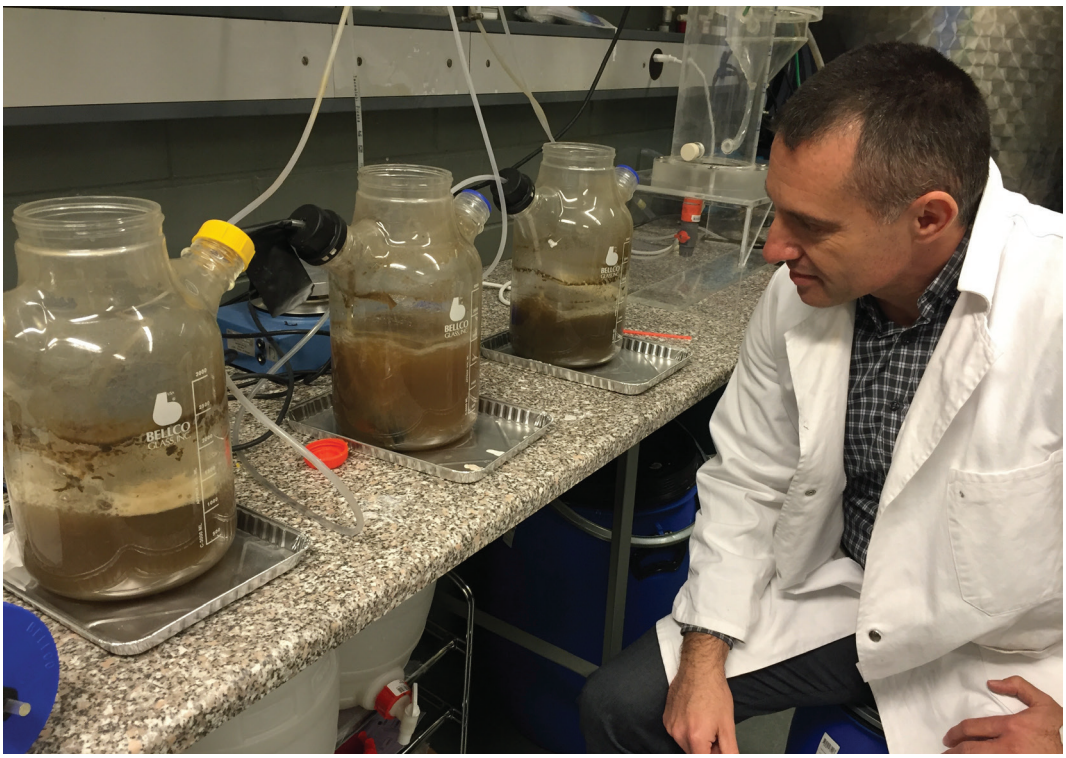
Energy Efficient Sewage Sludge

The purification of waste water from households and industry in the country's more than 4,000 wastewater treatment plants requires a considerable amount of energy. A novel method for the biological purification stage promises fuel savings on the order of eight percent. This technology will be tested in 2016 in two pilot plants in the area of Yverdon-les-Bains (Canton Vaud). The clean-tech innovation has global application potential.



Dr. Vice Šoljan, CEO of Cleantech company Puratis, in the laboratory in Orbe (Canton Vaud) observing three samples, with which he investigates the biological cleaning effect of various microorganisms. Photo: B. Vogel

Dr. Benedikt Vogel, commissioned by the Swiss Federal Office of Energy (SFOE)

Wastewater treatment plants (WWTP) are cleantech products par excellence. WWTPs use technologies to clean wastewater from households and industry, thus making an important contribution to the cleanliness of the water. Certain wastewater treatment technologies perform double duties in terms of clean technology - namely when they carry out their work with a minimum expenditure of energy. Such technologies are currently in demand in the wastewater treatment industry. Generally, WWTPs require a considerable amount of energy: A study by the Swiss Federal Office for the Environment from 2006 estimated the annual electricity consumption of all Swiss wastewater treatment plants at 450 GWh. This corresponds to the electricity

A technical report about the results of a research project in the field of bioenergy, which is financially supported by the Swiss Federal Office of Energy. The report has been published in the Kommunalmagazin (issue April 2016).

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consumption of 150,000 average four-person households. Around 40 percent of this energy, the study continues, could be saved through energy optimization. A West Swiss research project is currently working to recover a portion of this savings potential. This project, conducted by the company Puratis Sàrl (Orbe), will run until 2017 and is supported by the Swiss Federal Office of Energy (SFOE).

Biological Purification Stage

Wastewater is usually cleaned in a wastewater treatment plant in three steps: First, coarse dirt is removed using mechanical and physical processes. In the second step organic contaminants are biodegraded by microorganisms (bacteria, yeasts). Finally, during the third stage the waste water is cleaned chemically - with chemical oxidation, ultraviolet light or other tertiary processes.

