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Moving Bed Biofilm Reactor (MBBR) followed by UF Membranes for Removal of Organic Material and Total Nitrogen at a Surface Water Treatment Plant (Agra, India) Summary of One Year of Full Scale Operation

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INTRODUCTION

The Yamuna River in India serves as the source of potable water for over 2 million people in the city of Agra - home of the famous Taj Mahal.
WWTPs in cities upstream of Agra discharge secondary effluent into the Yamuna, at varying levels of quality, resulting in elevated levels of soluble pollutants and nitrogen compounds in the river water.
The existing Sikandra water treatment plant - based on cascade oxidation → coagulation → clarification → gravity sand filtration, could not provide satisfactory removal of soluble pollutants from the water. Following an extensive survey of alternatives - including Electrodialysis, Ion-Exchange, Reverse Osmosis, and a variety of biological systems - the Moving Bed Biofilm Reactor (MBBR) technology was selected.
Non-biological technologies were not considered due to high costs and generation of waste streams with high nitrogen concentrations. Among the biological treatment solutions explored, MBBR was chosen over Activated Sludge and MBR due to higher efficiency in low load conditions and superior process stability in cold water conditions.

After technology selection a pilot-scale plant was designed and operated for almost two years, in order to optimize the full-scale design and test operational scenarios.
The full-scale plant was commissioned in February 2014 - designed for production of potable water at a capacity of 144,000 m^3/d. MBBR capacity = 164,000 m^3/d.

PLANT DESIGN

The full-scale system was designed to treat river water to achieve treated water quality of NH_4-N ≤ 1.65 mg/l and TN ≤10 mg/l.

The plant consists of pre-treatment units (tube-settler for solids pre-sedimentation followed by fine screening), MBBR for the removal of soluble pollutants (BOD, COD, nitrogen) and submerged UF membranes for solids separation prior to disinfection.

Table 1 – Influent characteristics

Parameter	Inlet to MBBR, mg/l
BOD_5 total	29
BOD_5 soluble	17.4
Ammonia as N	17.9
Nitrate as N	5.1
Nitrite as N	0.7
TP	1.0

The MBBR was designed with a total Hydraulic Retention Time of approximately 2 hours, divided into five process stages:

- Stage 1 – Aerobic 1: preliminary BOD and NH_3 oxidation
- Stage 2 – Aerobic 2: final BOD polishing and NH_3 oxidation
- Stage 3 – De-ox: DO reduction and de-nitrification
  Ethanol is dosed, as necessary, to provide sufficient carbon source required for effective de-nitrification.
- Stage 4 – Anoxic: final de-nitrification
- Stage 5 – Post-aeration : reduction of residual carbon source and ensuring positive DO levels in the MBBR effluent.

Biomass carriers are utilized in all of the reactor stages.

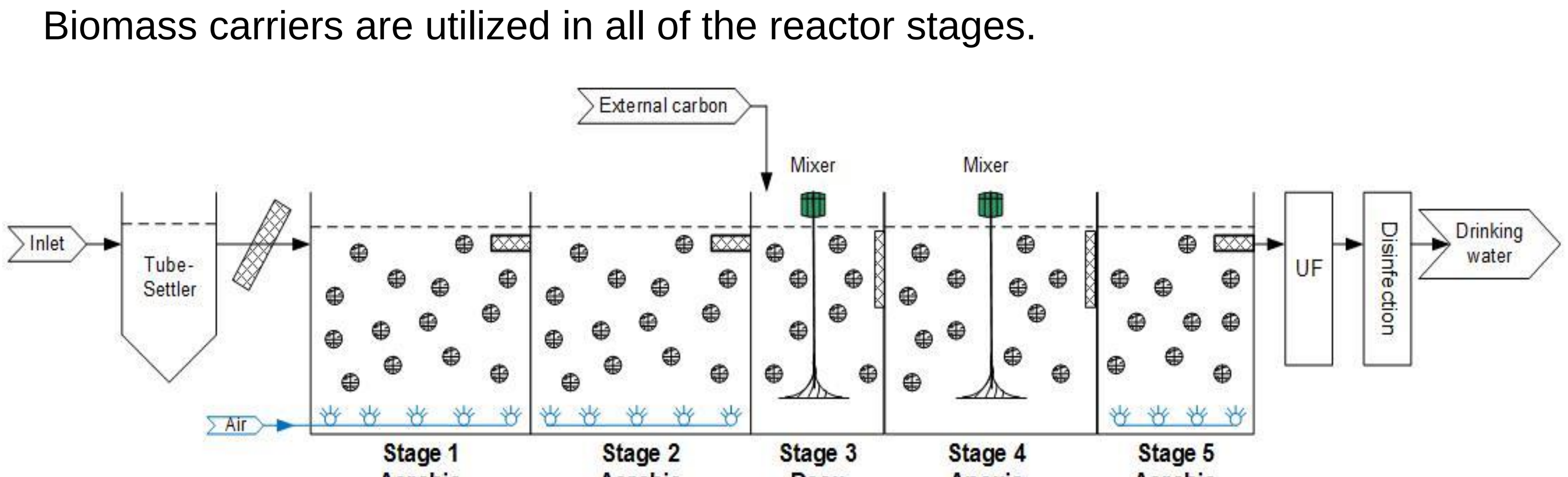

Figure 1 – Agra WTP: Schematic Process Flow Diagram

Figure 2 – Aerial view of the MBBR reactor

Figure 3 – Acclimated Aqwise Biomass Carriers (650 m^2/m^3)

CONCLUSION

The AGAR®MBBR - UF configuration demonstrates excellent robustness and has proven it can consistently meet performance goals and produce high quality drinking water, including at low temperatures.

