Environmental Technology

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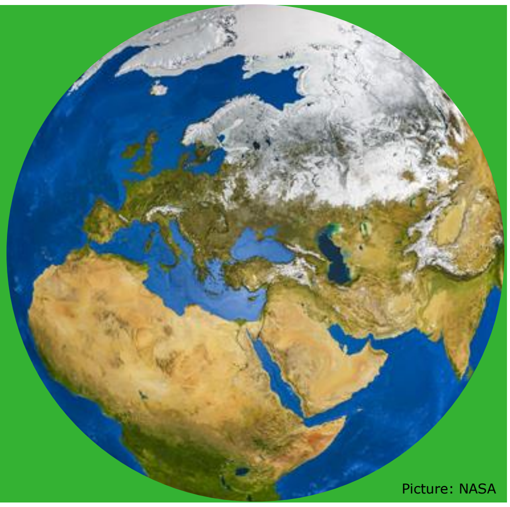
WAGENINGEN UNIVERSITY
WAGENINGEN UR



Picture: NASA

Short News

Tinka Murk personal professor at ETE

From September 1st 2013 Prof. Dr. Tinka Murk has been appointed a personal professor at Environmental Technology. She will contribute with ecotoxicological expertise on three different research topics.
First, she will be involved in developing improved technologies to remove micro-pollutants from waste water. Murk will specifically look at the ecotoxicological aspects: are toxic substances and their possibly toxic transformation products effectively removed? A second line of research is conducted in collaboration with IMARES and evaluates the effects of oil spill dispersants on the marine environment. 'We have observed that these soap-like compounds induce algae to form marine snow that aggregates with oil and particles and sinks to the ocean bottom', she explains. 'Here it suffocates the benthic life with a thick oily, toxic layer that hardly degrades.' A third topic concerns developing innovative water technologies for marine and brackish water. Examples are the reuse or cleaning of production or aquaculture water, or safe ballast water treatment.

50-year Anniversary

50 YEARS Environmental Technology

In April 2015, the sub-department of Environmental Technology of Wageningen University will celebrate its 50 year anniversary. For this occasion, a 2-day symposium will be held with the title: *Environmental Technology for Impact. Recovery of valuable resources from waste and wastewater.*
April 29 and 30, 2015, Orion, Wageningen
www.etei2015.org

Column ***Huub Rijnaarts***

On our blue planet, fresh water is the essence of life for terrestrial ecosystems and humans, and is increasingly under pressure. In many urbanized river basins, excessive fresh water extraction for industrial, agricultural, and domestic water purposes, leads to world-wide severe reductions in natural fresh water resources. In deltas, coastal and other regions, salt water intrusion and climate change further pressurize fresh water availability. In addition to diminishing quantities, water resources are threatened in their quality by low concentration inputs of chemicals originating from domestic effluents (like medicine and personal care product residues), agriculture (pesticides),and emissions from industry, fuel based traffic and heating. The department of Environmental Technology aims to resolve these problems by designing closed water cycles for urban, agricultural and industrial systems. We develop technologies to remove salt and unwanted chemicals from used water streams, and impacted groundwater and surface water/sediment systems. These technologies are based on natural (and therefore sustainable) processes using novel biological and (geo)chemical principles in reactor and in situ. We cooperate with governmental and industrial stakeholders strongly, and beyond high impact publications, application is our goal. Our department has been working on innovations for high quality fresh water for more than 48 years.
We would like to remind and again invite you to join us in our international conference on the occasion of our 50 year celebration on the 29th & 30th of April 2015, to further discuss the innovations in Environmental Technology that the world needs.

Honorary doctorate for former ETE professor Gatze Lettinga

In June, Professor Gatze Lettinga received an honorary doctorate in Environmental Technology from the University of Santiago de Compostella for his groundbreaking work in sustainable waste water treatment based on the natural sequence of anaerobic digestion, micro-aerobic and aerobic biological conversions. Professor Lema was his honorary promoter.