For the biodegradation step, treatment plants generally make use of an activated sludge process: microorganisms break down organic matter and nutrients (such as nitrogen or phosphorus) contained in the waste water from households and industrial plants. To keep this biological treatment process moving, oxygen must be supplied, which is mostly done by compressors. The more polluted the waste water is, the more oxygen required.

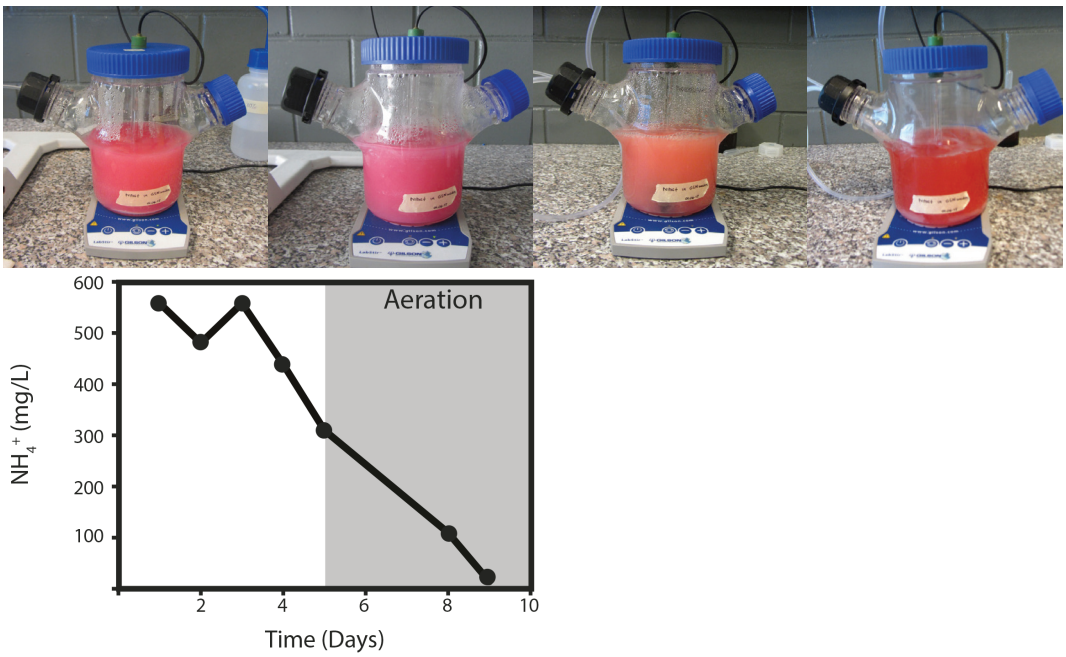
Because the oxygen demand of biological purification is so high, this step is very energy intensive. Here is where the Puratis company's project comes in: "With our new method for ventilation, we want to reduce the energy required by at least 20 percent," says Dr. Sc. Vice Šoljan, CEO of Puratis. This is the objective of the current research project. If Šoljan and his team can achieve this goal, sewage plants could reduce their energy consumption by six to eight percent, based on the total system energy needs.

An Industrial Process for Municipal WWTPs

Where activated sludge is used for biological purification, Puratis wants to replace the process with granular biomass. Similar to activated sludge, granulated biomass consists of microorganisms; both look like a cloudy, brown broth. The difference between the two can only be seen under a microscope: activated sludge consists of flakes from 0.07 to 0.12 mm size. Granulated biomass by contrast (as used by Puratis), consists of 0.2 to 0.5 millimeter sized large clumps. The microorganisms in granulated biomass produce exopolymers that act as an adhesive that causes the sludge particles to clump together in granular form.

Granulated biomass can purify wastewater with particularly high activity. As a result, sedimentation tanks can be built smaller, which also decreases the amount of ventilation required and thus energy use is reduced and consequently, cost. Vice Šoljan, a Croatian born biotechnologist who trained at the University of Zagreb, has been developing the granulated biomass method since 2002 for industrial enterprises, especially for cleaning heavily contaminated waste water from the chemical and pharmaceutical industries.

Meanwhile, the technology is already in use in four industrial plants in Slovenia and Hungary. "Under the current SFOE project we want to adapt the method for use in the less polluted wastewater of municipal sewage treatment plants," says Šoljan. "For the new application, we need to create a suitable substrate of microorganisms and we have to determine the technical parameters of a cleaning stage that works with granulated biomass."



The 600 ml volume glass bioreactor contains a culture of bacteria capable of degrading nitrogen in wastewater (nitrifying). The suspension remains in the bioreactor for nine days (photos show – from left to right – the sample at the beginning, after two, four and nine days). During this time the ammonium-nitrogen is reduced from 560 mg / l to 11 mg / l. This shows that the microorganisms are suitable for nitrification—the breakdown of nitrogen from municipal wastewater. Photos/graphic: Puratis

Two Pilot Projects Test the Energy Savings Target

Vice Šoljan stands in one of the offices that Puratis has rented in the technology parc of Orbe (Canton Vaud). On the lab bench are three glass containers. In each one bubbles a brown broth that is aerated with oxygen. "For our research we use real wastewater from the WTTP Geneva," says Šoljan. In the first glass container, the wastewater is treated with activated sludge, the second with granulated biomass, the third with a mixture of both. Since the start of the research project during the past year, scientists have made a granulated biomass that is suitable for use in municipal wastewater treatment plants. They have shown that the microorganisms effectively clean wastewater in a stable process.

