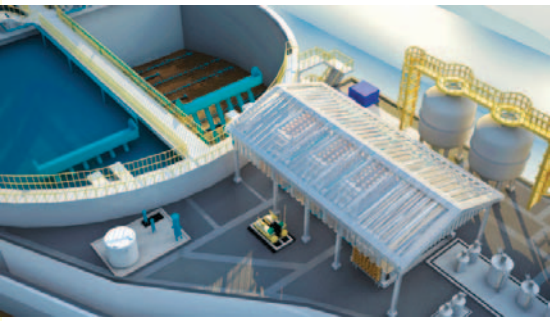
QUA UF Skid

Project Constraints

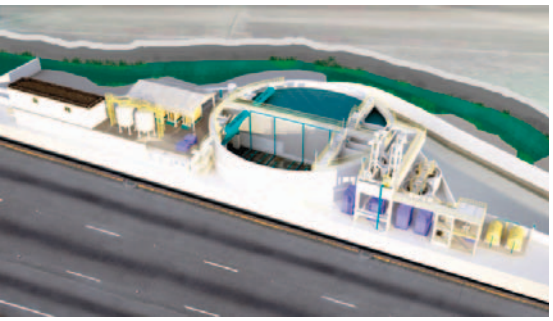
This project required extensive design ingenuity, as the space allotted for the plant was unusually shaped and smaller than what is suitable for a plant of this capacity.

Normally, a plant of this size would require at least 5000 square meters. However, Aquatech was allotted a plot of land half that size, 2600 square meters, to construct the MIAL wastewater plant. Instead of the normal square design, the plot provided is triangular in shape and completely surrounded by utility buildings and an adjacent river, allowing no space for potential expansion. These tight constraints were put into place to allow space for all components of Mumbai's airport expansion project without disrupting the airport's existing daily operation.

Additionally, the incoming water to the plant was variable in its quality. Since the wastewater entering the system is mainly from the airport and not usual city sewage, it was expected to be rich in Total Kjehldahl Nitrogen (TKN). It also was expected to have a high turbidity



MIAL Plant Rendering



MIAL Plant Rendering

and silt density index (SDI). Aquatech decided that the best way to combat the water quality challenges was to configure a combined biological and membrane process system.

Overcoming Design Challenges

Aquatech's engineers designed an innovative wastewater treatment system based on the limited plot size allotted. The MIAL plant is an integration of many technologies – a combination of biological treatment followed by advanced tertiary treatment based on UF and RO processes.

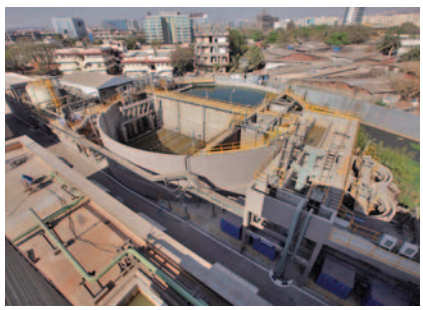
The primary treatment consists of coarse and fine bar screens followed by a grit chamber. The secondary treatment consists of a sequencing batch reactor (SBR) biological treatment technology followed by disinfection. The tertiary treatment includes a QUA® ultrafiltration (UF) pretreatment system followed by a reverse osmosis (RO) system, after which the water is reused and distributed for the airport's various purposes.

Aquatech's engineering team devised a circular design that took advantage of the basin shape to fit two SBR basins into the triangular plot. However, this design left a very small amount of space in which to place the recycle system. To address this issue, the Aquatech team placed the chlorine contact, feed, and permeate tanks (eight total) in a vertical configuration with the pressure sand filters, UF system, and RO system placed on top of the tanks. A typical wastewater treatment system calls for all of these components to be constructed in a series, but this configuration was not possible in this plant.

The vertical engineering design not only allowed the MIAL wastewater plant to adhere to the strict space requirements, but it also provided a more economical and optimized solution that would successfully provide high quality water over many years.

