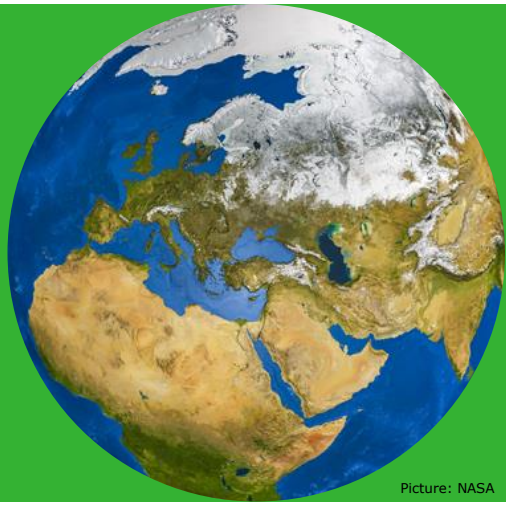
Environmental Technology

Newsletter | Spring 2020



Picture: NASA

WAGENINGEN UNIVERSITY
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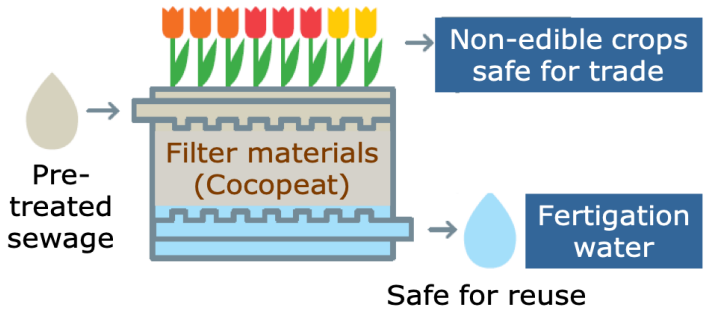
Best Presentation award for Elackiya Sithamparanathan

ETE researcher Elackiya Sithamparanathan won the 'Best Presentation Award' for her oral presentation at the 6th BeNeLux Young Water Professionals Conference, held from February 12-14 in Luxembourg. Her talk, '*Vital Urban Filter: A novel solution to remove micropollutants from urban wastewater for healthy reuse.*' was chosen as the winner from a total of 44 presentations. The organizing committee highly appreciated her visual and concise performance, highlighting the importance of the topic on water treatment solutions.

Clean urban wastewater

The scientist presented a novel water treatment technology, a so-called 'Vital Urban Filter' (VUF), to more effectively clean urban wastewater using biological, chemical and physical processes. In many of India's big cities, wastewater is not treated at all, and is discharged in local rivers. Nevertheless, people use this polluted water for irrigation and other purposes. The use of her VUF provides a cost-effective and efficient water treatment method.



Schematic representation of the VUF design.

Crucial step

To improve the water quality of India's big cities, Indian and Dutch research institutes collaborate within the LOTUS project to implement effective wastewater treatment methods. Elackiya's VUF forms a crucial stage in the technology. It is based on the traditional constructed wetlands, where filter materials, plants, microbiota and sunlight remove pollutants from wastewater. However, due to a different design and

Column

Sybrand Metz, Technical Director of DeSah

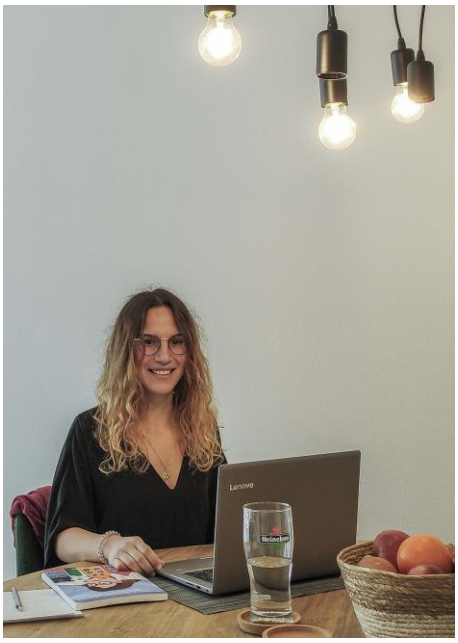
Climate change, droughts, population growth, and shortage of resources are all different drivers that make us aware that we should use our resources (water, energy and fertilizers) in a more sustainable, circular way. There are many different solutions that allow for a sustainable treatment of resources while maintaining a high, or offering an even higher, comfort level.

