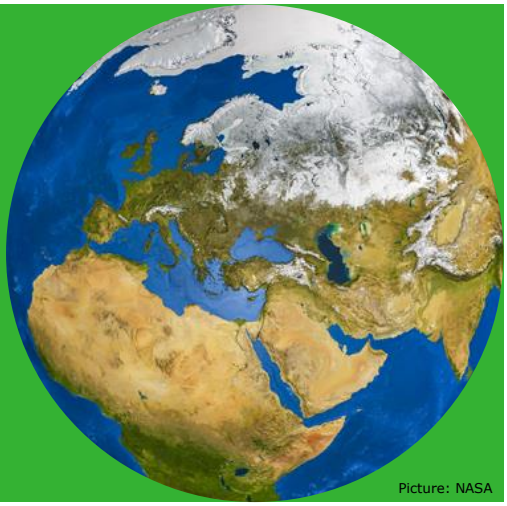
Environmental Technology

Newsletter | Spring 2014

WAGENINGEN UNIVERSITY
WAGENINGEN UR



Picture: NASA

News

Visit of Minister Schultz van Haegen

May 13th, the Minister of Infrastructure and Environment (I&M), Melanie Schultz van Haegen, visited the labs of ETE. I&M is responsible for almost all water policies in the country. The Dutch Top Sector Water invited the Minister to visit maritime, delta and water technology projects in the vicinity of Wageningen. The visit to our labs was the third and last part of her program.

The ETE staff explained a wide variety of water technology projects to the Minister. The removal of medicine residues and arsenic from water, degradation of micro pollutants in drinking water, minimizing the consequences of the BP oil spill in the Gulf of Mexico, and the microbial fuel cell (MFC). This last technology combines waste water cleaning with the generation of energy. Research to the MFC is co-financed by I&M, while the technology is applied in the new I&M building.

Professor Cees Buisman was very pleased with the Minister´s visit: ´This is the first time a minster visits our labs, I am very honored.´

Column **Cees Buisman**

In a sustainable world, 10 billion people with a more or less equal level of wealth can live without depleting resources or polluting the environment. In other words, all things can be done infinitely. This concept requires people to live within the boundaries of what our earth system may provide on the long term.
If we look around us, it is clear that this sustainable world has not arrived yet. With existing technologies this won't be possible either. To really become sustainable, we need breakthrough innovations and technologies. This starts with imagination and creativity. We have to leave conservative thoughts far behind us, such as 'it is too small', or 'it won't fit in existing structures', or 'we cannot make money with this'. Such simple assumptions kill the imagination. In addition, an open mind on scientific feasibility is needed. For creative, breakthrough technologies we need a different mindset and mostly also different people.
When these imaginary ideas lead to new useful technologies with a proof of concept, a period of improvements and optimizations will be required. The UASB reactor and the Thiopaq technology are examples of our department that were breakthrough innovations at the time and are now used worldwide. Discipline and 'out of the box' thinking is needed for researchers to stop improving existing technologies that were a success in the past, and start the imagination and creative cycle again. This process is exiting and also very inspiring for young PhD researchers starting their innovation careers.

Environmental technology wants to be such an inspiring place where imagination, creativity and 'out of the box' thinking will get all space it deserves and needs.

ETE congress 2015

To celebrate its 50 year Anniversary the sub-department Environmental Technology of Wageningen University will organize a 2-day symposium on April 29-30 2015:

Environmental Technology for Impact. Recovery of valuable resources from waste and wastewater.

The symposium will be held in the building 'Orion', at Wageningen UR Campus. Participants can send in abstracts on three main themes: 1. Biorecovery, 2. Reusable water, and 3. Urban system Engineering.

Biorecovery of valuable components from rest streams will be the main focus of the first theme. Such components can be anything, for example long-chain fatty acids, metals, but also bio-fuels to generate energy.

