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IWA Webinar "Advanced control systems for nitrogen removal in full-scale water facilities" – Q&A Report
27 July 2023

Questions received from during registration:

#	Question	Speaker	Answer
1	Are online nitrogen analysers such as nitrates and ammonia reliable?		Yes, for the process objectives of presented case studies the sensors are reliable. This requires good preventative maintenance and sensor ownership.
2	Based on their experience what is the low-cost technology to be used in the rural sector		The presenters do not have experience with low-cost technologies in the rural sector.
3	Chances of organizing an informative and educating Nigerians on water treatment recent innovations and upgrades	-	dismiss?
4	Differences between heterotrophic and autotrophic bacteria	Pau	Heterotrophic bacteria consume organic compounds from wastewater and break them down into simpler compounds, helping to reduce the organic load. Autotrophic bacteria utilize inorganic carbon sources like CO2 to synthesize organic compounds and play a crucial role in processes like nitrification, converting ammonia into nitrites and nitrates.
5	How can we control sewage auto-aeration?	-	Answered live as part of the webinar
6	I want to explore more about in-depth knowledge and future scenario of the related topic	-	dismiss?
7	Is it necessary to optimize DO setpoints continuously? and how frequently?		This depends on multiple factors including process objectives and equipment capabilities.
8	What are the smarter control parameters in connection of intermittent aeration?		Dismiss? This question isn't clear
9	What is the best available technology of nitrogen treatment in sewage?		Dismiss? Unclear what the question is asking

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10	Which sensor is convenient and useful for controlling DO in biochemical systems?		There many DO sensors on the market which provide good control of biochemical systems.

Questions received via the Q&A box from participants:

#	Question	Speaker	Answer
1	Pau: Direct O2 feed vs. air for nitrification and the downstream impacts on denitrification? on DO control any differences?	Pau	A reduction in O2 in the aeration tanks into a post-anoxic basin has been observed to reduce overall carbon requirements. Are you asking specifically about differences in performance for cascade (do -> airflow) versus direct O2 control?
2	Pau: For optimum nitrification, are their secondary or micro-nutrient deficiencies to be on the outlook for?	Pau	If I understand your question correctly, it is possible for there to be micronutrient deficiencies but it is rare in municipal wastewater. The most common limitation facilities experience is alkalinity limitations for nitrifiers.
4	Hi, only one Ammonia sensor is used in the last aerobic tank. Will it be good to another Ammonia sensor in the middle tank also?	Jeff	There are 2 aeration control zones, but it is only one tank. There is no wall in between the two zones. However, to answer your question, yes, more data is always good, but it comes with additional maintenance and risk of faulty data. I find that striking this balance identifying what is the "right" amount of sensors to achieve your objectives is very difficult.
5	Could you please clarify what stands for "wc" (in a circle together with NHx) in the end of the second aeration tank?	Jeff	Wet chemical. The terminology that I typically use is sensor/probe when the measurement is made in the tank at a high frequency of measurement. I call it an analyzer when the sample is pulled out of the tank and the analyte is measured up on the deck. The frequency of these measurements (from an analyzer) can be much lower, but they can also be more accurate. In this case, I call it a Wet Chemical analyzer because we are adding reagent to initiate a color change and measure the concentration that way.
6	Slide 24: What (How many) are all the inputs for data driven model development	Jeff	It is a univariate time series model, so we only need to track the mechanistic model errors over time. We currently use a sliding window over two days to capture the data-driven model inputs.

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7	What is the role of Sumo software (the mechanistic model) in the system?	Jeff	We use the mechanistic model to capture XB,A and nitrifier kinetics. The mechanistic model is a digital twin that runs continuously on live data. So XB,A and nitrifier kinetics should be representative.
8	How do you estimate the value of XAUT in your mechanistic model?	Jeff	The mechanistic model is a digital twin of the biological process. It is continuously running on real waste rates, temperatures, influent TKN, etc. XAUT is always changing and we are capturing that change with the digital twin.
9	Jeff: how do you think the 4 advanced model performance(s) compare to modelling a more simple approach of using the influent load as the primary signal to the aeration control valve and the effluent NHx as a secondary (trimming) signal?	Jeff	I'm not sure. I would have to think on this some more. If there is work out there where this has been done, I would like to see it.
10	What happens when the influent has a large amount of nitrogen in the form of nitrates?	Jeff	The model would not see this, but I also don't know if it would affect the model/controller's performance because the controller has one objective to get ammonia to setpoint and I think it could still do that with nitrate around. Now, I will say, not related to this work at all, we measure the nitrate going into the second stage anoxic zone and pace methanol based on this nitrate measurement. So, even though it's not really related to this work, we should be prepared to deal with that scenario.
11	Is the light grey line measured value?	Jeff	Yes. It is the measured mechanistic model error. These should have been scatter points and not a line - sorry.
12	How many data points are used for model training, testing and validation.	Jeff	model training = from t - 15 days to t - 75 days model validation = from t - 1 to t - 15 days model testing = from t to t - 1 day
13	Jeff: How has adoption by plant operators been with the complexity of this modelling system?	Jeff	Well, I should clarify - this hasn't been deployed yet. All of the upfront work has been completed and we really just need to hit the "go" button soon. I will say, though, that the operators won't know the difference. The design will be that if the ammonia goes high because of a faulty sensor, poor model performance, etc., then