At Desah we challenge the status quo in wastewater treatment. We believe that energy, fertilizers and clean water can be recovered from household wastewater locally and therefore being more cost-effective and sustainable compared to the current way of collecting and treating wastewater.

The key enabling technology in this approach is the anaerobic digestion of concentrated toilet water. Desah cooperates with ETE and Merijn Moerland in the run for life project for the recovery of fertilizers. Besides this project Desah cooperates with ETE in Wetsus since 2005. In fact, Desah is a spinn off company from Wetsus and comercializes the source separated wastewater treatment approach developed by ETE. An important highlight in the existence of Desah is the demonstration project Waterschoon in Sneek where 230 houses are equipped with vacuum toilets and where the wastewater is treated by anaerobic digestion. This project convinced others on the potential of the technology and installations are currently being build in the Netherlands, Sweden and Canada.

Wastewater treatment installation (Waterschoon) for black and grey water in Sneek.

using filter materials like coco peat, there is increased plant growth and microbiological activity. This results in a more effective pollutant removal. The use of ornamental plants, instead of marsh plants, adds a vital economic benefit.



Solid reasoning

Elackiya thinks she won the prize because of the importance of the topic she addressed. Also, her research purpose, solid reasoning regarding the experimental set-up and selection of contaminants to be removed probably contributed to her winning format. But she also made her presentation very attractive by using many images and graphs. 'Pictures from the experimental site, the use of graphs as well as the overall structured presentation helped me to convey the message', she says. 'The audience was clearly attracted to the visual aspects of my talk.'

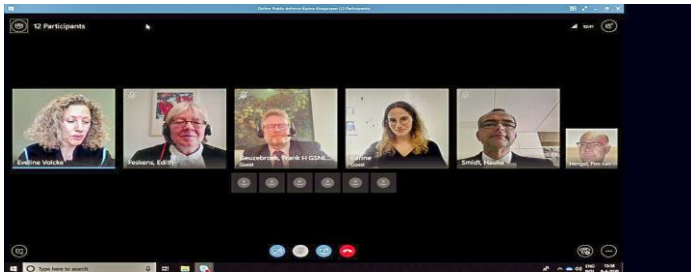
First online defence of ETE PhD thesis

Because of social distancing to minimize spreading of the Corona virus, Wageningen UR implemented an adapted format to continue PhD defences: the whole ceremony and defence are taken online. An unusual situation, but for Karine Kiragosyan, the first ETE PhD student defending her thesis online, it was a good experience. 'The technique worked well, I could see all opponents and also the Pedel was connected. And I even had an online party after the ceremony!'

In a very short time, the Corona virus has changed our society dramatically. Social distancing has partly locked our society, but at the same time, creativity has resulted in solutions to keep life going on as normally as possible. To allow PhD students to graduate, despite Corona, Wageningen UR organizes the defences online. A quite unusual and unique situation, but for Karine Kiragosyan it all worked out well. 'The student that defended his thesis before me had some technical issues with the connection', Karine says. 'That was nerve wrecking, but for me, the technology worked and it all went very smooth. After the first opening questions, I thought: ok, I can do this.'