From 1989 to 2001 Lettinga was professor of the Department of Environmental Technology. He and his group were honored with several prizes, including the prestigious Tyler Prize for Environmental Achievement in 2007. This prize is considered as the Nobel prize for environment. Lettinga also developed the so-called UASB-reactor system and complementary methods. The concept is efficient, cost effective and closes water and material cycles.

Professor Cees Buisman, former Ph.D. student of Lettinga, respects his scientific father for his enormous scientific output and his work abroad. 'Lettinga published hundreds of peer reviewed articles. He had a lot of projects in Africa, South America and Asia and educated many Ph.D students from these countries', Buisman explains. 'His anaerobic technology enabled third world countries to clean waste water at low costs and made them independent of western technology.'

Cees Buisman decorated

Professor Cees Buisman was granted the highest civilian award: during the annual Wetsus Congress, held on September 30th , he was decorated as Knight in the order of the Netherlands lion. The royal decoration was awarded to him by the Dutch minister Melanie Schultz van Haegen for his 'outstanding scientific achievements'. After his Ph.D. at Wageningen UR on sulfur technology, Buisman worked at Paques BV as director business development & technology. In 2003 he followed professor Gatze Lettinga at the Department of Environmental Technology. He founded a very successful research group and further developed innovative water treatment technologies, that are currently used worldwide. Next to his activities at Wageningen UR, he also co-founded Wetsus centre of excellence for sustainable water technology in Leeuwarden. At Wetsus, Buisman holds the position of scientific director. He also promoted and started collaborations between Wageningen UR and the industry in many different research projects.

Agenda

6 December, 16:00: PhD defense Tim Grootscholten, "Development of a mixed culture chain elongation
process based on municipal solid waste and ethanol"

6 December, 12:00-16:00: Mini-symposium Chain Elongation, Forum, Wageningen (http://www.wageningenur.nl/en/show/Chain-Elongation-Minisymposium-PhD-defence.htm)

11 December, 13:30: PhD defense Shahrul Ismail, "Anaerobic wastewater treatment of high salinity wastewaters: Impact on bioactivity and biomass retention"

27 February, 11:00: PhD defense Ralph Lindeboom, "Autogenerative High Pressure Digestion: Biogas production and upgrading in a single step reactor system"

Science: Phosphate recovery from waste water

Ph.D. student Taina Tervahauta discovered a new way to recover phosphate from waste water. The new method beats traditional recovery techniques, both in costs and phosphate quality.

Food production requires enormous amounts of fertilizers, including phosphate. Recovery of this important plant nourishment from waste streams is still quite low. Therefore, agricultural industries are dependent on mined phosphate from China, Morocco and the United States. But mining phosphate-containing rock has political and environmental problems. 'We are dependent on these countries for our fertilizers', says Tervahauta. 'In addition, the mining causes substantial environmental damage, while chemical extraction of phosphate from rock results in heavy metal-contaminated waste rock.' Finding alternatives for mining phosphate are therefore crucial.

Granules

Recovering phosphate from waste is the most obvious method to decrease mined phosphate demand. A couple of decades ago, anaerobic reactors were implemented to recover phosphate from household waste water. Such a reactor recovers methane, used to generate energy, and phosphate as struvite crystals (fig. 1). Besides phosphate, struvite also contains magnesium and ammonium. But the efficiency of phosphate recovery is rather low. Since only phosphate from the effluent is recovered, about half of all phosphate remains in the reactor's sludge bed (fig. 2). To increase efficiency of phosphate recovery methods from waste water, especially from reactor sludge, Tervahauta started with a traditional anaerobic reactor. She started up her reactor using separately collected toilet water, also called 'black water', from a demonstration neighborhood in Sneek, equipped with vacuum toilets (fig. 3). 'After running the reactor for a year I was surprised to find small granules on the bottom of the reactor', she says. 'My first thoughts were: who has been messing with my reactor?' The granules increased from the bottom up and eventually took over the sludge bed. She found similar granules (fig. 2) also at the demonstration site in Sneek and realized this might be something new.

