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ENERGY-EFFICIENT SEWAGE TREATMENT – HIGH-LOAD DIGESTION OF SEWAGE SLUDGE

SHORTER RETENTION TIME – MORE BIOGAS – REDUCED COSTS

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SHORTER RETENTION TIME – MORE BIOGAS – REDUCED COSTS

Sewage plants remove organic matter from wastewater. If the accumulating sludge decays, biogas is generated as a by-product. However, only 10 percent of the more than 10,000 sewage plants in Germany have a digestion tank. Smaller operations, especially, baulk at the costs of a new digestion tank. Instead, they enrich the sludge with oxygen in the existing activation basin, and stabilize it. Activation basins, however, require a lot of electricity and make a sewage plant the part of a municipality that eats up most electricity. At the same time, enormous energy potential is lost, since no biogas is produced. The digestion tanks of larger sewage plants are often out of date. They could considerably improve energy efficiency and cost-effectiveness by using the latest innovative technology.

High-load digestion of sewage sludge

The Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB has developed an energy-efficient high-load process for the fermentation of sewage sludge. It was put into operation for the first time in 1994 at the sewage treatment plant in Leonberg. In the meantime, this process is being successfully applied by four other municipal sewage treatment plants. The outcome: The high-load digestion converts the sludge into biogas in a considerably smaller space and more cost-effectively than the conventional digestion towers.

Fundamental advantages of high-load digestion:

- shorter retention time
- smaller digestion space
- enhanced degradation rate
- higher biogas yield
- no operational problems (foaming)
- easier to dewater
- lower operational and disposal costs

Limited disposal possibilities

The possibilities for disposal of sewage sludge from municipal wastewater treatment are being increasingly restricted. In future there will no longer be any demand for use in landscaping, utilization in agriculture is controversial, dumping of most sludges no longer possible. Incineration of sewage sludge will gain in importance, disposal is thus becoming more expensive. Aerobic sludge stabilization is expensive, frequently insufficient and no alternative for sewage plants > 10,000 PE.

***PE** = population equivalent | **TVS** = total volatile solids*

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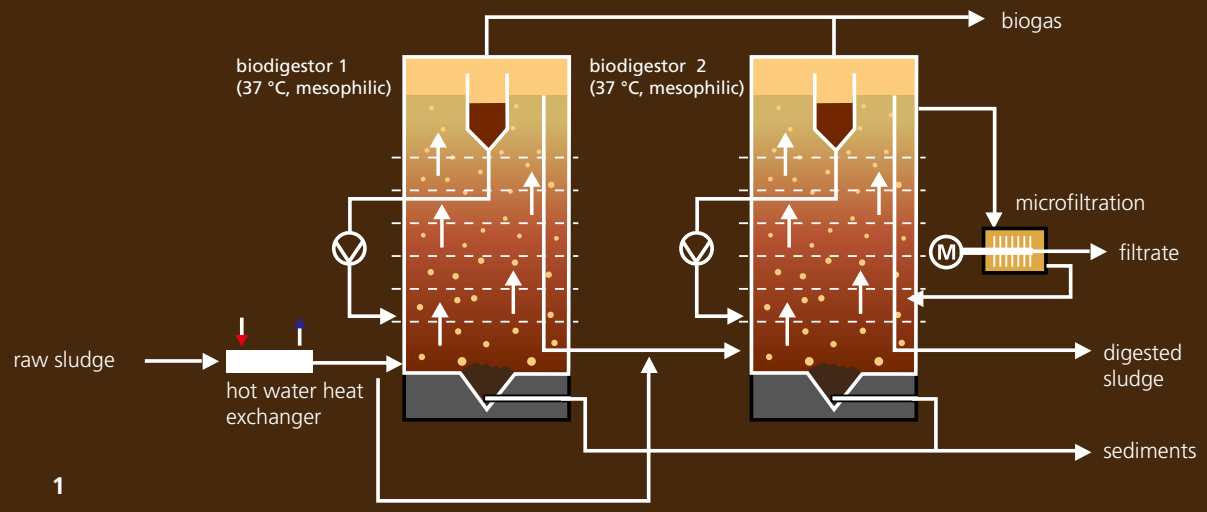
Intelligent utilization of sewage sludge as an energy carrier

