LIFT Scholarship Exchange Experience for Innovation & Technology (SEE IT)
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TRIP REPORT

SCHOLARSHIP UTILITY: *Fairfax County, Wastewater Management, Noman M Cole Pollution Control Plant (NMCPCP)*

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ATTENDEES: Sajana Chitrakar, P.E., Project Engineer, Fairfax County, Wastewater Treatment Division

TRIP DATES: 05/01/18– 05/03/18

UTILITIES/SITES VISITED:

Faculty of Applied Sciences, Delft University of Technology, the Netherlands
Garmerwolde WWTP, Netherlands
Epe WWTP, Netherlands

TECHNOLOGIES/INNOVATIONS SEEN: Nereda® Aerobic Granular Sludge

TRIP BACKGROUND and RATIONALE (250 WORDS): *What technology did you select to visit? What is the problem you are trying to address? How did you envision the LIFT SEE IT scholarship trip helping your utility?*

The primary objective of the trip was to determine if the Nereda® Aerobic Granular Sludge is an established treatment process that performs reliably at the established installations. We wanted to learn about the inception of this technology by visiting the laboratory where it was developed at the Delft University of Technology followed by the fully operational facilities at the Epe and Garmerwolde WWTPs to gain hands on knowledge on the maintenance and operation of this innovative technology. The only installation of this technology in the United States is the 0.2 MGD demonstration facility at the Rock River Water Reclamation District in Rockford, IL. There are no large scale installations in the United States.

The primary and secondary process improvement facilities at the NMCPCP are approaching the end of their useful life. As a result, facility improvement program is underway for the capacity increase and renewal of the existing infrastructure. However, the secondary process is limiting on the solids settling capacity and the capacity increase will encroach upon the available buffer which is not desirable. Hence the process intensification technologies that retain higher solids in the secondary process maintaining the same foot print is highly attractive.

Nereda® Aerobic Granular Sludge technology is one of the process intensification technologies currently marketed by Aqua-Aerobic Systems in the United States. As a part of NMCPCP secondary process upgrade program, a demonstration unit for the Nereda® technology is scheduled to pilot onsite later this year. The knowledge gained by the NMCPCP staff during the trip will be used to develop the pilot planning and testing for the pilot demo. Pilot testing results will inform the selection of the biological intensification process for the NMCPCP secondary process upgrade program.

The LIFT SEE IT Trip greatly help us understand the Nereda® aerobic granular sludge process better. The extensive research on the technology and the full scale installations that have been reliably operational provided confidence in the technology. The effluent quality of the Nereda® seems to be comparable to the secondary effluent at the NMCPCP but needs to be verified through the pilot testing.

TRIP SUMMARY (1 page max. Please include 10 photos and a 1-2 minute video montage from the trip. The video does not need to be professional, however if you have the means to create a professional video feel free to do so): *Why did you select the specific utility and technology for the visit? Based on your visit, do you think this technology/approach works for your utility? How useful was the trip in your decision making process? What were some of the trip highlights and takeaways?*

Delft University of Technology, Delft, the Netherlands

Delft University of Technology was selected for the site visit because the Nereda® aerobic granular sludge technology was developed in the research laboratory here by Professor Mark van Loosdrecht and his team almost 20 years ago. Their research led them to use the phosphorus accumulating organisms (PAO) for the basis of the aerobic granular sludge. The technology was developed through a public-private partnership with the Dutch Foundation for Applied Water Research (STOWA), six Dutch water authorities and Royal HaskoningDHV, a Dutch engineering consulting firm.

Visiting the research laboratory and hearing from the inventor himself answered many questions that we had about the technology and was very helpful. We learnt that the Nereda® process depends on retaining of the phosphorous accumulating organisms (PAOs) and Glycogen accumulating organisms (GAOs) which is the key to form the granules. The Nereda® technology works as a batch cycle with the following sequence – 1) simultaneous influent feeding in anaerobic conditions and effluent overflow 2) Aeration 3) Settling of granules. The anaerobic conditions in the granular blanket aid the PAO/ GAO selection resulting in the VFA uptake in the influent and from rbCOD. During the aeration sequence, nitrification occurs in the outer aerobic region of the granule and denitrification occurs in the inner anoxic region. The PAOs which are the nucleus of the granules take up soluble P during denitrification. The aeration sequence is followed by the quiescent settling that allows the formation of the granular bed.

The sludge volume index (SVI) for the granulated sludge is about 40mL/g compared to the conventional activated sludge SVI of 100-150. The quick settling sludge eliminates the footprint required for solids clarification. The slow setting flocs particles at the top of the granulated sludge blanket are wasted intermittently. The concentration of the wasted sludge is typically in the range of 2,000 mg/L and needs pre-thickening upstream of a solid handling process. The simultaneous feed distribution and effluent collection system design is critical to ensure that the proper upflow plug flow regime is established with no short circuiting. Nereda® technology also requires a robust pretreatment such as minimum 6 mm fine screens. System has successfully been applied with both raw screened influent and primary effluent.

