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# Efficient Wastewater cleaning for Insulin Production


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**Insulin production using biotechnology is now a standard procedure, but it leads to a high level of contaminated wastewater due to tensides which are difficult to break down. A solution provided by EnviroChemie shows how production wastewater output with varying levels of contamination and toxicity can be cleaned efficiently. It combines aerobic and anaerobic steps as well as a low-temperature evaporator. The key point of the water treatment method designed by the engineers is the fact that the different wastewater sources are first identified and analysed each in turn, and then individually processed in an efficient manner.**

Diabetes is a metabolic disease which leads to an excess level of blood sugar in humans. The trigger is the lack of or reduced effectiveness of the body's own insulin; a hormone which is produced in the pancreas. The main function of insulin is the regulation of the concentration of glucose in the blood. If this is not done effectively, then external insulin needs to be injected into the body.

While insulin was previously extracted expensively from the pancreas of pigs, nowadays it is synthesised. This recombinant (human) insulin accepted by the body. To create it, the insulin gene is introduced into the DNA of a bacteria cell. Typical hosts for production of the desired proteins are specially grown, non-pathogenic strains of escherichia coli bacteria. To release the protein produced out of the cell membrane without changing its primary structure, a non-ionic tenside is used, such as Triton X-100. This type of tenside is hormonally active and difficult to break down, so has to be removed again during the subsequent wastewater processing.

One of the European companies which produces recombinant insulin, among other things, is Bioton S.A. in Macierzysz (Poland). At the end of 2008, as part of an expansion of their production site, a new multi-step wastewater cleaning plant was commissioned with a high degree of automation. It combines maximum up-time with a high level of operational safety - one of the core requirements from the company relating to toxic wastewater which cannot be discharged into public water courses. In addition, the plant had to be as energy efficient as possible and operate sustainably.

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The new plant was developed and installed by the head-office of EnviroChemie in Rossdorf and their subsidiary in Warsaw. EnviroChemie is a leading European constructor of plants for industrial wastewater treatment, process water treatment and energy production from industrial wastewater. The plants installed at Bioton,range from aerobic and anaerobic reactors, to low-temperature evaporators for the toxic wastewater output from the insulin production, to a detection system for in-line measurements.

### Three separate cleaning processes

Following in-depth analysis of the insulin production process EnviroChemie proposed a customised solution. The wastewater coming from production is treated as three separate sources and are assigned to different cleaning stages. This has the major advantage that individual steps within stages can be scaled down better than if a uniform process was required for all wastewater. This reduces not just the cost of the plant technology, but also the operating costs. Because smaller and better defined wastewater sources can be treated more specifically and therefore more efficiently. For example, this makes it possible to treat the highly toxic wastewater contaminated with Triton X-100 separately and directly at its source, without ever mixing it with other waste water. This increases the operational safety of the biological cleaning stages and reduces their load. On the other hand, sanitary wastewater with low contamination can be fed directly into an aerobic processing stage without having to pass through all the other stages. This saves hydraulic capacity.The three separate flows to be processed consist of:

- highly contaminated wastewater from production with a COD level of up to 40,000 mg/l,
- tensides which are difficult to break down (Triton X-100) and
- slightly contaminated wastewater from sanitary areas.

The new system approach to wastewater processing for wastewater flows of up to 600m3/day is presented here. "In order to achieve the most efficient solution“, explains Piotr Stępień, who is responsible for the operation of the plant at Bioton. "Both we and EnviroChemie carried out extensive preliminary laboratory tests and pilot tests over several months." These covered purely aerobic biological processing, its combination with an anaerobic stage, as well as the wastewater containing the toxic Triton X-100 via the slow temperature evaporator. For the primary wastewater with high COD and BOD5 levels, a 3-stage safety approach has been developed by EnviroChemie.

### Integrated safety approach

The first part of the new safety approach consists of three mixing and equalisation basins (MEBs) which are each filled in turn. The volume of each is 240 m³ and matches the volume of highly contaminated wastewater which is produced over a 24-hour period. The second stage is continuous monitoring of toxicity in the recently filled MEB. These measurements then initiate the following different processes: If the wastewater is toxic then it is moved on immediately to the evaporator, as is the wastewater with the hormonally active Triton X-100.

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*After extensive laboratory testing, a decision was made for a customized plant solution*

If there is just a small quantity of the toxic wastewater then it can go directly to the aerobic stage. But if the tests only show high toxicity for anaerobic bacteria, then the wastewater is mixed with the sanitary wastewater and treated in the activation basin of the aerobic stage. Highly contaminated wastewater which is not toxic for the bacteria in the anaerobic stage are fed directly into the anaerobic reactor to produce biogas. Following the anaerobic processing, the wastewater is then further processed in the aerobic stage.

The third part of the safety approach for the highly contaminated wastewater from production is the redundant anaerobic stage. This consists of two lines which work totally independently from each other. Each of these consists of mixing and equalisation basins, the methane reactor as well as powerful measurement instruments. In the mixing and equalisation basins the pH value and temperature are constantly monitored. If, despite the intermediate storage, the wastewater is too acid or too alkaline, then the pH value is corrected by adding the correct amount of caustic soda or hydrochloric acid. A further process which takes place in the MEBs is the biological pre-acidification. Here organic materials such as carbohydrates, sugar, alcohol and long-chain polymers are hydrolysed and acidified. This is necessary to allow them to be broken down more efficiently in the methane reactor in the next step.