The high-load digestion process developed at Fraunhofer IGB makes sewage sludge digestion a process that can, as a result of the efficient conversion of the sewage sludge contents into biogas, contribute substantially to the cost-effectiveness and energy efficiency of sewage treatment plants. The process is therefore also suited for smaller treatment plants (10,000 PE) that so far stabilize the sludge aerobically with a high power consumption.

The sewage sludge is stabilized with net energy production by means of high-load digestion, can be dewatered to a higher TS level and the residual sludge disposed of by incineration at the lowest possible cost. The regenerative energy carrier biogas is derived as a product. The thermal energy requirements of the sewage treatment plant can be covered by the biogas obtained and further expenses can be saved by means of combined heat and power generation. The high-load digestion process therefore also represents an economically intelligent alternative and considerably improves the energy efficiency of municipal sewage plants.

1 *Sewage treatment plant in Schwerzen. The high-load digestion is economical also for smaller sewage plants (10,000 PE).*

2 *Sewage treatment plant in Tauberbischofsheim with two-stage high-load digestion and microfiltration.*



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TWO-STAGE HIGH-LOAD DIGESTION

The process

The improvement of operational conditions and the scale-up from laboratory and pilot plant up to technical scale has been the subject of longstanding and intensive R&D at Fraunhofer IGB. As a result the two-stage Schwarting-Uhde process (high-load digestion) was patented by Fraunhofer IGB and Schwarting (now Schwarting Biosystem GmbH) back in 1979. The process, with improved energy efficiency, high degradation rate and increased biogas yield, has been used since 1984 to treat organically degradable substrates (manure, biowaste, sewage sludge).

Excellent operational data compared with conventional digestion

Shorter retention time

Even with a high solid content the sewage sludge only has to remain approx. 5-7 days in the digestion tower instead of 20-30 days up till now. Thus organic load rates of 8-10 kg TVS/m^3·d are achieved instead of only 1-2 kg TVS/m^3·d.

High biogas yield

The high-load digestion can produce up to 23 liters of biogas per PE and day, depending on the quality of the raw sludge. Conventional digestion plants in contrast achieve a maximum of only 19.7 liters of biogas per PE and day on average [Haberkern et al; Steigerung der Energieeffizienz auf kommunalen Kläranlagen Umweltbundesamt Texte Nr. 11/08, Dessau-Roßlau, March 2008]. The gas can be used to supply the plant with energy or can be delivered as a technically and commercially usable energy carrier.

Less organic residues

In the course of enhanced biogas production the high-load digestion also reduces the organics – by 50 to 70 percent, depending on the specific combination of processes. The organic share of the dry residual matter is now only 50 percent. As a result, far lower amounts of sludge occur, as they can be dewatered and disposed of more effectively.

1 *Schematic diagram of two-stage high-load digestion process with microfiltration.*
2 *One-stage high-load digestion plant in in Ilsfeld.*

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Further improvement by microfiltration

The extension of the high-load digestion by microfiltration with the rotating disk filter, an energy-optimized and low-maintenance filter with ceramic membranes that was developed at the Fraunhofer IGB, has led to further substantial improvements. As a result of the concentration of the biomass, the retention time of the sludge can be reduced, the conversion and the quantity of biomass produced can be increased. Further advantages are an improved dewatering of the residual sludge, smaller amounts of sludge and thus reduced costs for sludge disposal. Additionally, the particle-free filtrate is rich in ammonium and phosphorus that can be recovered either by stripping or precipitation and can be used as fertilizer, or applied directly as liquid ferilizer.