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			the control system will automatically revert to simpler controls and we will get an alarm/notification that the switch occurred. This is when we will have to manually troubleshoot and return the system to advanced control. My goal is for the operators to not have to worry about it.
14	What are the most challenging issues when implementing the control from modelling environment to the real system? Model cannot predict well enough, the data sensor is not reliable, or Scada system connections setup?	Jeff	Data sensor is not reliable is an issue, for sure, but the biggest hurdle was getting the connections established to have data flow from the DCS to the modelling server and back. This took > 1 year. Also, we struggled with the model crashing and solved this by pausing when there was a problem (instead of shutting down) and then attempting to model again after the pause.
15	Jeff, can you share what ammonia sensor brand you are using? what range of ammonia are you measuring at the end of the tank? based from recent experience it appears that sensors for ammonia tend to have a hard time accurately detecting the levels below 1 ppm.	Jeff	Typical range of measurement is 0-3 mg/L, which we believe we can measure accurately with our wet chemical analyzers that we built ourselves. Stephanie covered this in her presentation. I do agree that ISE sensors are not accurate below 1 ppm.
16	What components are there in a complete control system that you deliver to the WWTP?	Jeff	I think that this depends on the objective of the facility. For HRSD NTP, we have some very stringent limits - instantaneous TIN can never exceed 5. This has been part of the driver behind the more advanced control system. If you're just trying to control ammonia, I would say you need at least an ammonia sensor(s)/analyzer(s), DO probe(s), and modulating aeration control valves - assuming you have diffused air. This is a very tough question to answer.
17	Hi Vicky, how do we reduce energy consumption? and in terms of efficiency, what aeration and control technology is the most efficient?	Vicky	live answered
18	Vicky: any consideration of an additional rule: carbon footprint, i.e., CO2eq emissions reduction?	Vicky	For sure, it is not contemplated in our philosophy, indirectly yes due to energy reduction

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19	I have a question to Mrs. Ruano. OPR probes are known to be prone to adjusting to the average numbers. What is the accuracy needed (sufficient to control the processes) and if this kind of probes are available at the market currently? How reliable this probes system for a long period of operation?	Vicky	My experience, is that they are very robust, and for anaerobic/anoxic conditions are quite stable, and not so much accuracy, without decimals. There are several at the market with good quality
20	Jeff Sparks: How frequently do you update the mechanistic model parameters in the Digital Twin? and what is the typical data-range you use to recalibrate the model parameters?	Jeff	We are trying to find the new/updated nitrifier kinetic parameters every 24 hours, but this is probably too frequent. And, when we do these optimizations, we use the last 7 days of data. On a similar note, the digital twin gets new data from the control system every 1 minute, e.g. flows, waste rate, DOs, influent TKN, influent COD, etc.
21	Jeff: the control slide that Stephanie showed (10:57 am) is a schematic representation of my question	Jeff	I will look back at this. My email is jsparks@hrsd.com. Can you send me an email and we can discuss more separately?
22	Have you considered the possibility of developing software sensors to measure for example NO2?	Vicky	Not yet, but it would be really interesting in order to further considered the impact of NO2 generation depending on the operation of the biological process.
23	What is the energy requierment to mix anoxic zone to have the better contact between micro and water?	Vicky	To guarantee proper mixing the best as far as I know should be a mixer, in order to minimize oxygen in the chamber.
24	Vicky, yes energy reduction generates CO2 eq reduction but in this case there is no accounting for the added C source for denite	Vicky	In the case that I have shown there is no C addition, because denitrification is also forced in the anoxic chamber.... but when there is limitation of C for denitrification, there is another controller that optimised this dosage in order to minimise it...but if there is limitation and you can not change infrastructure is the solution that you have...
25	last speaker: did you do any kind of N2O monitoring in the PdN reactor (as diffuse emissions)?	Stephanie	we are working on that now

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26	Not sure is this covered, are any of these processes control applicable for high saline environment such as seawater?	Stephanie	Unknown, this work has been completed in municipal wastewater with a low salinity.
27	What type of valves are used for air control? Current experience with PID, butterfly valves do not provide sufficient range for control.	Stephanie	As more lineal behaviour better, but you can work with butterfly just adjusting your output of the control system must be adapted to the control valve curve
28	Where is the best location in aeration tank for sensors, for example, nitrate or ammonia sensors?	Stephanie	The location should be determined by your goals and objectives while utilizing this process control. Typically, the nitrogen sensors are located at the end of the aeration tanks.
29	Jeff and Klaus: What is your experience about sensor faults or failures. When they fail, how control happens	Stephanie and Jeff	I tried to answer this verbally, but we try to automate this the best we can so we automatically put data into bad quality when there is a fault and we alarm. When they fail, we have to revert to simpler modes of control.