Environmental Technology

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WAGENINGEN UNIVERSITY
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Picture: NASA

Two new tenure track positions for ETE

ETE has gained funding for two new tenure track positions. The new employees will strengthen the team with new expertise, filling in important knowledge gaps.

ETE has made clever use of funding from the Ministry of Education to boost innovation. 'ETE has excellent opportunities for developing innovative technologies. Wageningen UR academic board has asked us to propose and describe potential positions', ETE Professor Huub Rijnaarts says. 'Together with my colleagues, especially Jouke Dykstra, we made an inventory of new expertise needed. Luckily we were granted funds for two junior tenure track positions.'

One of the tenure trackers will deal with improving the infrastructure and technology around wastewater treatment. ETE has excellent expertise in this field. 'But we have to deal with increasingly concentrated, slurry-like waste streams, with a varying and sometimes high viscosity', Rijnaarts says. 'This influences the chemical and biological processes in our wastewater treatment and resource recovery reactors.' This means that conditions may differ within the same reactor and consequently, so do different processes. The new tenure tracker should have and build expertise regarding fluid mechanics and effects on processes, to smartly benefit from these differences in more efficient resource recovery.

The other tenure tracker will deal with challenges in urban engineering, by using so-called smart grids: a network of transport lines that optimizes supply and demand of resources, using advanced models and monitoring. 'In the circular economy, sustainable energy, but also resources recovered from wastewater treatment, are produced at different locations', Rijnaarts explains. 'To efficiently distribute these towards the customers smart grids can be used: how do you adequately match supply and demand in time and space?' Developing and applying models to optimize production, storage, transport and delivery will be an important task of this new position.

By April 1st 2020, ETE expects to welcome the new colleagues.

Column

Huub Rijnaarts & Cees Buisman

In 2020 it is 55 years ago that the Department of Environmental Technology was established. That means that in the first week of June 2020, it is time again for our traditional conference, held every five years. The central theme of this unique conference will be focused on innovations, technologies, systems and concepts that can solve pollution issues as well as resource recovery challenges. For example, removing selenium or pharmaceuticals from wastewater, while recovering phosphate or selenium to close nutrient cycles.

We invite all environmental engineers worldwide to participate in our conference and give a scientific contribution by presenting their latest innovations and technologies. We believe environmental technologies are more needed than ever in a world with an ever-growing population that never seems to have enough wealth, putting a high burden on the environment.

In addition to our conference, we will also organize an alumni event for professionals graduated at ETE in Wageningen. Please have a look at the program on our website: www.etei2020.org

Together we can innovate faster and solve problems more effectively!

Marcel Mulder prize for electrochemical phosphate recovery

During the Wetsus Congress from last October, the Marcel Mulder Prize was awarded to PhD researcher Yang Lei. This annual prize of € 5000,00 is awarded to the Wetsus scientist that made the most exceptional performance in the field of water technology in the past year. Lei is working at ETE and performs his research in the Resource Recovery theme at Wetsus.

Patented technology
'I think I won this prize because, together with my colleagues, I developed an electrochemical based technology for phosphate recovery from waste streams', Yang says. 'The technology is now patented and could provide a good solution for waste streams to recover phosphate.' Phosphate recovery is increasingly important, because natural reserves are expected to run out within a few hundred years.

Advantages
The beauty of the novel technology lies in its simplicity. An electrical current applied in the wastewater generates hydroxide ions (OH^-) at the cathode. This results in a locally elevated pH. As a result, calcium and phosphate ions, already present in wastewater, form calcium phosphate that precipitates at the cathode. These can easily be harvested. Yang: 'The advantages are multiple: we make use of the coexisted calcium ions to precipitate phosphate, we don't need to adjust the pH before and after treatment and we don't need a liquid-solid separation process to separate the precipitates from the wastewater.'

High ranking journals
Yang published already 10 papers on his technology, all in high-ranking journals. But despite his achievements, the scientist remains modest: 'I did not do all the work by myself. My supervision team and master students contributed a lot to the development of this technology.'