It is concluded that the MBBR process provides an innovative and competitive alternative to conventional treatment methods.

Figure 4 – Well mixed media in aerobic stage

Figure 5 – Retention screens in aerobic stage

RESULTS AND DISCUSSION

Influent ammonia loading during August 2016 – July 2017 varied between 0.13 to 2.7 kg/m^3 media/day.
Figure 6 presents monthly average MBBR inlet and outlet ammonia levels and treated water quality after the UF membranes. The monthly average Ammonia levels entering the MBBR varied between 1.6 to 20.3 mg/l, with outlet levels consistently less than the required 1.65 mg/l.

During January to April 2017, parallel to the decrease of feed water temperature, the inlet ammonia levels increased to above the design criteria, as a result of reduced nitrification during the cold season in the wastewater treatment plants upstream of the Agra WTP which discharge treated effluents to the Yamuna river.
Fluctuations demonstrated an increase of 10 - 30% above the original design criteria. Despite this fact, MBBR outlet ammonia levels remained below the required level, while operating with increased DO levels.

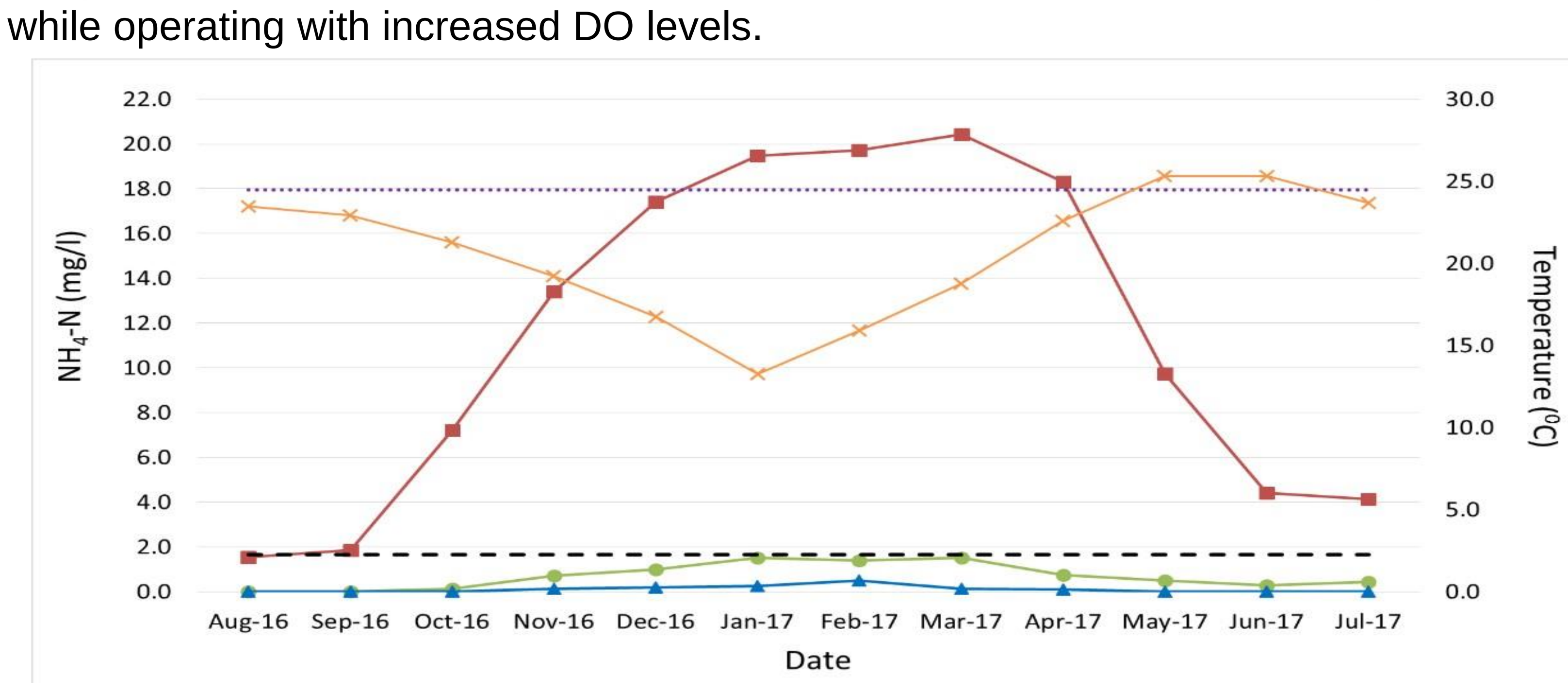

Figure 6 – Monthly average influent and treated water ammonia concentrations vs. water temperature

Figure 7 presents the monthly average inlet and outlet TN levels in the MBBR system, followed by the UF membranes. The monthly average influent TN to the biological system varied between 5.3 to 21.8 mg/l, while the TN level in the treated water was consistently less than the required 10 mg/l.

