TANWATER – REDUCTION OF NITROGEN DISCHARGE FROM THE LEATHER INDUSTRY

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Abstract

The tannery Elmo Leather AB in Sweden has recently finalized a new wastewater treatment plant using an innovative system for nitrogen removal. The innovation of the plant is the implementation of a nitrification and denitrification step in the treatment of tannery wastewater. The technology has before not been considered feasible in wastewater treatment plants for the leather industry, due to the composition of the tannery wastewater.

The construction of the wastewater treatment plant started in March 2004 and the plant was taken into operation in April 2005. The total cost for the project was slightly above 5 million Euros and the investment cost around 4, 3 million Euros. The project was supported by the EU LIFE Financial Instrument with 913.999 Euro.

The plant has been running during one year and the performance of the plant has been very stable and as example can be mentioned that the reduction of nitrogen in the plant has never been below 80 % despite the Scandinavian winter conditions. During September 2005 – April 2006 the average reduction of some key parameters has been the following: BOD-removal 98%, COD-removal 92 %, Nitrogen-removal 89 % and Chromium-removal 89 %.

In summary, this EU LIFE-supported project has demonstrated that it is possible to reduce the nitrogen discharge from the leather industry by more than 80 % in a cost-effective way.

Background

The tannery Elmo Leather AB in Sweden is today the largest manufacturer in the world of exclusive furniture leather and one of the six largest manufacturers in the world to the automotive Industry, and is operating worldwide in about 40 different markets. Elmo Leather has around 400 employees, of which 340 persons are employed by Elmo Leather AB in Svenljunga.

Elmo Leather AB has during many years focused on having an environmental sound production of leather and by making changes in processes and making substitution of chemicals the environmental impact has been substantially reduced. In order to make further progress and achieve further improvements, the company needed to introduce a new treatment process for the tanning industry in order to reduce the nitrogen pollution in the wastewater even further.

At that time, the wastewater from the tannery was discharged to the municipal wastewater treatment plant in Svenljunga together with municipal wastewater from Svenljunga (although the major load to the treatment plant was coming from the tannery production). The present situation was a barrier for the tannery to increase the leather production in the future and furthermore the environmental authorities in Sweden which are very strict were pressing the
The tannery started therefore in 2002 the first plans to build a new treatment plant with a clear goal that the nitrogen removal should be high (more than 80%) and stable. The nitrogen removal should not be affected by changes in the composition of the wastewater nor by the harsh winter conditions in Svenljunga where temperatures down to more than -20°C is not uncommon.

Preparatory phase
The preparatory phase consisted of three parts which were selection of technology, applications to authorities for a building permit and an environmental permit and finally application for financial support from the EU Life financial instrument in order to obtain financial support.

Selection of technology
The project started by an extensive survey of results from other wastewater treatment plants. The study showed that nitrification and denitrification of tannery wastewater in order to reduce the nitrogen content in the wastewater has gradually been discussed as an option in countries with strict nitrogen discharge limits. However, due to severe difficulties in controlling the process and odour problems the process has not been introduced or considered possible to introduce for treatment of tannery wastewater. Only in a very few tanneries attempts have been made to implement a nitrification/denitrification phase in the activated sludge plant. However, the experiences showed that the process gets disturbed regularly and it has therefore not been considered as a technique applicable to tanneries. The EU BREF-Document (IPPC-Directive) for tanneries state “Due to the difficulties in controlling this process (nitrification and denitrification), it cannot be considered general practice for individual plants”.

The removal of nitrogen from effluents by nitrification/denitrification is used by some municipal wastewater treatment plants in Europe (easier to treat than wastewater from tanneries). In the first biological process (nitrification) the ammonia nitrogen is oxidised into nitrate. This process takes place under aerobic conditions, i.e. in the presence of oxygen. In the second process (denitrification), the nitrate is reduced to gaseous nitrogen, which escapes into the atmosphere. The denitrification takes place under anoxic conditions.

The innovation in this project was to introduce and apply a technology to reduce nitrogen in the wastewater, which are used by other sectors into the treatment of tannery wastewater.