The prize is financially supported by Vitens, the Province of Friesland, Patent office Arnold and Sytsma, the North Netherlands Watercycle Authorities and Wetsus.

Selected publication
Lei Y., Santosh N., Saakes M., van der Weijden R.D., and Buisman C.J.N. 2019. Calcium carbonate packed electrochemical precipitation column: New concept of phosphate removal and recovery. Environ. Sci.& Technol. 53, 10774-10780.

Business development award for Steffen Georg

ETE PhD student Steffen Georg won the WaterCampus Business Development Course 2019. During this yearly challenge, talented (PhD) researchers with little experience with business yet learn how to turn their innovative technologies and services into a viable and successful business case. The final challenge, held in November, was to pitch their idea for a jury of business developers. Georg won participation in an accelerator program to further develop his business.

Georg's winning idea was to recover NH_3 and NH_4^+ from manure and to subsequently reuse it as a precursor in the fertilizer industry. 'My idea excelled in the contest because it offered a possible solution to the problems of the current Dutch nitrogen crisis. It is inspired on my PhD research where we recover nitrogen from wastewater', Georg explains. 'I thought it would be a good idea to connect my business to an actual problem with a high impact on society in The Netherlands.'

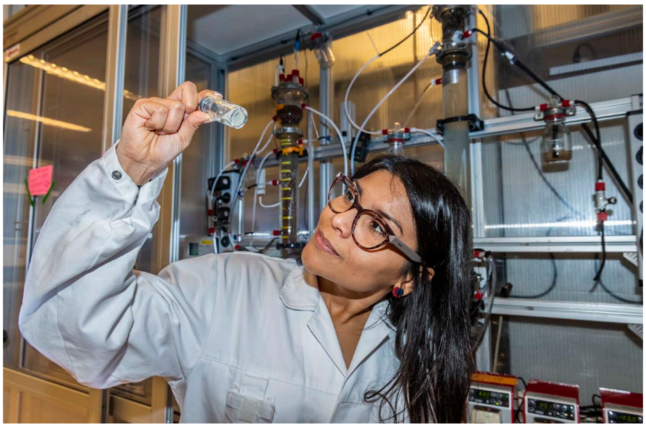
The principle of his technology is to produce electricity from organic material present in manure using bacteria. The electricity generated is subsequently used to form ammonium sulphate from the NH_4^+ and fosphate present. 'Ammonium phosphate can be used as a precursor in the fertilizer industry', Georg explains. 'This way we close nitrogen cycles, while we utilize the energy generated in the same process. This makes the technology sustainable.'

From March 16-20, 2020, the WaterCampus organizes the European WaterCampus Business Challenge for Start-Up companies or persons that are in the process of becoming a Start-Up. The organizers are now looking for new participants. To obtain more information or to register, please send an Email to: **marco.degraaff@wetsus.nl** or **ronald.wielinga@wetsus.nl**.

This research is part of Wetsus Resource Recovery Theme.

Science: Cleaning mining waste using microorganisms

Using a combination of chemistry and biology, PhD researcher Silvia Vega developed an effective method to convert toxic arsenic, present in mining waste, into scorodite. These are stable iron-arsenate crystals that can be stored safely. The method is environmentally friendly, cost-effective and helps to deal with the increasing problem of arsenic-containing mining waste.



Copper and gold mining and the subsequent processing of these metals is associated with the production of large quantities of waste, containing a variety of metals, including arsenic. This waste is successively stored in so-called mine tailings. These consist of a mixture of ground waste rock and effluent containing chemicals. However, the arsenic present may easily leach into the environment, poisoning water supplies. Globally, arsenic pollution affects millions of people. 'I am originally from a mining town in Chile, and have experienced the effect of arsenic pollution specially on drinking water which can't be directly consumed from the tap', Vega says. 'And this problem will increase in the future, since only rock containing small amounts of copper is left. Mining these low-grade ores results in even more arsenic waste.'