Energy-efficiency even for smaller sewage plants

In a cost-benefit study the Fraunhofer IGB has shown that it also pays small sewage plants to transfer to more energy-efficient processes – even if they have to invest in a sludge digestion unit. Based on a sewage plant for 28,000 inhabitants, we calculate that the plant can reduce its annual waste management costs from 200,000 euros by as much as 50,000 euros if sludge is decayed in a high-rate digestion unit with microfiltration, as opposed to treating it aerobically.

With the high-load digestion process around 60 percent of the organic matter is converted into biogas – the yield is approximately a third more than in the traditional digestion process. The biogas obtained can be used to operate the plant by means of combined heat and power generation in the block-type thermal power plant. In the case study, energy costs are reduced by a further 50,000 euros annually by reducing the amount of oxygen used and as a result of the plant producing its own electricity. The use of residual sludge in agriculture is controversial and nowadays this is frequently dispensed with in Baden-Württemberg. Additionally, sludge may no longer be disposed of on landfills. However, the alternative of incinerating the sludge is not sustainable, as wet sludge does not make a positive contribution to the regenerative production of energy. So an effective reduction of sludge through digestion pays off, even for small sewage plants up to 30,000 PE which up to now stabilize the sludge aerobically with high input of energy.

OUR REFERENCES

The high-load digestion is at present being used by five municipal sewage treatment plants in the German state of Baden-Württemberg:

- Sewage treatment plant Mittleres Glemstal, Leonberg: There, a two-stage high-load digestion plant went on line in 1994.
- Sewage treatment plant Heidelberg: In 2001, the oval digestion towers were extended by an upstream high-load stage, without suspending the supply line. Foaming in the digestion tower was effectively eliminated in this way, operational dependability was assured and 50 percent degradation achieved in stage 1.
- Sewage treatment plant Tauberbischofsheim: Here, a two-stage high-load digestion with microfiltration is in operation, which was built and put into operation in stages.
- Sewage treatment plant AZV Mittleres Wutachtal, Schwerzen: Here, a one-stage high-load digestion with microfiltration went on line for the first time for a small sewage treatment plant with 10,000 PE.
- Group sewage treatment plant Schozachtal: A one-stage high-load digestion plant with microfiltration was put into operation on this 35,000 PE sewage plant in 2008 and now replaces aerobic sludge stabilization.

SERVICES OFFERED

For 25 years the Fraunhofer IGB has been developing biotechnological processes for the treatment of water and waste – from the microbiological fundamentals to a technical and pilot scale plant:

- Processes for aerobic and anaerobic wastewater purification
- Substance recycling from wastewater
- Analyses of sewage plants for enhancement of energy efficiency
- Filtration technology for the treatment of wastewater and sewage sludge
- Analyses of sewage sludge fermentation to determine design parameters
- Individual, cost-saving extension of sewage treatment plants

1 *Sewage treatment plant Mittleres Glemstal, Leonberg.*
2 *Sewage treatment plant in Heidelberg.*

FRAUNHOFER ENERGY ALLIANCE

The Fraunhofer Energy Alliance is a gateway to R&D services in energy technology and economics. Above all small and medium-sized companies, but policy makers and the energy business sector too, benefit from Germany's technology leadership in energy efficiency and renewables. The IGB contributes its knowledge in the exploitation of the material and energy resources contained in raw, residual and waste organic materials for biogas production as well as membrane technology, particularly for gas purification and reforming and fuel cell applications.
www.energie.fraunhofer.de

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www.syswasser.de

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Fraunhofer IGB brief profile

The Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB develops and optimizes processes and products in the fields of health, chemistry and process industry, as well as environment and energy. We combine the highest scientific standards with professional know-how in our competence areas – always with a view to economic efficiency and sustainability. Our strengths are offering complete solutions from the laboratory to the pilot scale. Customers also benefit from the cooperation between our five R&D departments in Stuttgart and the institute branches located in Leuna and Straubing. The constructive interplay of the various disciplines at our institute opens up new approaches in areas such as medical engineering, nanotechnology, industrial biotechnology, and environmental technology. Fraunhofer IGB is one of 69 institutes and independent research units of the Fraunhofer-Gesellschaft, Europe's leading organization for applied research.

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