One of the major suppliers of nitrification/denitrification systems in Europe did together with Elmo Leather in Sweden perform laboratory trials in 8 months on the use of nitrification/denitrification technology on tannery wastewater. The trials were successful and the results from the trials were used for up scaling to full scale in order to effectively demonstrate that the technology can be used on wastewater from tanneries. Examples of important factors to obtain a stable cleaning process are: the plant has a strict process control (especially pH and balance of nutrients is important); the plant is a 2-step plant (toxic compounds degraded in step 1) and the plant has a possibility for hydraulic equalization (to avoid fluctuations in e.g. chloride concentration).
Permits

The first contacts regarding the wastewater treatment plant was taken with the relevant environmental authorities in February 2002 and the application for a permit was delivered on the 26 March 2003. The building permit was received by the local authorities on the 2003-11-10 while the environmental permit was achieved on the 10 February 2004, which was later than expected. As a result of the time-consuming process to receive the environmental permit the actual start of the construction of the plant was delayed by more than 6 months.

Application for financial support

LIFE, the Financial Instrument for the Environment, introduced in 1992, is one of the spearheads of the European Union's environmental policy. It co-finances projects in three areas and environment is one of these areas. LIFE-Environment aims to implement Community policy and legislation on the environment in the European Union. This approach enables demonstration and development of new methods for the protection and the enhancement of the environment.

Elmo Leather AB in cooperation with Nordeconsult prepared an application for financial support to the LIFE Environment Financial Instrument. The application was submitted to the European Commission in November 2002 and was granted a funding of 913.999 Euro.

As part of the contract with the European Commission, Elmo Leather AB has performed a number of dissemination activities about the project to stakeholders (leather industry, other industries with similar wastewater as e.g. textile industry, consultants, wastewater treatment companies, authorities, decision makers and the general public).

Technical description

An overview of the plant is given below and followed by a description of the plant.
The principle of the WWTP is the following. The wastewater flows from the tannery to the new inlet pumping station through a 2mm screen. The wastewater is then pumped to biological treatment.

**Step 1 Biological Treatment (Equalization and removal of COD and toxic matter)**

The wastewater is pumped into the first aeration tank, which has a volume of 2000 m³. The tank serves as a buffer tank for equalization of flow and pollutants. At the same time the tank is used as an aeration tank where micro-organisms are grown to oxidize a great part of the organic matter and sulphide in the wastewater. Oxygen is supplied through robust aerator mixers to secure a stable operation of the first biological step. Phosphoric acid is dosed to support the growth of micro-organisms.

*Deaeration:* From the aeration tank the wastewater flows to a deaeration tank where iron salts and polymer can be added to improve performance of the first settling tank.

*Settling/Sedimentation:* In the first settling tank most of the suspended solids in pre-treated wastewater are removed. Excess sludge collected at the bottom of the settling tank is pumped to sludge dewatering in the existing sludge dewatering building. Sludge can also be pumped back into the aeration tank to improve removal of organic matter in the system.

*Intermediate pumping station:* Pre-treated wastewater is collected an intermediate pumping station. The wastewater is then pumped to the second aeration tank. The wastewater is pumped into the aeration tank at intervals depending on operation mode in the aeration tank.
2. Step - biological treatment
The final purification of the wastewater takes place in the second aeration tank. The tank is designed with a big volume (5100 m³) so biological nitrogen removal can take place.

Nitrogen removal: The nitrogen is present in the wastewater mainly as ammonia. The nitrogen removal is a biological process performed by two processes: nitrification and denitrification. In the first biological process the ammonia nitrogen is oxidized into nitrate. This process takes place under aerobic conditions, i.e. in the presence of oxygen. In the second process (denitrification), the nitrate is reduced to gaseous nitrogen, which escapes into the surrounding atmosphere. The denitrification takes place under anoxic conditions, which means that oxygen is not present or in anoxic zones of the flocks. In this system, the combination of aerobic and anoxic conditions (which is necessary for the nitrogen removal) is created by switching off the aeration when denitrification is taking place.

Deaeration: From the aeration tank the wastewater flows to a deaeration tank where polymer can be added to improve performance of the final settling tank.

Settling: In the final settling tank, the suspended solids settles and the treated wastewater (almost free from suspended solids) is transported to a disc filter, which has a maximum size of 10 µm to ensure that levels of remaining suspended substances are low. A flow-controlled sampler is used in the well after the disc filter to check the pollution levels of the treated water. After this the treated water is discharged. The major part of the sludge will be pumped back to the second aeration tank, while a minor part of the sludge is pumped to sludge dewatering in the existing sludge dewatering building. It is important for the stability of the nitrification/denitrification that micro-organisms from the sludge are transferred back to the aeration tank.