The second theme, **reusable water**, includes all research dealing with technologies to clean waste water for reuse. For example, in irrigation and toilet flushing. Special attention will be given to technologies to remove micro-pollutants from waste water. These substances are present in waste water at very low concentrations and include a wide range of substances: from medicine and personal care residues to microplastics and pesticides. 'Waste water treatment plants are not designed to remove these components', says researcher Jan Weijma, member of the organizing committee. 'Heavy technologies, like chemical or UV breakdown, are effective but costly.' Therefore, new and cost-effective technologies are needed to clean waste water from these residues.

Urban system engineering deals with managing all logistic aspects from a 'circular economy', where waste is reused and cycles closed. For example, when a city only uses sustainable energy, supply and demand may not always match. 'Solar and wind energy are not always available when needed', says Weijma. 'Matching supply and demand by storing surplus energy when available is one of the solutions. Other resources, like water present similar challenges.'

Over 50 speakers and poster presentations about the latest findings and advances in these dynamic res-search fields will be presented. The symposium will bring together the most eminent, international speakers on Environmental Technology. This event will offer a great opportunity to share experiences and findings and discuss opportunities and solutions in the field. In addition, future directions for research on re-source recovery and closing cycles can be discussed. The symposium is therefore an excellent opportunity for researchers, industry representatives and end-users to meet and interact and discuss science.

Important deadlines:

1 October 2014: Deadline for abstract submission
1 December 2014: Deadline for early registration
1 February 2015: Notification of abstract acceptance

For more information: **www.etei2015.org**

Agenda

PhD defences (Aula, Wageningen):

4 July, 13:30: Nora Sutton, "Microbiological and geochemical dynamics of the subsurface: chemical oxidation and bioremediation of organic contaminants"

8 September, 16:00: Kanjana Tuantet, "Algae to upcycle nutrients from concentrated urine and UASB digested wastewater"

19 September, 16:00: Mieke van Eerten-Jansen, "Power to gas: using bioelectrochemical systems to convert electricity into fuels"

10 October: three PhD defences in Leeuwarden:

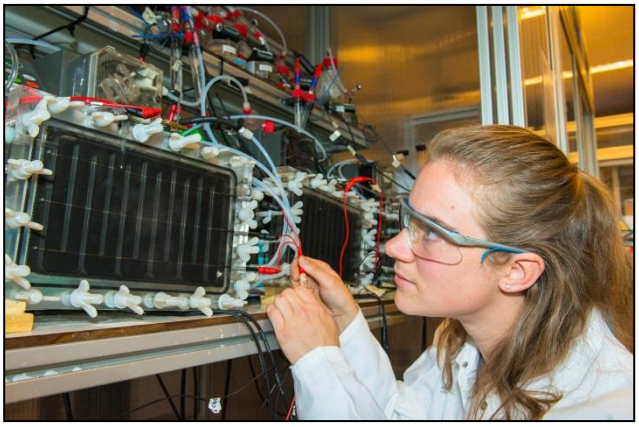
Taina Tervahauta, "Maximum reuse of carbon, phosphorus and water from domestic waste water"

Johannes Kuipers, "Resonant inductive powering of ultraviolet light emitting diodes and electrodes for water treatment"

Alexandra Deeke, "Capacitive bioanodes enable storage of renewable energy in Microbial Fuel Cells"