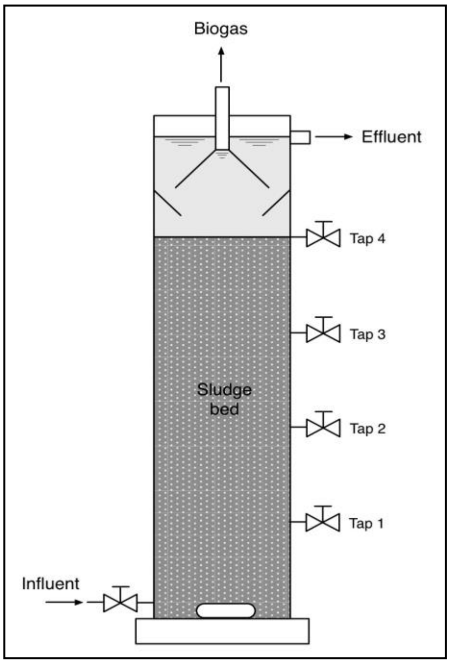


Fig. 1. Schematic view of the anaerobic reactor.

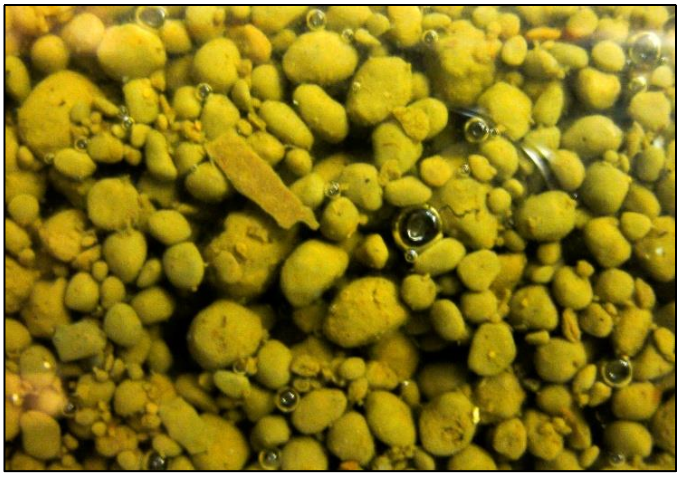


Fig. 2. Calcium phosphate granules in the anaerobic reactor.

Higher value

The scientist started to sample the mysterious granules to find out more about their composition. 'After drying, chemical analyses showed that the composition of the crystals was mostly phosphate and calcium', Tervahauta says. 'Further analyses confirmed our belief that it was pure calcium phosphate, partly crystalline, partly hydrated crystals.' By law, phosphate recovered from waste water, either struvite or the calcium phosphate granules, cannot directly be used as fertilizers. A processing step is required to make it suitable for use in agriculture. Due to the presence of magnesium and ammonium, struvite is unsuitable to process in existing systems because these compounds damage the system. A big advantage of Tervahauta's granules is that they can be processed in the existing fertilizer industry. 'From a marketing point of view, the granules have a higher value than struvite', states Tervahauta. 'Not only because they are easier to process, but also because no extra chemicals are required and we don´t need a second reactor to recover phosphate, like we do for struvite.´ In addition, the granules contain less contaminants, like heavy metals, compared to other phosphate recovery products, phosphate rock and artificial phosphate fertilizers. Future research will focus on maximizing granule formation in the reactor, while minimizing the amount of phosphate in the effluent. Tervahauta: 'We will set up experiments where extra calcium will be added to the reactor. Possibly, this will bind to phosphate and the formation of calcium phosphate granules will be increased.'