Efficient method

Karine successfully defended her thesis: *Maximization of sulfur formation in the presence of organic sulfur compounds in a dual-bioreactor gas desulfurization system*. Together with company Paquell, she studied the removal of sulfur compounds from natural gas. 'When only hydrogen sulfide (H_2S) is present in gas, bacteria can oxidize it to pure sulfur, resulting in an efficient removal', she explains. 'But sometimes organic sulfur components are also present, like thiols, and these are toxic to bacteria.' Using the patented double reactor system, developed by Paquell, Karine managed to develop an efficient method for sulfur removal. Her first step was to select bacteria that were resistant towards the thiol toxicity. Then, she identified the chemical pathways and reactions that were most efficient in converting all sulfurous compounds into pure sulfur.



Online party

For a smooth organization of her defence, a specially designated coordinator was responsible for the online connection. 'When I logged in to Skype for Business and saw myself on the screen, I thought: OK, I'm live now', Karine says. 'But I really liked that everything was kind of similar to an ordinary defence: I could see all opponents, dressed up in their toga's, and also the Pedel was present. That was all really nice!' However, due to Corona rules, no Paranymphs were allowed to be present in the room with her, and they couldn't participate through skype because the number of connections should be limited due to possible disturbance. Karine: 'So, it was quite sad that my friends can't support me by my side, but I knew that they were watching.' The 45 minutes of the defence passed very quickly. 'The words 'Hora est' from the Pedel, meaning 'it is time', came as surprise for me', the scientist says. 'After the ceremony, I was relieved and wanted to party, but of course I couldn't. However, my friends organized an online party. That was a great surprise!'

Science: Urban planning and design for sustainable cities

Future cities have to be more sustainable to deal with limited resources and climate change. ETE scientist Ilse Voskamp is analysing energy and water use in Amsterdam. In addition, she is identifying key factors influencing consumption of these resources. This knowledge forms a scientific basis for landscape architects and urban planners to design sustainable cities.

Cities are hotspots of consumption and waste production. Consumption of resources like raw materials, food, water and energy is increasingly concentrated in urban areas. Nowadays cities even consume about three quarters of global material and energy supply. These resources are not only used by residents and industrial processes, but also to operate and maintain an extensive infrastructure of electrical networks, sewage systems and drinking water treatment facilities. At the moment, already more than half the world population is living in cities and urbanization is still ongoing, putting extra pressure on limited reserves and the earth's ecosystem. Therefore, more sustainable city designs are needed to safeguard reliable resource supply, avoid resource depletion and the continuing destruction of the natural world. So, urban planners and designers need science-based information for different, sustainable and climate-robust city designs, where resources are efficiently utilized and recycled.

Evidence-based decisions

Worldwide there are thousands of cities that have expressed their ambitions to become more sustainable. These cities also have in common that they expect to have a substantial growth. The city of Amsterdam is one of them: more than 50.000 houses are planned to be built in the coming 15years. This is an excellent opportunity to design more sustainable residential areas. But before starting resource-conscious building projects, information regarding so-called 'urban metabolism', is crucial. This term refers to all resource flows into and out of the city. Voskamp: 'A city is almost like a living organism or an ecosystem, where there's input of all kinds of resources like building materials, food, water and energy. On the other hand, there's also output like waste, waste water and CO_2 emissions. A sustainable city closes cycles by smart reuse and recycling, similar to what happens in a natural ecosystem.' Information regarding resource flows can help planners and designers to make evidence-based decisions for

making cities more sustainable and work towards circular urban metabolism.

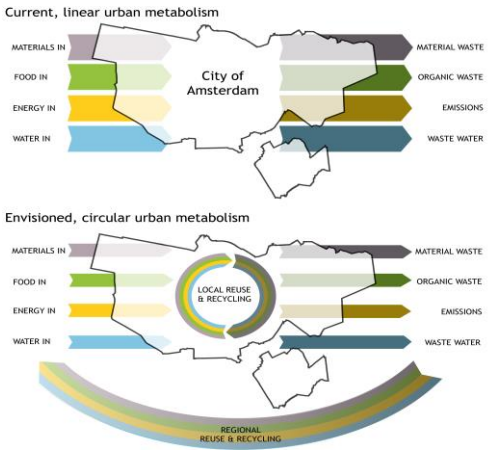


Fig. 1. Schematic representation of linear vs circular metabolism.