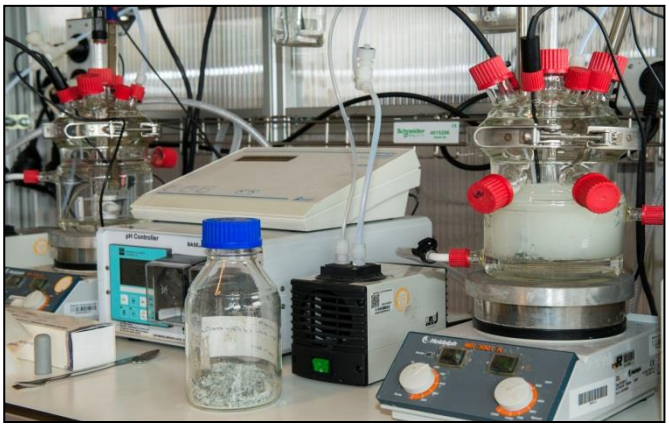
Top publications

The year 2012 was an exceptionally good publication year for ETE. A total of 64 articles were published, many with high citation scores. Based on the citation analyses carried out by Web of Science (ISI), almost half of the publications (29) fell in the category 'top 10%' publications, while eight even scored as 'top 1%' publications. This means that out of all papers published that year worldwide, these belong to the top 10%, or the top 1%, best cited papers of that year.
Based on this high scientific performance, ETE received an extra financial bonus of € 30.000 from the board of directors of Wageningen UR.



Experimental set-up of microbial fuel cells

This gratuity is awarded to groups with outstanding scientific performance, based on number and quality of publications, number of Ph.D. students and funding. Professor Cees Buisman, head of ETE, is satisfied. 'We are very happy with these high citation scores and the bonus. They prove the scientific community appreciates our papers ', he says. 'It also shows that the quality of our papers increases every year. The new focus of our department on the microbial fuel cell, bio-crystallization of metals, energy recovery from waste, desalination as well as the involvement of more external professors and companies in our research has clearly contributed to more papers with higher impact.'



Experimental set-up to study bio-crystallization of metals

Short news

Award for Kirsten Steinbusch

ETE post doc, MSc. and Ph.D. graduate Dr. Ir. Kirsten Steinbusch was awarded the Hoogewerff Stimulation Prize 2014. This prize is granted every three years by the Foundation Hoogewerff-Fund and aims to stimulate innovation in the field of process technology research.

Steinbusch was granted the prize because of her groundbreaking research activities in the field of conversion of organic waste into valuable components and building blocks for the chemical industry. She started her own company W2C (waste to chemical) to introduce this technology into the market.

Marjolein Helder speaks at TEDxBinnenhof

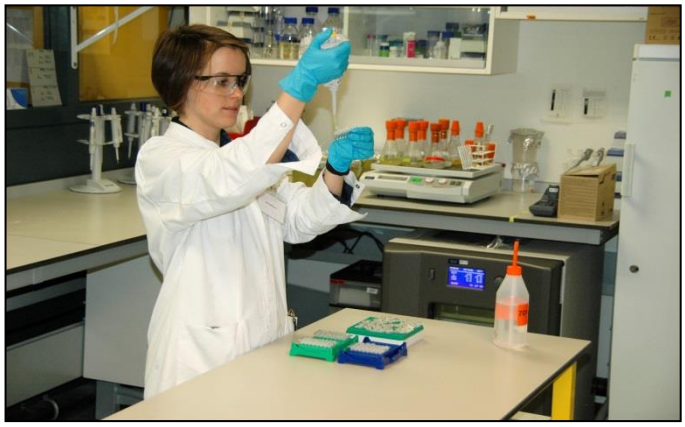
On March 31st alumna Marjolein Helder, researcher at the Sub-Department of Environmental Technology and CEO of the company Plant-e, was one of the eleven speakers at TEDxBinnenhof. The theme of the day was "Global challenges, Dutch solutions".

Helder spoke about generating electricity from living plants. The principle of this novel technology is that microorganisms degrade organic material excreted by the plant's roots, while releasing electrons.

Calculations have shown that one hectare of plants generates enough energy for 80 households. Helder demonstrated the principle by charging her cell phone using plants. She finished her presentation with a song 'It's not easy being green' and received a standing ovation.

Science: Improved energy recovery from waste water

Ph.D. researcher Lena Faust improved the energy efficiency of anaerobic waste water cleaning plants with at least 20-30 %. She optimized sludge production by limiting the sludge retention time in the system and concentrated organic matter using bioflocculation. This resulted in more biogas production.