Biological Treatment – Reliable SBR with Innovative Design

Aquatech chose an advanced SBR technology to combat the plant's biological treatment needs. However, this treatment step proved to be challenging to design in as a result of the limited space to work within. To solve this problem, Aquatech selected an SBR system that operates both biological treatment and solid-liquid separation in a single reactor basin that alternates operation modes, eliminating the need for final clarifiers and high return activated sludge capacity. This SBR system is designed to minimize the plant footprint while optimizing process performance and energy efficiency.



MIAL Full Plant

Figure 1: MIAL System Flow Diagram

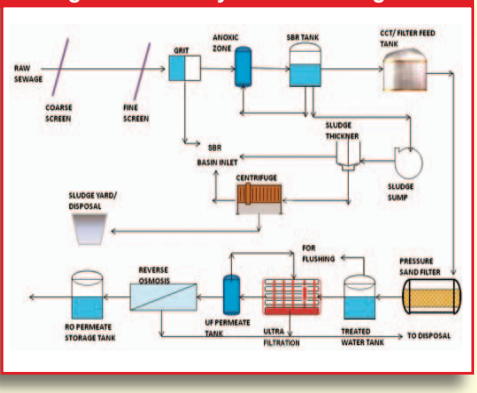


Figure 2: Raw Feed Water Quality Analysis

Feed Water Analysis

Description	Units	Raw Sewage
Temperature	°C	Ambient
pH	---	67-8.1
BODS at 20°C	mg/l	100-260
COD	mg/l	120-450
Total dissolved solids	mg/l	200-700
Total suspended solids	mg/l	65-250
Total Kjeldahl Nitrogen	mg/l	5-60
Ammonical Nitrogen	mg/l	2-40
Hardness as $CaCO_3$	mg/l	50-100
Sulphate	mg/l	40-110
Chlorides	mg/l	100-300
Oil & Grease	mg/l	<10
Total Alkalinity	mg/l	150-375
Silica	mg/l	5-30
Phosphorous	mg/l	5-7

Figure 3: UF Feed Water Quality Analysis

UF Feed Water Quality

pH	6.7 - 8.1
Turbidity (NTU)	Variable Up To 12
TDS (mg/l)	700
BOD (mg/l)	< 20
COD (mg/l)	< 60
Temperature Max	25° C

Figure 4: MIAL Q-SEP Transmembrane Pressure (TMP) Averages for a Six Month Period

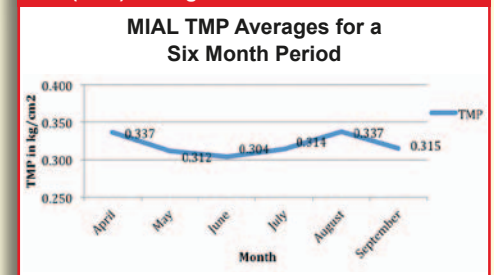


Figure 5: MIAL Turbidity Averages for a Six Month Period

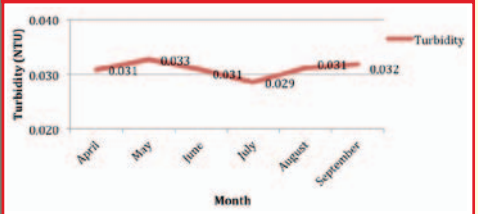


Figure 6: Final Treated Water Quality Analysis

Treated Water Quality

Description	Units	After Biological Treatment	After RO (for HVAC use)
Temperature	°C	Amb	Amb
pH	---	7.0-8.0	7.0-8.0
BOD at 20 °C	mg/l	--	BDL
COD	mg/l	--	BDL#
Total dissolved solids	mg/l	<=700	< =150
Total suspended solids	mg/l	--	BDL
Total Kjeldahl Nitrogen	mg/l	<= 10	<=2
Ammonical Nitrogen	mg/l	< =2	<=1
Oil & Grease	mg/l	<= 5	BDL
Phosphorous	mg/l	<2	<2

