

Love and art: key requirements for modeling and control of wastewater treatment plants

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Wastewater treatment plants – or water resource recovery facilities (WRRF) as they are now called – involve a magical world: microbial ecosystems. Microbes constitute the Earth's most ancient, abundant, and diverse form of life. To a large extent, we humans are indebted to microbes for our continued presence on Earth.

Among the many useful functions performed by microbes, their role in producing some of our finest foods (bread, cheese and wine among others) is worth a mention. Healthwise, gut microbes (i.e., our gut microbiota) provide us with the energy needed to breath, move and think and from a sanitary perspective, they guarantee the treatment and valorization the residues (i.e., dejections, waste and wastewater) of human activity.

Almost 30 years ago, I was recruited as a research scientist in a small lab in the south of France. My mission was to start a research group working on process modeling and control. At that time, my host laboratory was composed of microbiologists and bioprocess engineers working on carbon, nitrogen and phosphorus removal from wastewater. Therefore, I was the only mathematician in the whole laboratory. The hiring of my first master student heralded the foundation of my group, which I baptized 'Process Engineering and Control Engineering group'. This name was chosen, not just for the catchy acronym (i.e., PE[a]CE), but to emphasize the fact that modeling and control research must relate to real processes. Indeed, the message that I have always communicated to students is that if you want to discover something that is both useful and beautiful, you first have to understand the intimate workings of the application, in this case the process.

Over the years, one of my main sources of scientific inspiration has been Water Science and Technology (WS&T). Indeed, the content of this journal is grounded in real-world problems and written by practitioners. In particular, I believe that I have read cover to cover all of the special issues devoted to

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the ‘Instrumentation Control and Automation’ (ICA) conferences. The first ICA conference was held simultaneously in London and Paris in 1973 (it must have been a nightmare to organize a conference in two different locations!), while the 7th edition (1997) was held in Brighton. For the latter, a paper that I enthusiastically submitted to the conference was accepted... as a poster. Unfortunately, the rules in my laboratory stated that to attend a conference you had to be accepted for at least an oral communication. What a disappointment it was! I had to wait four more years for the next one, organized in Malmö in 2001. This time, to increase my chances of success, I submitted no less than 6 papers! All were accepted.....as posters. Of course, my proposals dealt with modeling and control of anaerobic digestion processes, while most ICA attendees at that time were working on activated sludge. No oxygen, no interest from the ICA community! However, to my great surprise the Chair of the 2001 ICA conference (a certain Gustaf Olsson) contacted me by email. He told me that he really appreciated my published work and encouraged me to attend the meeting in Malmö. To help convince my lab director, he invited me to chair a session during the conference. Eureka, it worked! The conference was memorable, not only for the science presented but also for the encounters I experienced. Among these, was my encounter with Gustaf. I was proud and flattered to be invited by Gustaf to dine at his table for the gala dinner! Gustaf, you probably do not realize, but your generous gest toward the young scientist that I was at that time has influenced me ever since. As a senior scientist, I try to emulate your example in my relations with younger colleagues. Clearly Gustaf, your generosity and humbleness, are manifestations of your love of both science and people. Those are very inspiring and noble qualities.

Twelve years after my ICA baptism in Malmö, I had the honor to organize and chair the 11th ICA conference held in Narbonne. Fittingly Gustaf, you accepted to deliver the opening talk at the conference. I was immensely proud, because you are an iconic figure of ICA, having attended every edition since 1973. Moreover, your ability to foresee future trends is always so accurate and so appropriate! Your talk resulted in a paper published – of course – in *WS&T* (Olsson *et al.*, 2014), the journal you saved a few years earlier when the world of the scientific edition decided it could no longer be referenced as an international journal because of its specific policy regarding the selection of papers presented at international conferences (Figure 6.1).

Building a model and calibrating it to accurately represent experimental data is a subtle art. Over the years, I have battled to reconcile experimental



Figure 6.1 Pictures of Gustaf Olsson at the opening of the ICA conference in Narbonne in 2013.



Figure 6.2 Gustaf and me after a PhD defense in Girona, Spain.

data with simulations. When it all comes together, when the structure of the equations reflects the biological reactions involved and when parametric values reflect the experimental kinetics and the sensitivity to variations is low....in a nutshell, when the model is precise, reliable and robust – it is like music to my ears. Finding and assembling the different pieces of the puzzle, in this case the model, is a major undertaking. However, when one is successful, it is like a musician that discovers music that matches the lyrics of a song.

My analogy to music provides the opportunity to recall a lasting memory of the ICA conference in Quebec in 2017. For the opening session, we were all gathered in the amphitheater, waiting for the conference to begin. As participants waited in expectation, they were treated to piano music. Everyone assumed that it was recorded. However, when the curtains opened we discovered that it was the multi-talented Gustaf, playing the piano!

Last but not least, another memory comes to mind. A few years ago, Gustaf and I were invited to a PhD defense in Girona, Spain. Following the defense, during the lunch a waiter approached our table and said 'be careful, the plate is hot'. So, what was Gustaf's reaction? He reached out and touched the plate. He immediately exclaimed 'whaooh, it's hot!'. At that moment, your basic curiosity got the better of you, rather like a child thirsty for new discoveries! That day, the only thing that separated you from childhood was the fact that it was your first day of retirement!

For all of these great memories and for everything you did to promote ICA and the cause of WRRF all over the world, *tack så mycket*, Gustaf. I already miss your presence, but I know you'll always be around if needed (Figure 6.2).

REFERENCE

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