Disadvantage

To make mine tailings less toxic before disposal, arsenic must be oxidized, commonly using a powerful oxidant, like hydrogen peroxide. Thus, toxic arsenite, As^{3+}, is oxidized to the less toxic arsenate, As^{5+}. However, these processing costs are high and therefore, mining waste usually remains untreated. As a result, it poses a serious hazard to people and environment. 'Technologies for better arsenic management, before disposal, are desperately needed', Vega states. 'So, we developed a method to convert arsenic waste in a stable form, allowing safe and long-term storage.'

Extreme versatility

But to reduce the toxicity of mining waste is a complex task due to the complex mixture of chemicals present and the high acidity. Besides the toxic As^{3+}, they also contain high amounts of other metals, including iron (Fe^{2+}). Microorganisms could potentially play a role in breaking down or modifying this complex mixture of metals, due to their extreme versatility to grow on all kinds of different substances. Hence, Vega aimed at finding suitable microbes to play a key role in the conversion of the toxic As^{3+} into the non-toxic As^{5+} form. But, in addition to be able to grow on chemicals, such as Fe^{2+} present in mine tailings, the microbes should also be able to thrive in this acidic environment while they overcome the toxicity of As^{3+} present. Eventually, the scientist found iron-oxidizing microorganisms that were able to survive at high temperatures and high acidity. The researchers found that the addition of activated carbon (AC) to the process reduced the toxicity of arsenite present, allowing the microbes to effectively oxidize the Fe^{2+} into Fe^{3+}. The toxic As^{3+} was oxidized into As^{5+} with AC as a catalyst, followed by the precipitation of iron-arsenate, or scorodite (Fig. 1). These greenish crystals are non-toxic and can safely be stored for a long time without the arsenic leaching out.

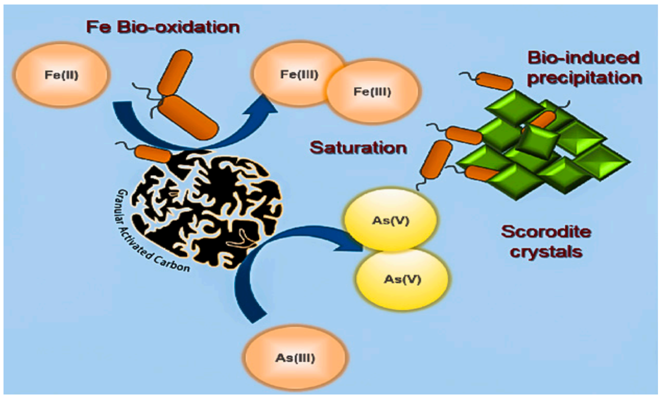


Fig. 1. Schematic representation of the reactions involved in converting toxic arsenic (As III) into scorodite crystals.

Although, the arsenic and iron could be oxidized with only AC present, no scorodite crystals were formed when the microorganisms were absent. But when Vega added the iron-oxidizing microorganisms, scorodite crystals were formed. Clearly, the microbes played a crucial role in crystal formation. The scientist thinks that organic material from these microbiota, so-called EPS, might serve as starting point for scorodite crystal formation, similar to a condensation nucleus that is a starting point for the formation of water droplets.