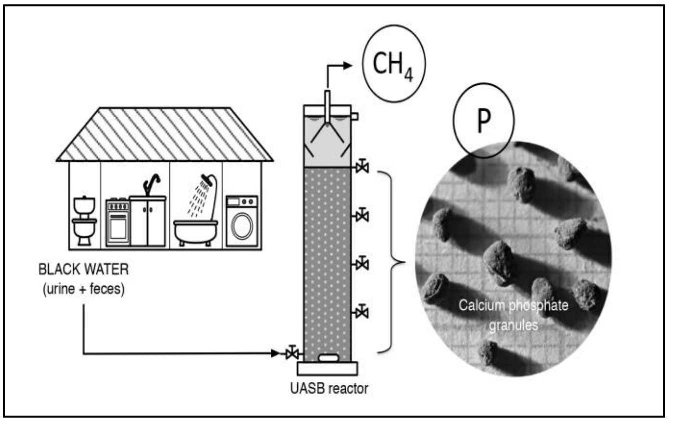
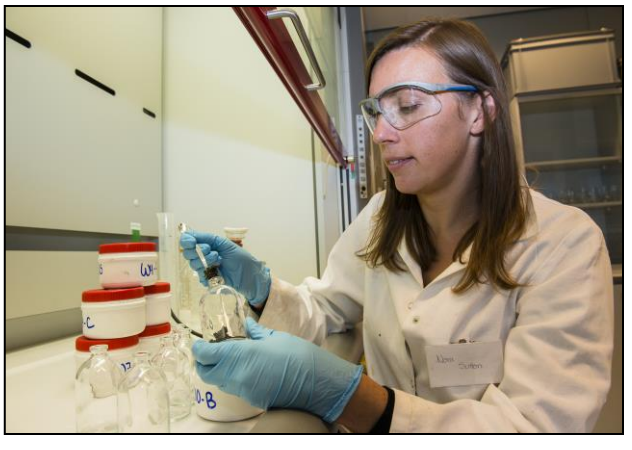


Fig. 3. Schematic overview of the demonstration neighborhood in Sneek and the route of black water into the anaerobic reactor.

Key publication: Tervahauta T, van der Weijden RD, Flemming RL, Hernández Leal L, Zeeman G, Buisman CJN (2013). Calcium phosphate granulation in anaerobic treatment of black water: A new approach to phosphorus recovery, Water Research, in press.

Decontaminating soil



Soil polluted with organic contaminants may be cleaned using chemicals or microorganisms. Nora Sutton, researcher at Environmental Technology, combined both methods and developed an efficient, cost-effective and more sustainable method to clean polluted soil.

Industrial and agricultural activities or improper disposal of waste may result in the contamination of soil with organic contaminants. Common pollutants are petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAH's) and pesticides, but also chlorinated solvents used by dry-cleaners. Not surprisingly, the extent of soil pollution is usually Associated with the degree if industrialization and chemical usage of an area. Contaminated soil may pose a health risk to humans due to contact or inhalation exposure. Contaminants may also disperse in the groundwater and contaminate water supplies. In addition, there may be significant harmful effects on the ecosystem. Therefore, cleaning polluted soils has been prioritized in many countries.

Specific bacteria

Contaminated soil can be cleaned using bacteria. The efficiency of this bacterial degradation strongly depends on the type of pollution and the type of bacteria present. For example, many bacteria are able to degrade petroleum hydrocarbons, such as diesel. 'They eat diesel, just like we eat bread', says Nora Sutton. 'Diesel is their carbohydrate source.' Chlorinated solvents from dry cleaners, for example tetra-chloro ethene (PCE), are degraded by just a few specific bacteria species. These bacteria require very anaerobic conditions to do the job. 'These bacteria don't eat the pollutants, but breathe it, like we breathe oxygen', says Sutton. 'They are less abundant, and are sometimes not even present in the soil, so often they have to be added.'

The best of two worlds

An alternative to bacterial soil cleaning is chemical cleaning. The two methods represent two separate worlds, each with their own history. Both methods have their pros and cons. Bacterial cleaning is relatively inexpensive, but takes a long time. Using chemicals, usually strong oxidizers, is much quicker, but also more expensive. In addition, chemical oxidants kill bacteria and may degrade soil organic matter, resulting in a clean, but very poor soil.