Crucial data

Currently, information regarding urban metabolism, including resource flows like energy and water, can be generated using a so-called *material flow analysis*. This method helps to understand and to quantify all resource input and output from a city. 'Unfortunately, the data collected using this method are not detailed enough and are therefore not suitable yet to help urban designers', Voskamp says. 'It gives information about resource use in the whole city, but lacks crucial data on use in individual city parts.' In addition, designers need to know underlying reasons for a low or high resource use of particular residential areas, which is currently not provided by this method. For instance, a high energy and water use can be due to the type and age of a house and the presence of a garden. Also, the type of consumer is important and water and energy consumption patterns can also be a reflection of a household size or income level. According to Voskamp, this type of information is crucial to (re)design residential areas sustainably.

Smart choices

Urban metabolism is not only influenced by consumers and house types; also changes in society play a role, the scientist found out. For example, increased economic growth, and a consequent higher standard of living of the residents, may result in more water and energy use. Therefore, to make smart choices for a sustainable design, it is essential to know the group of residents and their specific needs first. 'Different consumer groups have different preferences', Voskamp explains. 'Factors regarding age, income and household size determine what type of house fits a specific group, while at the same time these factors influence water and energy use.' Depending on the kind of residents, fundamental choices have to be made regarding house and garden size, atmosphere in the neighborhood, green areas, and infrastructure. The challenge for the designer is how to integrate all this within a sustainable design. A larger house with a garden could result in higher water use for irrigation and energy use for heating. But at the same time, a large house has more room for solar panels on the roof, while more space around the house enables the residents to recycle or harvest rainwater on their own property. Also, a garden allows a better water drainage after extreme rainfall, making such an area more climate-proof. But the same could also be achieved by integrating more, green public space in the area. Voskamp: 'So, having this level of detailed information regarding consumer characteristics, resource use, and the possible coherence, is important for designers and planners to better understand resource flows. This helps them to eventually come up with resource-conscious solutions and improvements in their designs that fits different consumer groups.'

© OMA/FABRICations/Lola Landscape architects (2018)

Artist impression of the future 'Bajes Kwartier' in Amsterdam.

Future vision

According to Voskamp, a sustainable design of neighborhoods in the city also requires strategic sustainable planning, a future vision how you want Amsterdam to be in 50 years' time. This vision is also needed to match the choices made for residential areas with this vision for the city as a whole. Voskamp: 'What are the desired type and size of houses, and what possibilities do they offer for a resource-conscious design? To what extent is there the possibility to implement renewable energy technologies and recycling on larger properties, for example in industrial areas, instead of residential areas?' Eventually, for Voskamp a sustainable Amsterdam is much more than just optimizing resource flows and recycling: 'It is also about livability

and resilience to a changing climate, where dealing with more extreme heat and rainfall in the city will be important issues', she says. 'In the future, I envision a sustainable Amsterdam that is part of a much larger sustainable ecosystem.'

This research is part of the Urban Pulse II research project under the auspice of the Amsterdam Institute for Advanced Metropolitan Solutions (AMS). In Urban Pulse, academic, societal, and industry partners aim to acquire an understanding of the spatial and temporal dynamics of resource flows in Amsterdam.

Selected publications

Voskamp, I.M., Sutton, N.B., Stremke, S., & Rijnaarts, H.H.M. 2020. A systematic review of factors influencing spatiotemporal variability in urban water and energy consumption. J. Cleaner Prod. 256: 120310. https://doi.org/10.1016/j.jclepro.2020.120310

Voskamp, I.M., Spiller, M., Stremke, S., Bregt, A.K., Vreugdenhil, L.C., & Rijnaarts, H.H.M. 2018. Space-time information analysis for resource-conscious urban planning and design: a stakeholder-based identification of urban metabolism data gaps. Resour. Conserv. Recycl. 128, 516e525. https://doi.org/10.1016/j.resconrec.2016.08.026

Science: Recovering nutrients from human toilet waste: producing pathogen-free phosphorous and nitrogen, while generating energy.