Municipal waste water treatment plants most commonly use aerobic treatment to clean sewage. The technology is robust and effective, but requires a lot of energy: more than half of all energy used is consumed by aerating the system. In addition, energy recovery form organic compounds is not possible, since this fraction is degraded during the cleaning process. Waste water cleaning could become more energy-efficient if organic compounds are retrieved and anaerobically digested (fermented) into methane. However, Dutch climatic conditions limit the use of anaerobic waste water treatment, since this requires relatively warm waste water, around 25-35 °C. In addition, high concentrations of organic matter are needed. 'Concentrating organic matter from sewage is a key step to make anaerobic wastewater treatment feasible', Faust says. 'Energy from the organic fraction can be recovered instead of being degraded.'

Sticky polymers

Wastewater treatment plants produce sludge, a muddy substance consisting of particles, organic matter, ions and microorganisms. It can effectively be fermented into methane (biogas) when concentrations are sufficiently high. To concentrate sludge, microorganisms play a key role. They stimulate the congregation of smaller particles in waste water, including organic material, into larger flocs: bioflocculation (fig. 1).
Faust aimed at maximizing organic material in the reactor, increase flocculation of this substance, and efficient production of methane by optimizing operating conditions in her aerobic bioflocculation test reactor (fig. 2).

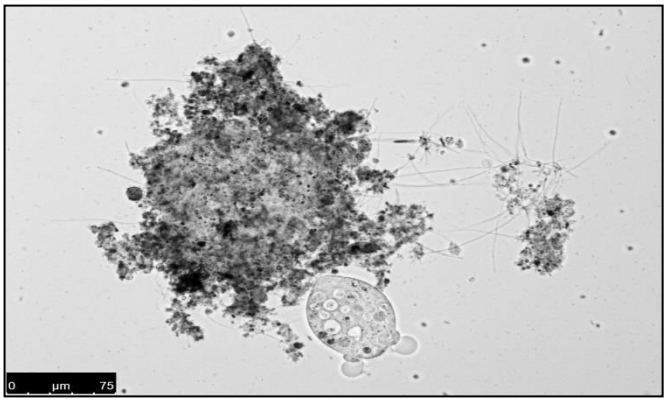


Fig. 1. Microscopic image of flocculated sludge. At the bottom a protozoa is visible. The filamentous structures are filamentous bacteria that help to keep sludge flocs together.

The process of bioflocculation requires sufficient oxygen in the system. Only under these conditions microorganisms produce sufficient amounts of sticky biopolymers, responsible for 'gluing' organic compounds together. This results in larger sludge flocs and improved flocculation.

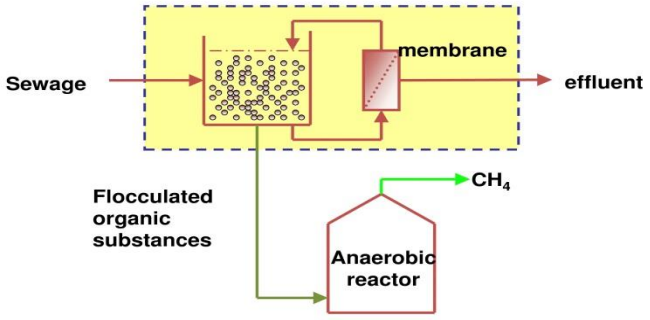


Fig. 2. Schematic overview of the test reactor. A membrane (dashed line) separates organic matter and clean effluent.

Bioflocculation also depends on the presence of positively charged ions that bind to the negatively charged biopolymers, forming some kind of network (fig. 3).