Fig. 1 Field work in Poland.

Combining chemical and bacterial contaminant break down could result in improved soil-cleaning procedures. 'The general idea has always been that oxidizing chemicals and microorganisms do not mix', says Sutton. 'The chemicals damage the bacterial walls, thereby killing them. In addition, some treatments result in very acidic or alkaline conditions that are incompatible with bacterial growth.' Nevertheless, Sutton was determined to try to get the best of two worlds: she investigated the possibility of combining chemical and bacterial soil clean-up methods.

Devastating

Sutton collected soil samples from diesel-contaminated sites in Poland and PCE-contaminated sites (fig. 1), in The Netherlands to use in her laboratory tests.
In addition, she carried out experiments at contaminated sites. The scientist first applied a mild chemical oxidation using hydrogen peroxide, permanganate or persulfate to lower initial contaminant concentrations. During the chemical reaction she assessed the impact of the chemical cleaner on the bacterial populations present. Population size and species diversity were assessed using DNA-based techniques. The effect of the oxidant was pretty devastating, in some cases causing the pH to drop to around 2 and killing most bacteria. At the diesel-contaminated site in Poland, Sutton observed a 1000-fold decrease in bacterial population size. But when the oxidative reaction had stopped, bacteria recovered remarkably quickly, especially diesel-degrading species. Within a few months these species recovered and sometimes even exceeded initial numbers. 'The oxidant had created favorable conditions for bacterial growth by degrading organic matter and releasing nutrients', Sutton explains. 'The recovery of solvent degrading bacteria took longer, because conditions have to become very anaerobic for these species.'

Fine balance

Many contaminant-degrading bacteria proved to be surprisingly resilient towards chemical oxidation. This indicates that an initial chemical cleaning step could be combined with a second cleaning round involving just bacteria, as shown in fig. 2.

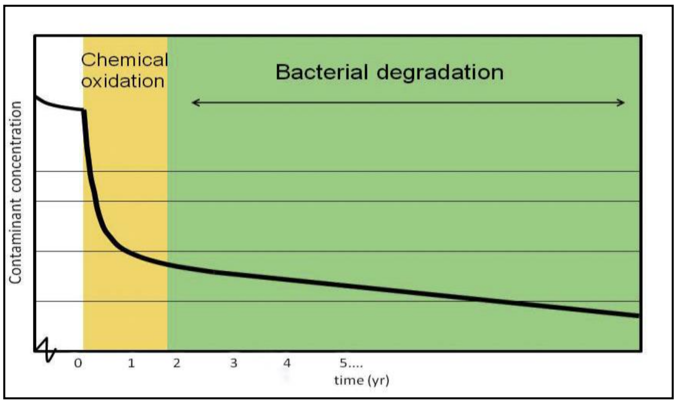


Fig. 2. Schematic representation of combined chemical and bacterial cleaning, 'bioremediation' of contaminated soil.

Advantages are obvious: it is quicker than using just bacteria, while less chemicals are needed, since chemical oxidants only have to degrade part of the contaminants. This saves money and reduces soil degradation. In addition, chemicals help bacterial clean-up by increasing contaminant bio-availability, making it easier for the bacteria to degrade remaining contaminants. Combining chemical with bacterial cleaning methods may indeed combine the best of two worlds, as Sutton hoped. The scientist is now developing concepts how to combine and optimize these two clean-up methods at polluted sites. 'Too much chemicals in the first clean-up step harms the bacteria and makes their recovery unnecessary slow, while also damaging the soil', she says. 'With too little chemicals there is insufficient degradation, meaning that contaminant concentrations may be too high for reasonable bacterial clean-up. It is a fine balance.'

Key publication: Sutton NB, Langenhoff AAM, Lasso DH, van der Zaan B, van Gaans P. Maphosa F, Smidt H, Grotenhuis T, Rijnaarts HHM (2013). Recovery of microbial diversity and activity during bioremediation following chemical oxidation of diesel contaminated soils, Applied Microbiology and Biotechnology, in press

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