The risk in this phase is that the very sensitive nitrification/denitrification step will not function optimally due to fluctuations in the inlet water from the processes. Corrective measures can be carried out if necessary. Dilution water from the effluent of the municipal treatment plant can be added to the plant in order to avoid large fluctuations in the inlet concentration of chemicals (as e.g. salt) to the new WWTP. A high degree of control and monitoring systems of the process has been included in the plant.

Environmental Performance
The construction of the new wastewater plant started in March 2004 and the first trials of the plant started in January 2005. These trials consisted of dry test of the machinery (pumps and other equipment).

The wet trials of the plant (testing pumps, pipes and other equipment) using water started in February 2005. During March 2005 the building up of an active biomass started (using activated sludge from municipal wastewater treatment plant as starting material).

Initial trials using actual wastewater started in April and on the 21 April 2005 the first water was discharged from the treatment plant to the river.

The wastewater treatment plant is now operating and running with wastewater from the tannery. The preliminary results so far are positive and as an example can be mentioned that the nitrogen removal is working according to the expected goals.
The monitoring programme was finally defined and approved by the regional environmental authorities in June 2005. A high number of parameters are controlled every month.

The preliminary results of some key parameters from September 2005 - April 2006 are given in the table below.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Incoming (mg/l)</th>
<th>Outgoing (mg/l)</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>4287</td>
<td>76</td>
<td>98.2 %</td>
</tr>
<tr>
<td>COD</td>
<td>9125</td>
<td>738</td>
<td>91.9 %</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>566</td>
<td>60</td>
<td>89.3 %</td>
</tr>
<tr>
<td>Chromium</td>
<td>7.2</td>
<td>0.80</td>
<td>88.9 %</td>
</tr>
</tbody>
</table>

Elmo is sending regular reports to the authorities (Länsstyrelsen) about the performance of the plant. The plant is working well so far and especially the nitrogen removal is high (even higher than the target values). The parameters where the reduction so far is slightly below the target values are phosphor and suspended solids. Optimization of both the processes in the factory and in the running of the treatment plant are ongoing in order to increase the reduction of phosphor and suspended solids.

It should be noted that the plant now has been running during one year and the performance of the plant has been very stable and as example can be mentioned that the reduction of nitrogen in the plant has never been below 80 % despite the Scandinavian winter conditions.

**Financial Data**

The investment cost of the plant was around 4.3 million Euro (total cost for project slightly above 5 million Euro) and the plant has been dimensioned for a flow of around 1250 m³/day. The running cost mainly consists of costs for personnel, chemicals, energy, maintenance and sludge treatment. The cost for some of these parameters (personnel and energy) differs between many EU-countries and it may be difficult to directly estimate the running cost at European level. The running cost for chemicals in the new plant has so far been 0.34 €/m³ which should be compared to 1 €/m³ which was the cost at the old wastewater treatment plant. The cost for energy is approximately the same as for the old plant and the energy consumption is around 8-9 KWh/m³. The total treatment cost for the dimensioned flow including the investment cost (depreciation 20 years, no interest rate) but excluding cost for sludge handling is around 1.5 – 1.6 €/m³ which is a competitive price for wastewater treatment.

**Summary**

The environmental policy at Elmo Leather AB shows that it is possible to reduce the environmental impact for leather production substantially. Elmo Leather AB did first minimize the pollution by introducing best available technologies in the production by changing processes and substituting chemicals. In order to further reduce the pollution, a new waste water treatment plant was built with the support of the EU LIFE financial instrument.

The wastewater treatment plant at Elmo Leather AB which has been in operation in full scale for more than one year has shown that it is possible to obtain a stable and long-lasting
reduction of the nitrogen discharge in the wastewater by more than 80% in a cost-efficient way by using the TANWATER nitrification/denitrification technology.

There is a large potential for transferring the results and the technology to other tanneries or wastewater treatment plants dealing with tannery wastes. In order to facilitate that transferability, an extensive dissemination of the experiences from the project was carried out.

A picture from above of the plant is given below.