Student collaboration provides new insights into high-quality drinking water at lower cost

September 7 2021

Queen Mary Chemical Engineering students Jamila and Phoebe with colleagues in the Waternet labs, Amsterdam. Credit: Queen Mary, University of London

Extensive purification is required to produce reliable and tasty drinking water. Purification consists of a series of processes, and water softening is an important step in water treatment. Currently, most water softening

processes use a specific type of softening reactor, known as liquid-solid fluidised (LSF) bed reactors. It is estimated that millions of cubic meters of water per year are softened using this approach.

The recent study, published in the journal *Chemical Engineering Science: X*, used state-of-the-art computer simulations as well as experimental data to examine the fluid dynamics within these softening reactors.

Traditionally, it has been thought that these reactors show homogeneous behavior, where grains within the reactor are uniformly dispersed throughout the fluid without observable gaps.

However, the research team, which included researchers from Eindhoven University, Delft University, Queen Mary, Utrecht University of Applied Sciences and water cycle company Waternet, found that these softening reactor granular beds instead had a heterogeneous structure with local voids and instabilities.

It is expected that these findings will enable the optimisation and improvement of current drinking water softening processes, as the observed heterogeneity affects crystallization and chemical reactions associated with the softening process in unexpected ways. In turn, this could lead to the production of high quality softened drinking water at a lower cost, and with reduced CO_2 emissions.

Providing students with research experience

Two Queen Mary undergraduate Chemical Engineering students, Jamila Rahman and Phoebe Berhanu, are co-authors on the paper and were involved conducting the experiments, as part of their Industrial Placement year at Waternet Amsterdam last year.

Dr. Edo Boek added: "It's exciting to see that within the first cohort of

our new Chemical Engineering program we've been able to provide our students with the opportunity to become co-authors on a peer-reviewed published study, as well as provide them with vital industrial experience."

We spoke to Jamila and Phoebe about their Industrial placement experience at Waternet and how it feels to contribute to a published research paper.

How did you become involved with the research?

"We were previously aware of the project due to our problem-based learning module as part of the course. However, it was the enthusiasm of Onno Kramer (Waternet and TU Delft) regarding the gap in this science which really drew us to it. We started with discussions on quantifying methods and the scope of this idea ultimately led to this published paper."

Could you tell us a bit more about your industrial placement?

"The industrial placement began with familiarizing us with the fluidisation columns at Utrecht University, we spent this time working with other interns, testing the flow and particle behavior of multiple particle types, noting any differences in visible void patterns. This naturally progressed into a development of our own personal projects for Waternet, while also working with Onno on his Ph.D. theory. He was planning to demonstrate that liquid-solid fluidisation systems were usually heterogeneous not homogenous as stated in many literature articles. Onno was a flexible and understanding supervisor who allowed us to develop our independent learning abilities, giving us the freedom to ask questions and receive the answers where possible, even when it was

not related to the task."

What skills do you think this project helped you develop?

"We have developed professional communication skills as well as conflict resolution. We have also learnt how to work independently as we would not be given straightforward directions and it was our responsibility to define and navigate our projects. Therefore, we have learnt to take self-accountability and taking proactive actions."

Phoebe: "I worked on Rapid Sand Filtration (RSF) and the workings of the particles within Waternet and the UK. I believe during this time I developed my independent research skills, and my understanding of how to summarize large quantities of text and its importance."

Jamila: "I focused on using ImageJ (a software used to process and analyze scientific images) and its importance for understanding particle size and involvement with its fluidisation behavior. The main skills I learnt were detailed analysis and problem solving."

What impact do you think this research will have?

"This research explicitly shows that heterogenous mixing is the usual case, not homogeneous. This will open up for more productive calculations for quantity and tailored processes for industrial use, meaning it will be both cost effective and lead to less potential waste. For us this research has really demonstrated, to ourselves mostly that if we apply ourselves, we can achieve, if we open our minds to new opportunities, we can be guided into new adventures."

What did you enjoy most about your placement?

"We enjoyed the culture of working in a large company, of meeting interesting people with years of expertise in the field behind them, of having the flexibility to be creative and innovative. As we went abroad for this placement, traveling around in Europe and exploring the Netherlands was a highlight as well!"

How do you think your placement will help you in your career/further study?

"So far this placement has become an interesting talking point in almost all of our interviews. The fact that we went abroad for our placement really sets us apart from other candidates. It also indicates our ability to work successfully in an industrial and professional environment. Also, we have experienced two styles of management during our time at Waternet, both different and unique which will hopefully prepare us to become managers or supervisors ourselves in the future."

More information: T.M.J. Nijssen et al, Experimental and numerical insights into heterogeneous liquid-solid behaviour in drinking water softening reactors, *Chemical Engineering Science: X* (2021). DOI: 10.1016/j.cesx.2021.100100

Provided by Queen Mary, University of London