As part of the EU-funded project Run4Life, ETE scientist Merijn Moerland is developing a method for efficient and hygienic nutrient recovery from toilet waste. To avoid the presence of human pathogens, allowing the nutrients to be applied as fertilizers for crops, the scientist is modifying existing wastewater cleaning processes to operate at higher temperatures.

Phosphorus (P) and nitrogen (N) are important nutrients for plant growth in agriculture. Because of a growing world population, demand for these fertilizers is increasing. However, a lot of N and P is lost, for example due to insufficient recovery: less than half of all phosphorous and only a few percent of nitrogen are recovered in current wastewater treatment plants. Since nutrient reserves are limiting, closing cycles by recovery and subsequent recycling is highly important to guarantee sufficient supply in the future. In addition, insufficient retrieval may result in discharge in surface waters, where they may cause eutrophication, resulting in massive algae blooms. This damages the ecosystem.

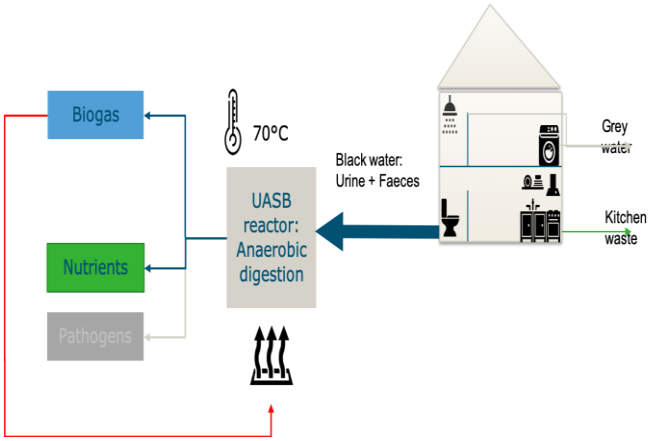
Highly diluted

Currently, a more efficient recovery of these nutrients is difficult due to their low concentrations in household wastewater. Relatively clean water from shower and kitchen (grey water) as well as more polluted and nutrient-rich toilet water (black water) is mixed, ending-up in the same sewage stream. 'This results in highly diluted nutrients, that are more difficult to recover', PhD scientist Merijn Moerland says. 'To make this process more efficient, a separate collection of relatively clean grey water, from shower and kitchen, and toilet waste, black water, is needed, for example, using vacuum toilets.' Grey water can be reused, for example as irrigation water, with relatively little treatment. Black water, however, contains large amounts of P and N, and has to be cleaned separately while recovering nutrients. On a yearly basis, about 4.5 kg of N and 0.5 kg of P can be recovered per person. But the presence of human pathogens, like viruses and bacteria, limits the use of these nutrients: they cannot be used as fertilizer for crops because of safety and health issues.

Vacuum toilet using about half a liter of water per flush, instead of six liters in conventional toilets.

Generating energy

To make the N and P recovered safe for reintroduction in the food chain as agricultural fertilizer, the pathogens have to be removed. To achieve this, Moerland modified an existing biological process for black water cleaning: the well-known *Upflow Anaerobic Sludge Blanket* (UASB) reactor. 'In a first step, microorganisms ferment the organic compounds into biogas. The absence of oxygen preserves the energy present', he explains. 'In this process, the nutrients become dissolved in the solution and can be recovered.' However, to remove the pathogens present, the process has to be performed at a higher temperature of 55-70 °C. At these temperatures, pathogens are expected to be killed, but at the same time, it is challenging to find temperature-resistant bacteria, that can still ferment the organic compounds present at this higher temperature.



Schematic overview of separate collection and processing of black water. Anaerobic digestion at high temperatures kills human pathogens, while biogas is produced for heating the system.