Effective RO Pretreatment to Combat Variable Feed Water

Since the wastewater designated for treatment was complex, it required a system that could treat highly variable quality water. A UF system followed by an RO system was integrated into the system to provide a complete treatment solution. Please see Figures 2 and 3 for a detailed feed water quality analysis. Aquatech evaluated both UF and conventional media filtration for pretreatment to MIAL's RO system. Since the water feeding the pretreatment system was sewage wastewater, the pretreatment step needed to be designed to handle variable water qualities and extremely high turbidity levels. The primary goal of the RO pretreatment system was to reduce the silt density index (SDI) and turbidity of the water feeding the RO to a point where RO cleaning would be minimized. Media filtration was unable to meet this requirement, so energies were focused on evaluating several UF membrane suppliers.

Aquatech chose Q-SEP® hollow fiber ultrafiltration modules developed by QUA because their high surface area and operating efficiency allowed the plant to use fewer modules and fit the plant's tight space constraints. Q-SEP's patented cloud precipitation process produces a very narrow pore size distribution and offers higher flux and lower fouling characteristics that proved to be very beneficial in insuring that the membranes effectively treated the water.

Since its installation, the UF system at Mumbai International Airport has been running successfully, providing low turbidity water to the RO unit and meeting the requirement of the airport's needs. The UF transmembrane pressure (TMP) has been below 0.4 bar (5.8 psi) on average; and Figure 4 shows a sample of the data over a six-month period. The average product water turbidity has been consistently very low (less than 0.04 NTU as per the instrument reading) (shown in Figure 5) and SDI has been less than 3, which meets the RO membrane inlet requirement.

The Q-SEP membrane cleaning is done by regular backwashes and CEBs. Cleaning in place (CIP) has not been required since startup of the UF membranes, and the RO membranes are cleaned every 3-4 months. RO cleaning is done as part of the plant operational protocol and not due to fouling of the membrane (as shown by the low TMP values). This is an improvement compared to the average CIP every 1-3 months for RO membranes following standard ultrafiltration membranes using treated sewage wastewater as feed.

Due to the success of the Q-SEP UF membranes upstream, the RO system employed has been running successfully since installation without any issues. The ultrafiltration system served as a valuable component to ensure the plant's continued reliability for the airport's needs.

Aquatech successfully completed installation and commissioning of the MIAL project in 2014, and handed over the wastewater treatment plant to MIAL in early 2015. The site is fully operational and performing well in auto mode. The sewage wastewater treatment plant has been in operation for more than a year and is successful due to its innovative design and integration of optimized and advanced treatment technologies.

The extraordinary design and efficient and effortless operation of the Mumbai International Airport plant have made it an outstanding example of technological and engineering advancement in the Indian municipal wastewater market. **WWA**

About the Author

Ajanta Sarkar is General Manager, Application Engineering for Aquatech Systems Asia Pvt. Ltd. She is a chemical engineer from LIT Nagpur with post graduation in management from Symbiosis Pune, and has over 25 years' experience in process design and estimation of water treatment, seawater desalination and wastewater recycle and reuse systems. Ajanta has worked on large seawater desalination systems in India, the Middle East and Europe, and in the power as well as municipal sectors. She has also worked from concept to commissioning on recycle and ZLD projects with end users in the textile, refinery and chemical sector.

Fred Wiesler is the Director of Sales and Marketing at QUA Group LLC. He earned a Bachelor of Engineering (BE) degree in Mechanical Engineering from the State University of New York (SUNY) at Stony Brook. Wiesler's deep experience encompasses a wide range of water treatment technologies including Electrodeionization, Reverse Osmosis, Ultrafiltration, UV and Ion Exchange and such markets as the semiconductor, power, pharmaceutical, fine chemical, and food & beverage industries.