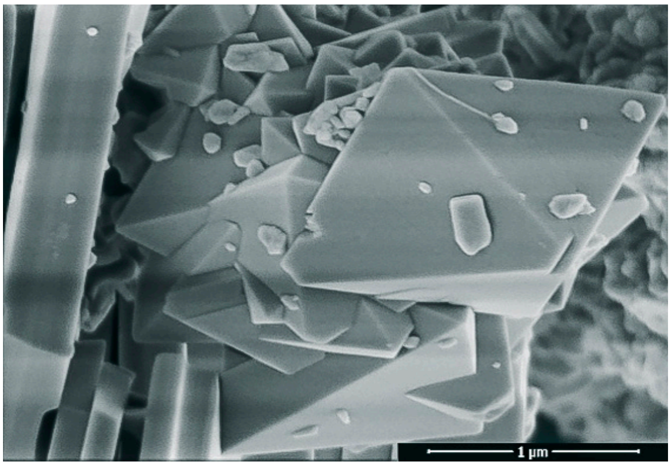
Costly chemicals

Vega showed the proof of principle to effectively deal with arsenic waste using a combination of chemical and microbiological conversions in a cost-effective way: there is no need to use costly chemicals. Recently, she successfully scaled up her method from a 250-milliliter volume to a laboratory reactor, containing nine liters. And the principle of the new method can possibly also be used to recover other metals from low-grade ores or mine tailings still containing small amounts of valuable metals. Vega: 'Since low-grade mining becomes more and more common, every little bit of recovered metal counts for a cost-effective operation.'

This research was funded by Chilean government (CONICYT) and Paques BV

Selected publication:

Vega-Hernandez S., Weijma J., Buisman C.J.N., 2019. Immobilization of arsenic as scorodite by a thermoacidophilic mixed culture via As(III)-catalyzed oxidation with activated carbon. J. of Hazard. Mater. https://doi.org/10.1016/j.jhazmat.2019.01.051



Electron-microscopic image of scorodite crystals.

Science: Effective wastewater treatment by using Vital Urban Filter technology

Together with Dutch and Indian partners, PhD student Elackiya Sithamparanathan collaborates in the LOTUS-HR project, developing a so-called Vital Urban Filter (VUF). This filter is designed to boost wastewater treatment by a combination of biological, chemical and physical processes. Elackiya: 'With the technology, we aim to treat urban wastewater, especially from Indian megacities to allow its safe re-use for irrigation and some household applications, such as toilet flushing.'

'Here we test different designs of our Vital Urban Filter, Elackiya Sithamparanathan says. She points at a row of pots containing plants. 'These plant species, growing on coco peat, have shown to be very suitable to be used in our new water cleaning filter.' A network of thin black tubes supplies wastewater from a big tank into the coco peat. The interplay of different components in VUF, such as microbes, plants and filter materials results in the removal of pollutants resulting in cleaner water. By collecting and analyzing the treated water, the scientist measures the efficiency of the technology to remove various pollutants from the wastewater. A preliminary version of VUF installed at LOTUS pilot plant site, in New Delhi, India was recently visited by the Dutch King and Queen during their trade mission.

Improving water quality

Elackiya's research aims at improving water quality in urban areas, such as India's big cities. Many of those cities suffer from highly polluted water streams. For example, the 16 km long Barapullah drain in New Delhi is one of the biggest open sewer systems. It discharges around 125 million liters of wastewater into the Yamuna River every day. Existing treatment technologies have not been implemented, resulting in the Yamuna River being declared as a dead river. Nevertheless, people still use the river water for irrigation and religious purposes. To solve this big environmental issue, Indian and Dutch research institutes collaborate in the LOTUS project. Different institutes are responsible for different cleaning steps. After the pretreatment, using the well-known anaerobic UASB technology, pre-treated Barapullah drain water is further processed using algal(photo) bioreactors and Elackiya's newly developed VUF.

The Barapullah drain in New Delhi: one of the biggest open sewer systems

Economic benefit

The VUF design (Fig. 1) is inspired by the traditional constructed wetlands, but differs by a denser filter material, allowing intensified plant growth and microbiological activity, and thus more efficient pollutant removal. Also, the use of ornamental plants instead of marsh plant species is different. These decorative plants have commercial value and thus provide an economic benefit to the system. However, it is vital that both the produced plants and the effluent are safe to use. Therefore, the scientist has performed several tests to understand basic processes about pollutant sorption, plant uptake and biodegradation in her VUF and uses this knowledge to improve the efficiency of the system. According to her studies, coco peat is one of the excellent filter materials that can be used: it performs really well, is readily available and inexpensive. Two decorative plant species, Periwinkle, and Syngonium, grow well in her system and are efficient pollutant removers in combination with coco peat.