The researchers plan to tackle the decisive step of the SFOE-funded research project during the course of 2016: With two pilot plants that carry out the biological purification process of WWTPs on a scale 1:1000, they hope to show empirically the expected energy savings of granulated biomass. The first pilot plant (2,500 l tank capacity) will begin operation in spring and continue for three to six months in the WWTP of Yverdon (Canton Vaud). The second (12,000 liters) is expected to begin operation in autumn and also continue for three to six months, likley in the area of Yverdon / Orbe.

Both pilot plants will have two parallel cleaning processes with activated sludge and granular biomass - so the new method can be compared under identical conditions with the conventional method (see text box). The basis for the operation of the two plants is a mathematical process model, developed by BlueWatt Engineering Sàrl (Lausanne), that was created on the basis of previous experiments. The modeling creates the parameters for a future-oriented control process as well as for optimal design layout of the reactors.

Energy and Investment Costs Are Saved

Currently there are various efforts to continue to improve the biological treatment step of wastewater treatment plants. Besides granulated biomass, granulated activated sludge can also be used (see textbox). Puratis researcher Šoljan hopes to provide a particularly flexible method based on granular biomass. Flexible means that the method can also be implemented in existing WWTPs that have reached their volume limits and that thanks to the use of the new method, can increase their capacity without constructing new pools. "In this application, plant operators could not only save energy costs but also investment costs," emphasizes Šoljan, who has the markets in Switzerland and abroad in mind.

"The two pilot projects in the Vaud are an important intermediate step," says Dr. Sandra Hermle, head of SFOE Research program biomass. "If successful, an innovation with considerable energy-saving potential for WWTPs may emerge." To publicize the new technology to an interested public, Puratis established, in addition to the two pilot plants where energy efficiency is researched, two demonstration plants where the new technology in operation is openly displayed: one plant (70 m^3: batch mode) went into operation in December 2015 in the small town of Ilinden near the Macedonian capital Skopje. A second demonstration plant (20 m^3: continuous operation) is planned in the northern Vaud for Spring / Summer 2016.

- To visit the pilot and demonstration plants and for any related questions, please contact: Dr. Vice Šoljan, CEO Puratis Sàrl, vice.soljan [at] puratis.com.
- For further information on the project, please contact Dr. Sandra Hermle (sandra.hermle [at] bfe.admin.ch), head of the SFOE-research program bioenergy.
- For further technical papers on research, pilot, demonstration and flagship projects in the area of bioenergy visit the site: www.bfe.admin.ch/CT/biomasse

Various Microorganisms and Different Methods

The biological purification of waste water has been to date largely carried out with activated sludge. When used in WWTPs, there are two common methods: continuous operation and batch operation. During *continuous operation*, the wastewater to be cleaned first enters an aeration tank where it is mixed with the sludge and then aerated to bring the cleaning process into motion. If the microorganisms have done their work, the water-sludge mixture enters a clarifying pool, where the activated sludge is separated from the purified water (through sedimentation) and is then used anew for purifying waste water again or accordingly disposed. The *batch operation* achieves the same cleaning results, however, it only requires one pool instead of two. During this process, the individual steps are carried out sequentially. The batch process is more flexible in terms of the duration of treatment, and is more efficient in removing nutrients.

If instead of activated sludge one uses granular biomass, the cleaning process can also be done in continuous mode or in batch mode. The scientists plan to test the advantages and disadvantages of both methods with the two pilot plants. The smaller pilot plant in the WWTP of Yverdon will run using continuous operation, the second plant scheduled to launch in the autumn 2016 will run in batch mode. "We want to test our novel process for both methods and then compare the results," says Vice Šoljan.

The granulated biomass purification process (short: ARIES method) developed by Puratis should be distinguished from biological wastewater treatment using granular activated sludge (short: NEREDA process). The NEREDA process is a more recent development that, for example, in the Netherlands is already in use. In the NEREDA process, the granulation (of the activated sludge) proceeds during the course of the cleaning process. In the ARIES-method, however, the granulation (of the biomass) takes place prior to application in the process: Here specific microorganisms are granulated in the laboratory, for which special bacteria are used, and the granulated biomass is then added to the biological treatment process in the treatment plant.

To prepare the granulated biomass from the laboratory for use in treatment plants, engineering skills and knowledge of ARIES technology are required. For the preparation, special tanks called propagators must be used in treatment plants. From there, the granulated biomass enters the actual sedimentation tank; once it is added, it usually grows repeatedly without external intervention. Only occasionally must it be complemented with additional granulated biomass from the propagator. BV

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04/2016