Garmerwolde WWTP, the Netherlands, Nereda® Aerobic Granular Sludge Treatment Process

Garmerwolde WWTP was selected for the site visit because it operates the Nereda® aerobic granular sludge technology next to a conventional activated sludge technology, allowing for direct comparison. It serves the population equivalent of 140,000 with the average daily flow of 30,000 m^3/day (9.5 MGD) with the hourly peak flow of 4,200 m^3/hour (26.6 MGD). About half of the flow is treated by the AB (Adsorption/ Bio-oxidation) activated sludge process and the other half by the Nereda® system. Plant operator, Pascal Kamminga, explained to us that in summer time, they are able to push about 60% of influent to the Nereda(R) system and still meet the effluent discharge limits. The foot print for the Nereda® system appeared to be much smaller compared to the footprint of the AB process. The annual average effluent discharge limit for the Garmerwolde WWTP is TN < 7.0 mg/L and TP < 1.0 mg/L. Unlike NMCPCP, Garmerwolde does not have a NH_3-N limit allowing them to operate the reactors in low DO concentrations during aeration cycle. During high flow conditions in 2014 and 2015, they fed ferric chloride to the reactors to aid the phosphorous removal. The operator reported that it has not been needed since then.

Garmerwolde WWTP has 6 mm perforated screens followed by a detritus tank for grit removal. There are no primary clarifiers. A flow equalization tank is just upstream of the two Nereda® reactors. Wasting is done intermittently to get rid of the fluffy sludge at the top of the granule bed. The wasted sludge is pre-thickened in a sludge tank before being fed to the belt thickeners.

The reactors are equipped with the DO probe, NH_3-N, NO_3, analyzer, & Redox Analyzer. Aeration is based on the NH_3-N setpoint followed by the anoxic/ aerobic cycle. The Nereda® Controller is a PLC that is tied into plant's SCADA system. The Nereda® Controller comes with different "Recipes" where the batch cycle times, feed rates, aeration & anoxic times can be varied depending on flow and load conditions. The operator decides the level of control.

Epe WWTP, Netherlands, Nereda® Aerobic Granular Sludge Treatment Process

We visited the Epe WWTP which is the first municipal installation for the Nereda® Granular sludge technology in the Netherlands. This plant has been operational since 2011 and was inaugurated by the then Crown prince, now the King of the Netherlands. The average daily flow of the Epe WWTP is 8,000 m^3/day (2 MGD) with the hourly peaking factor of 4.5 and population equivalent of 54,000. The plant receives 25% of its COD load from slaughterhouses in the area. The Nereda® reactors at the Epe plant were designed to meet the effluent discharge limit of TN of less than 5 mg/l and TP of 0.3 mg/L. The process is un-manned most days of the week and operated from the central station of the Water Authority. There are three batch reactors with no flow equalization upstream. The system was designed such that one of three reactors is always in the feeding sequence. *The* reactors were equipped with mixers as a performance precaution. However, the mixers turned out to be unnecessary and have never been used. There is a sludge pre-thickening tank that receives the intermittent wasting from all three tanks. The pretreatment system consists of screening, sand trap and oil & grease removal. Nereda® system is followed by sand filtration before final discharge.

Key Takeaways from the trip:

- ✓ Nereda® Aerobic Granular Sludge is an innovative treatment process that has reliably met the effluent discharge limits in several facilities in Europe. The process has been studied in the laboratory for almost 20 years and operated at municipal wastewater treatment plants for more than seven years.
- ✓ The small footprint required for the process seems very attractive for both capital cost and land use considerations. In addition, the process eliminates the need of mixers and circulation pumps. Hence there is reduced capital equipment cost and electricity cost. The visited plants in Garmerwolde and Epe demonstrate reduced energy usage of about 40%
- ✓ For pretreatment, both the visited WWTPs have 6 mm perforated screens and grit removal. Neither of the visited wastewater treatment plant had primary clarification. The Garmerwolde WWTP had upstream flow equalization (buffering). The BNR process at NMCPCPC has pre and post flow equalization, which seems to be favorable for Nereda® process for wet weather management.
- ✓ The Nereda® process produces effluent quality comparable to the NMCPCP secondary effluent of TN of about 5 mg/L and TP of 0.5 mg/L. Unlike the NMCPCP, both the WWTPs visited do not have ammonia discharge limits. The Nereda® process effluent has a TSS concentration of about 10 mg/L. Like NMCPCP, the Epe WWTP had effluent filtration. So, the Nereda® process would appear to fit into the NMCPCP's treatment flowsheet. However, the operational and reliability data of the process for Fairfax County's wastewater characteristics and effluent requirements is unknown. The pilot demonstration is necessary for better decision making.
- ✓ The flow pattern of wasting from the secondary treatment process for Nereda® process is different than conventional activated sludge. Therefore, the impact of granular sludge on the NMCPCP solids handling process needs to be fully examined.
- ✓ The NMCPCP incinerates its biosolids with onsite multiple hearth incinerators. Multiple hearth incinerators have been known to have traces of cyanide in their scrubber water returned to plant headworks. The plants visited did not have onsite incineration. So, we were not able to observe the effect of incinerator scrubber water on the Nereda® process
- ✓ The plants visited have full instrumentation packages to optimize the Nereda® process and minimize energy use. Therefore instrumentation calibration and maintenance is important.