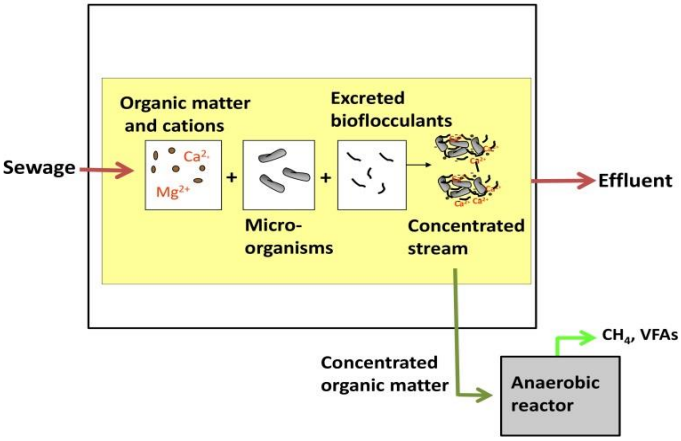
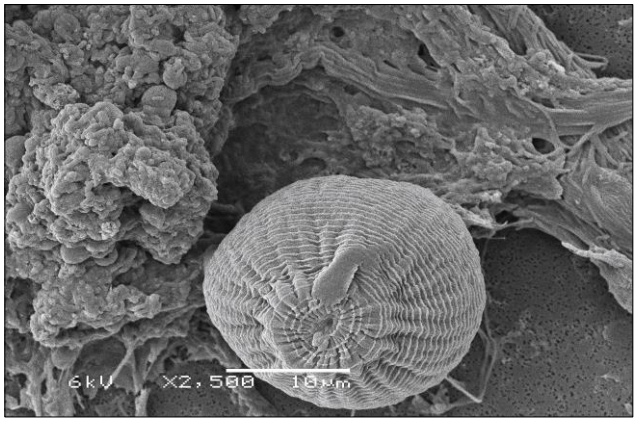


Fig. 3. The process of bioflocculation.

In an experiment, Faust tested if adding specific ions to sludge would improve bio-flocculation. Sodium (Na^+), calcium (Ca^{2+}) and aluminum (Al^{3+}) were added to different types of sludge to see their impact on flocculation. The experiment confirmed the important role of ions in this process. 'Adding sodium resulted in flocculation in sludge from industrial waste water only. This sludge already contains sodium ions', Faust explains. 'For standard sludge from municipal waste water plants adding calcium and aluminum resulted in the best flocculation'. Her results indicate that these ions could be added to waste water to stimulate flocculation.



Microscopic image of sludge. The round structure is a protozoa

Balance

In addition to ions, the time sludge is retained in the reactor is another important parameter that can be manipulated to optimize energy production. The longer this retention time, the more flocculation occurs. But also more organic material is degraded, resulting in less fermentable material and consequently less methane. But if the retention time of sludge is too short, flocculation might be insufficient. 'An important step to improve reactor performance and energy efficiency was to figure out the optimal sludge retention time: flocculation should be enough, while degradation of organic material is limited', Faust says.

'Our experiments showed that a retention time of half a day resulted in a good balance between sufficient flocculation and minimal organic matter degradation.'

Critical component

Although important steps have been taken to improve the reactor's efficiency, it is still too early to apply the system in full scale waste water plants. The membrane in the reactor is a critical component according to the scientist. It is easily clogged by smaller particles, resulting in much higher energy requirements to pump the fluid through. Future research efforts will now focus on this problem. And Faust has already ideas in what direction to find the solution. 'We have to design a smart and practical way to clean the membrane, so it can be applied in full scale waste water plants', she explains. 'For example, by reversing the water current, backwashing, the membrane could be flushed.'

Key publication: Faust L, Temmink H, Zwijnenburg A, Kemperman A, Rijnaarts H, 2014, High loaded MBRs for organic matter recovery from sewage: Effect of solids retention time on bioflocculation and on the role of extracellular polymers, Water Research, 56, 258-266.

This project is part of the theme "membranes for wastewater treatment and reuse" at Wetsus, and supported by Shell, Evides and Paques.

Contact

Annemiek ter Heijne (Environmental Technology)
E: Annemiek.terHeijne@wur.nl
www.wageningenur.nl/ete

Hans Wolkers (Wild Frontiers B.V.)
E: Hans.Wolkers@gmail.com
www.wildfrontiers.nl, www.science-explained.nl