Hybrid system

Although the VUF is still being perfectionated, an earlier design is already operated on site to clean wastewater from the Barapullah drain in New Delhi. In this version, the water flows horizontally through the system. Anaerobic conditions in the horizontal flow system results in a better nitrogen removal, but limits other pollutant removal. 'The vertical flow, used in our new design, has other benefits, like more aerobic conditions and thus a more efficient microbial activity and pollutant removal', Elackiya says. 'We are now working to design a hybrid vertical and horizontal flow system, where the benefits of the horizontal and vertical flows are combined, maximizing the performance.' In April 2020, the new VUF is planned to be operative at the Barapullah drain. The scientist envisions the future implementation of the VUF as a decentralized solution to treat various types of wastewater in different parts of the world.

LOTUS-HR project is financed by the Department of Biotechnology, Government of India and TTW/NWO, The Netherlands. Collaborating research institutes are Wageningen University and Research, Institute of Ecology (NIOO-KNAW), Delft University of Technology, IHE Institute for water Education and VU University Amsterdam from the Netherlands, and Indian Institute of Technology Delhi, National Environmental Engineering Research Institute and The Energy and Resources Institute from India.

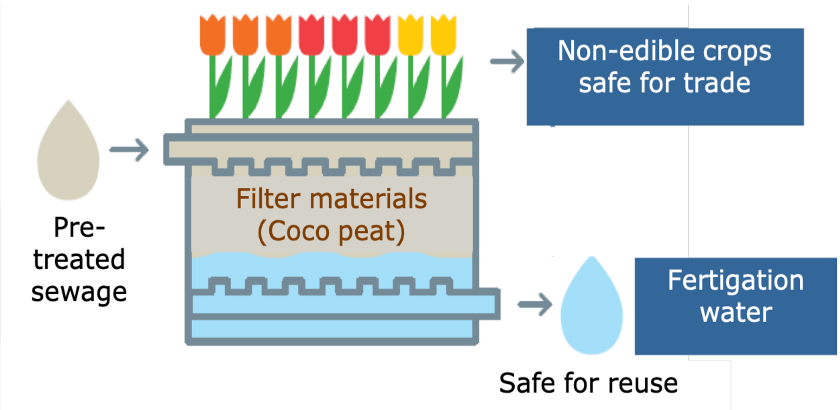


Fig. 1. Schematic representation of the VUF design.

Agenda

PhD defences (Aula, Wageningen):

Yang Lei December 6th 2019, 16.00h. Electrochemical sewage water treatment to remove and recover phosphate.

Rosanne Wielemaker December 19th 2019, 11.00h. Fertile Cities, from losses to loops: nutrient flows from new sanitation to urban agriculture.

Emilius Sudirjo February 12th 2020, 13.30h. Plant Microbial Fuel Cell (Plant-MFC) in Rice Paddy Field: A power source for rural area.

Thomas Wagner February 25th 2020, 12.00 in Amsterdam. Removal and transformation of conditioning chemicals in constructed wetlands treating cooling tower water.

Dainis Sudmalis March 3rd 2020, 13.30h. Biological Nutrient Removal.

Karina Kiragosyan April 4th 2020, 13.30h. Biological removal of higher thiols in the biological desulfurization process.

Silvi Vega Hernandez April 2020 (to be confirmed). Arsenite oxidation and removal in the Bioscorodite process.

Conferences

ETEi2020. June 3-5 2020. Wageningen.

ETE alumni day June 5th 2020.

Electrochemistry for electrification and energy transition toward a sustainable future (ESEE2020) June 14-18 2020, Leeuwarden.

The 8th International Congress & Exhibition on Arsenic in the Environment (As2020) June 15-17 2020, Wageningen

1st International Chain Elongation Conference October 2020, Wageningen

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