Biodegradability Test with Laboratory Wastewater Treatment Plants

Place: Somewhere Date: Any Occasion: Joyful!

A new symbol of technological progress and economic growth is complete. Many were invited to the opening ceremony; everyone came.

12:00. With the touch of a button and a flourish, the Minister of Economics opens the new production plant. In his official speech, he once again stresses the importance of the new product line for the safeguarding of the business location: Jobs, tax revenue, prosperity...

Then the guests of honour proceed to the enjoyable part.

13:14. The aroma of the festive meal is assaulted by a penetrating putrefactive note. The wastewater from the new plant has caused the city's wastewater treatment plant to collapse. Citizens phone the town hall in alarm. Instead of higher tax revenues, there is the threat of fines for exceeding the discharge limits...

With biodegradability tests this would not have happened

Before wastewater can be led back to a body of water, it has to be cleaned - normally in a biological wastewater treatment plant. But is it even possible to clean it biologically? To determine this in advance, biodegradability tests are carried out in laboratory wastewater treatment plants.

Why biodegradability tests?

In a biological wastewater treatment plant, the bacteria of the sewage sludge 'devour' the organic wastewater components. They use part of this for their own energy needs; the organic compounds are degraded to carbon dioxide and water. They change part into their own body substance, to grow and reproduce; this creates excess sludge from which biogas is extracted in digestion tanks.

But not all organic compounds are biodegradable. Compounds that are not degraded by bacteria would end up in the water unchanged. Residuals of medicines, organic fluorine impregnating chemicals and other chemicals in rivers and even drinking water have made the headlines again and again.

Not only that: some compounds are toxic to the bacteria in the wastewater treatment plant. They prevent even compounds that are actually biodegradable from being removed from the wastewater.

With biodegradability tests, one can make a prediction about this. Biodegradability tests can be required

- to test new chemicals or preparations before they go on the market (REACH process),
- to determine whether the wastewater of a company is leading to problems
- to determine whether the activated sludge of a wastewater treatment plant is breaking down certain wastewater components correctly - for example such medications as antibiotics, or hormones, cosmetics and household chemicals.

Biodegradability test: how does it work?

Tests on biodegradability are described, for example, in ISO 11733 (2004)[1].

For the testing of the biodegradability of a substance or preparation, one usually proceeds on the basis of an artificial wastewater that is comprised according to the specifications of the standard of biologically easily degradable substances and the nutrients necessary for the bacteria (for example, ammonia, phosphate and others). For the biodegradability test, this artificial wastewater is added to the substance to be tested.

The water from the collection tank is regularly - for example, daily - taken and analysed. It is studied in terms of TOC (total organic carbon) and/or COD (chemical oxygen demand), and depending on the situation

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the individual substances to be studied, or their breakdown products, or sometimes nitrogen or phosphorus compounds.

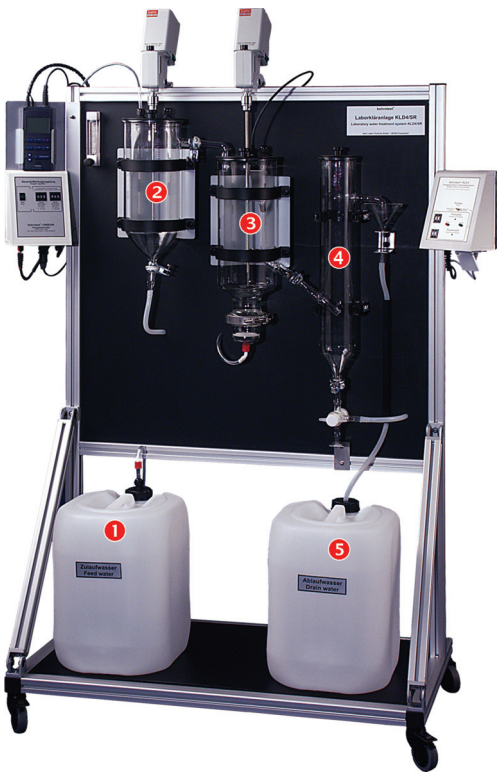
For comparison, alongside the actual biodegradability test there is always a blind test in which only the artificial wastewater, that is to say without the test substance added, is handled in the laboratory wastewater treatment plant.

The following are studied:

- Does the degree of degradation change due to the substance added to the water (measured, for example, as COD or TOC of discharge versus influx) compared to the artificial water to which nothing is added? This gives an indication of the possible toxic or inhibitory effects of this substance.
- Does the concentration of the substance to be studied change as it passes through the laboratory treatment plant - is it broken down or bound in the sludge - or does it run through unchanged? This yields information about the biodegradability of this substance.
- Is the substance easily biodegradable from the first moment, or must the bacteria first become accustomed to it?
- Does the biodegradability depend on the age of the sludge, that is to say the pollution of the treatment facility? In a highly polluted sedimentation tank, after all, fast-growing bacteria that only utilise the substances that degrade most easily quickly dominate; only with minimal pollution do slower-growing bacteria also have a chance.

Laboratory wastewater treatment plants

Laboratory wastewater treatment plants have the task in these biodegradability tests of mapping the processes in the treatment plant on a small scale. Much like a large treatment plant, they have aerated activation tanks, sedimentation basins and sludge return pumps. They are available in various configurations, from simple single-stage treatment plants to plants with a denitrification phase.