### Evaporation of tenside which is hard to decompose

The wastewater supply from insulin production at Bioton contains Triton X-100, a non-ionic tenside, along with high levels of COD and BOD5. The typical load per litre of wastewater is 7,000 mg. This is a health risk and so is sent directly to the evaporator. A second line was installed here to provide redundancy. In a vacuum distillation plant the wastewater is first concentrated to the threshold of the substances' solubility and then passed on to the separator, this is done without any moving parts, so without any problems from wear.

In addition the distillate created by the evaporation process is used together with a heat exchanger to pre-heat the incoming wastewater. The next steps are the sterilisation of the distillate at an evaporation temperature of over 120 °C and low pressure of around 600 mbar. This is followed by transfer to the activation basin, the aerobic stage, together with the rest of the wastewater. The concentrate created by the evaporation is disposed of as a hazardous waste.

### Greater efficiency with anaerobic pre-treatment

"The anaerobic stage included in the EnviroChemie approach is not in fact mandatory", explains Mr Stępień, "but brings huge benefits for the plant as a whole in terms of efficiency." Because the COD measures of aerobic and anaerobic biological breakdown show that with a combination of the two the

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COD level can be reduced by nearly 100%. First of all an anaerobic process is used to reduce the majority of the BOD5 and COD; the rest is then converted in the aerobic reactor by introducing additional air (oxygen). In addition, the energy needed for anaerobic processing, at up to 0.1 kWh/kg COD is only about 1/10th of the energy required for the aerobic version. And the amount of sludge created is noticeably less. These factors alone reduce the running costs to the point where the anaerobic reactor, despite its higher initial costs, is rapidly amortised. If the waste heat from the anaerobic reactor is also recycled, this saves further energy, so reducing operating costs.

The main difference between the aerobic and anaerobic processes consists of the fact that with aerobic COD reduction around 50% of the input is used to build up the biomass, and around 50% is emitted as carbon dioxide. In comparison to this, in anaerobic COD reduction only 5 to 15% of the COD of the input is converted to biomass, while 75 to 80 per cent is converted to methane in the form of biogas.

Both the Biomar-ASB reactors from EnviroChemie for anaerobic biological reduction are UASB-sludge blanket reactors (Upflow Anaerobe Sludge Blanket) each with a volume of 400 m³. They use the counterflow principle. The wastewater is pumped into the reactor from below and flows upwards through the biomass. In the upper part of the reactor there is a 3-step-separation system developed by EnviroChemie, which separates biogas, sludge particles and clean wastewater from each other.

### In-line measurement and heat recovery

With the detection system built into both anaerobic reactors the operator has the option of measuring and recording the level of contamination of the wastewater within the various areas of the reactor. The clean wastewater is collected in the drainage system and transferred to the Biomar OSB aerobic wastewater processing system. The typical conversion rates in this sludge blanket reactor are in the range of about 3,000 keg COD/m3 per day being eliminated. The biogas created from the liquid phase of the wastewater is captured in the upper part of the reactor, fed through a condenser separator and after appropriate preparation can be fed into the natural gas grid system. With a full load, biogas volumes of up to 1,000 m³/d can be achieved, which improves the energy balance of the plant.

The anaerobic processes run at 35° to 38° Celsius, which heats the wastewater prior to its transfer to the methane reactor. In order to keep the energy needs for heating to a minimum, the wastewater is passed over a heat exchanger, which uses the waste heat from the output of the methane reactor. Further heat is created by adding steam.

The third wastewater flow is sanitary wastewater. It is initially collected in the sewers and then pumped through a filter plant to separate solids and large particles into the mixing and equalisation basins. From there it reaches an activation basin for the aerobic stage and, together with wastewater which is toxic for bacteria from production and the permeate from the evaporator, it is then cleaned further.

This task is done by single cell organisms and bacteria. In the so-called activated sludge, oxidising elimination occurs in the presence of added oxygen, reducing the levels of COD and BOD5. This also applies to nitrate and phosphate compounds. As the final cleaning stage before discharge into the river Utrata the wastewater passes through a sand filter to separate out suspended particles. The COD and BOD values are below 125 mg/l and 15 mg/l respectively.

## Summary

The highly contaminated wastewater at Bioton comes from production and from the manufacture of recombinant insulin. The system solution developed by EnviroChemie for wastewater treatment meets the two key requirements from the customer: the greatest possible safety of operation for the entire wastewater process and energy-efficient plant technology which uses the necessary raw materials sustainably and minimises operating costs. The EnviroChemie approach includes separating the wastewater from production into separate flows for evaluation and subsequent transfer to different treatment stages: anaerobic processing, aerobic processing, evaporation unit. An integrated detection

*A compact plant solution – all treatment unit in one building*

system and modern process controls enable monitoring, controlling and documenting the status of the wastewater in the various zones at all times. With the three-stage safety approach for processing highly contaminated wastewater flows it is ensured that no toxic wastewater is discharged into public waterways. The required threshold values for introduction of clean wastewater from the various wastewater sources are respected which allows direct discharge into the river Utrata.