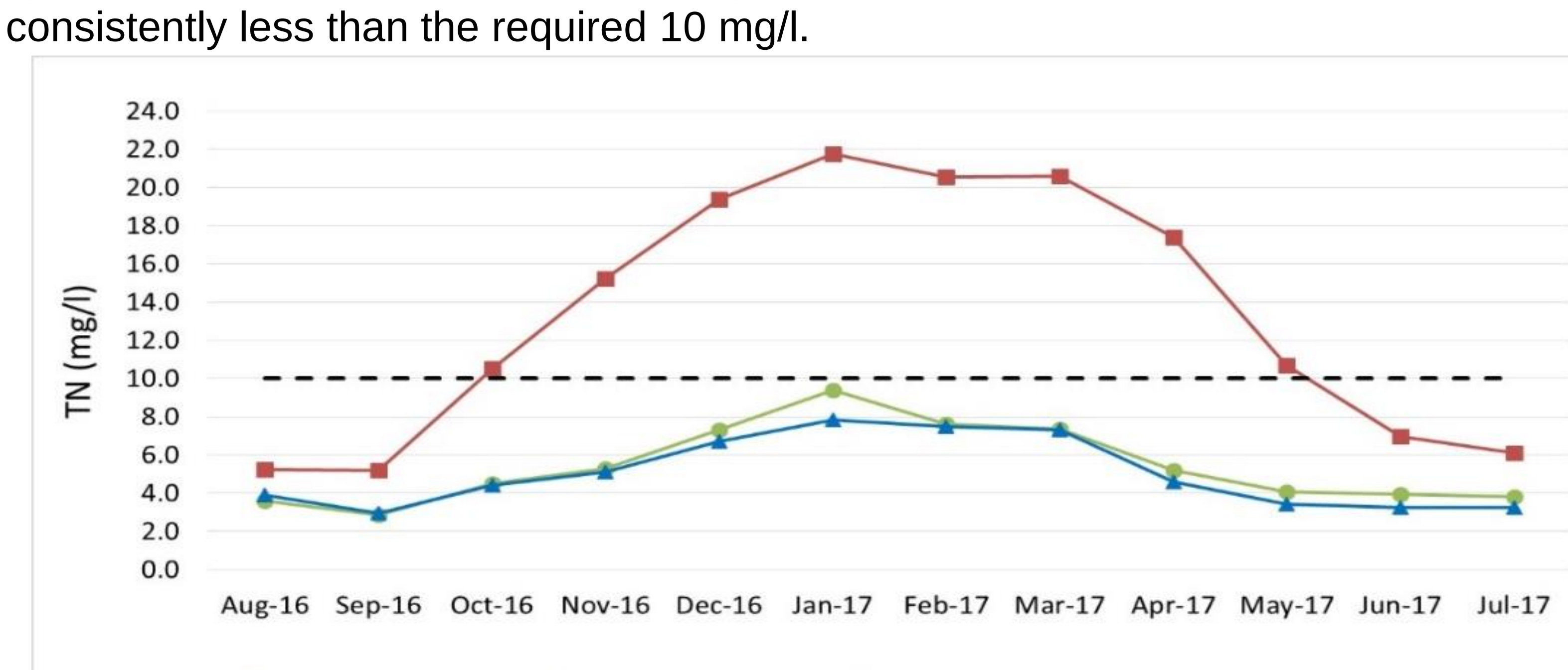

Figure 7 – Monthly average influent and treated water Total Nitrogen concentrations

References: [1] Aspergen H., Nyberg U., Andersson B., Gotthardsson Jansen, J. C., 1998. Post Denitrification in a Moving Bed Biofilm Reactor process. Water Science and Technology; [2] Ødegaard H., Rusten B., Siljudalen J., 1998. The Development of the Moving Bed Biofilm Process – from Idea to Commercial Product. Proceedings, WEC/EWPCA/IWEM Specialty Conference INNOVATION 2000, Cambridge, UK; [3] Rusten B., Hem L. J., Ødegaard H., 1995. Nitrification of Municipal Wastewater in Moving Bed Biofilm Reactors. Water Environment Research; [4] Blanc R., Leshem U., Kelkar U., Kumar S., and Rakesh A.K., 2013. Treatment of Polluted River Water for Potable Reuse using a 5-Stage Moving Bed Biofilm Reactor (MBBR). Proceedings of the 9th International Conference on Biofilm reactors (IWA); [5] Nof K., 2015. Removal of Nitrogen Compounds from River Water in India Using MBBR. Department of Civil and Environment Engineering, Technion