The picture shows a plant with an activation phase and a denitrification phase. From a storage tank❶, a pump transports the wastewater into the activation tank❷. It is filled with activated sludge, usually that of the nearest treatment plant. It is aerated with a controlled air pump, and stirred with a stirring motor. The discharge of the activation tank ends up in the denitrification tank❸. There it is also stirred, but not aerated, so that the bacteria must use the nitrate in water as a source of oxygen. Thus the content during the course of 'fertilizing' (eutrophicating) nitrogen compounds is reduced.

From the denitrification tank the water enters the settling tank❹. There the sludge settles at the bottom and is pumped back into the activation tank; the treated wastewater flows into the collection tank❷.

Example: Degradation of bisphenol A in biological wastewater treatment

An illustrative example of the use of laboratory treatment plants is provided by the tests on the degradation of bisphenol that were carried out by M. GEHRING et al at the TU Dresden.[1]

Bisphenol A is used, for example, in the production of plastics, component adhesives and plasticisers. Although the compound was originally developed precisely because of its hormone-like action, it was only determined later on that it can develop adverse effects in the aquatic environment.

In the test series at the TU Dresden, a synthetic wastewater with bisphenol A concentrations of some 5 to 15 µg/l was collected and treated in a laboratory wastewater treatment plant. The flow rate was 0.5 l/h, that is to say 12 litres per day. The experiment was continued for 8 weeks; the bisphenol-A content was analysed weekly at various points in the treatment process:

- in the intake❶
- in the water in the activation tank❷
- in the water in the denitrification tank❸
- in the discharge❺
- in the sludge in the activation tank❷
- in the sludge in the denitrification tank❸

This yielded a quite differentiated picture of the situation during biological degradation:

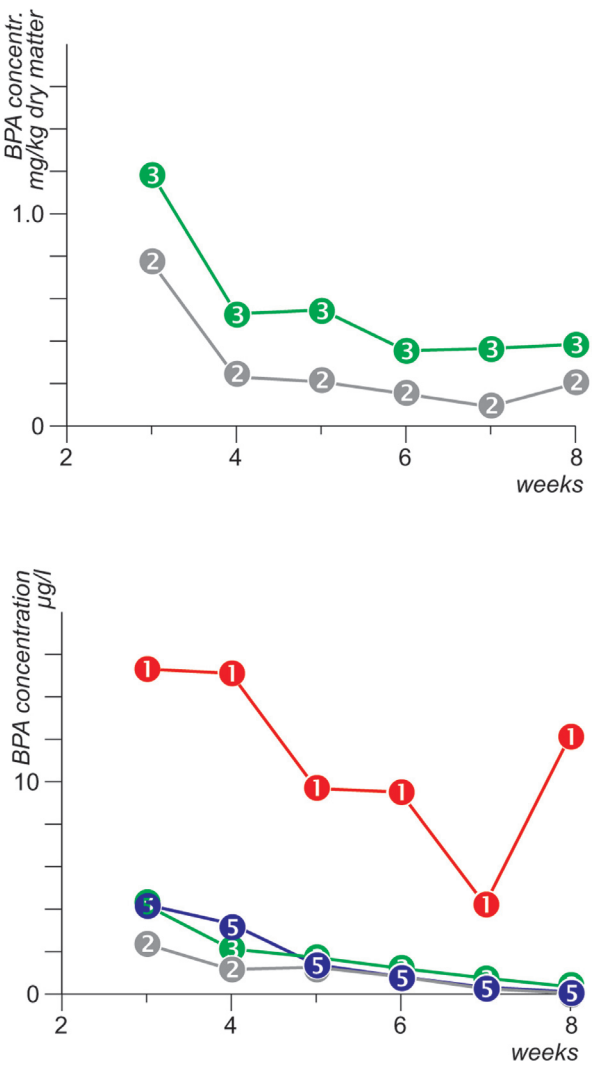
- Bisphenol A was found to be biodegradable, but the microorganism flora took several weeks to adjust to this wastewater component.
- To a considerable extent the substance is adsorbed into sewage sludge; in response to an incorrect transport procedure (if the sludge becomes anaerobic in the settling tank) it can, however, be released back into the discharge water from here.
- With a proper procedure it was possible to suppress the concentration of bisphenol A in the treated water under the detection limit.

What are the benefits of the study in a laboratory treatment plant?

The biodegradability test in a laboratory treatment plant makes it possible to study such processes on a small scale under conditions that are close to reality:

- Continuous processing of the test substance in realistic concentrations over any period of time makes it possible to observe the adaptation of the activated sludge to the test substance.
- Sludge return allows the formation of sludge with a sludge age that is near reality.
- The opportunity to take samples of the water and the sludge at different points in the treatment process allows a differentiated investigation of the processes involved in the biological treatment process.

Biodegradability conditions as these were demonstrated in the quoted test occur in many substances. The complicated interplay of adsorption on sludge, re-release and biodegradation or slow acclimatisation of activated sludge to a wastewater component could, for example, not be studied in a BOD measurement.



Course of bisphenol-A concentration in water and sludge at various points in the treatment process (redrawn after[1])

[1] *M. Gehring et al., Vortragsskript, TU Dresden 2002, http://rcswww.urz.tudresden.de/~gehring/deutsch/dt/vortr/020419ge.pdf*