Efficient nutrient recovery

To find the right temperature-resistant bacteria, Moerland collected sludge from running anaerobic reactors. This sludge usually contains many different species of bacteria. By running such a sludge sample in a reactor at 55 or 70 °C, only the heat-resistant bacteria survive. Eventually, by using this natural selection, he managed to collect the right bacteria for the process. During the next steps, the scientist tested the effectivity of the high temperature to kill the pathogens present, and to fine tune reactor conditions, like pH and flow rate. Finally, Moerland had to develop an efficient nutrient recovery technology. 'One of the challenges is to have the chemistry for nutrient recovery working: black water contains a lot of solids and different components', Moerland explains. 'In this highly varied chemical mixture everything reacts together. It is therefore difficult to find the right chemistry to retrieve the nutrients present.'
As soon as the chemistry works, the next step is to design a system that is as simple and straightforward as possible and can easily be applied in a residential area. Moerland: 'Preferably the whole process of biogas production and nutrient recovery should take place in a single reactor. To make the process as energy neutral as possible, the biogas formed can be used to heat the reactor.'

Real-life situation

Moerland is currently developing the high-temperature cleaning and nutrient recovery process in the laboratory using small, five-liter set-ups. Once the technical challenges have been solved, the next step is to test the concept in a real-life situation. 'Together with water technology innovation company DeSah BV, we are planning to implement these high temperature reactors in an experimental residential area, consisting of 32 houses in Sneek', Moerland says. 'I expect that we can start large-scale testing within half a year.' If the technology works out as expected, safe fertilizers can be recovered from human waste.

Selected publication

Bisschops I., Kjerstadius H., Meulman B., & van Eekert M. 2019. Integrated nutrient recovery from source-separated domestic wastewaters for application as fertilisers. Curr. Opinion Environ. Sust. 40: 7-13.
https://doi.org/10.1016/j.cosust.2019.06.010

Environmental Technology for Impact 2020 conference

With great pleasure the department of Environmental Technology (ETE) will host the virtual ETE for Impact conference to celebrate the 55th anniversary of the department.

More than 50 speakers will cover the most innovative developments in the field of treating and valorising waste and (waste)water. Environmental Technology for Impact 2020 will provide a state-of-the-art overview of many more conventional or future technologies to tackle environmental challenges in the coming decades. These include resource recovery, micro-pollutants removal, and fuel cells.

Information and registration

The online conference will be held Wednesday June 3rd in the afternoon (starting at approximately 12:30 GMT+2) and Thursday June 4th in the morning

(Starting at approximately 8:30 GMT+2). You can find more information and a button for (free) registration on **www.etei2020.org**. Also keep track of updates on our website.

Keynote speakers

The following keynote speakers will update us on the most recent developments in Environmental Technology:

- Dr. Ghada Kassab - University of Jordan
- Prof. Francisco J. Cervantes – UNAM

We look forward to "meet" you in our online conference in June 2020!

Agenda

PhD defences (Online):

Arslan Ahmad, June 5th 2020, 11.00h. Arsenic removal by iron-based co-precipitation.

Delaram Azari, July 3rd 2020, 11.00h. Future urban energy systems: Harnessing demand side flexibility and managing data uncertainty.

Silva Vega Hernandeze, September 1st 2020, 11.00h. Arsenite oxidation and removal in the bioscorodite process.

Azie Sabri, September 4th 2020, 11.00h. Antibiotics and antibiotic resistance genes in wastewater: where and how to remove them.

Louis Legrand, September 11th 2020, Wetsus. Flow-through capacitive processes for carbon capture and energy recovery from flue gas.

Pauline Sosa, September 11th 2020, Wetsus. Recovery of valuable polymeric solutions by lowering the salinity using electrodialysis.

Victor Ajao, September 11th 2020. Wetsus. Wastewater-based flocculation.

Kasper de Leeuw, November 3rd 2020, 16.00h. Engineering chain elongation bioprocesses for branched fatty acids.

Conferences

ETEi2020. June 3-4 2020, 13.30h. Wageningen.

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