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Anaerobic treatment of effluent from recycled paper

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The first anaerobic wastewater treatment plants were installed in 1983 and anaerobic technology has since spread widely through the pulp and paper industry, especially in recycled based paper and board mills. Most of the installed anaerobic reactors are Upflow Anaerobic Sludge Bed (UASB) type reactors.

In the past decade recycled paper has become an important raw material for paper production. Together with the increasing use of recycled paper, paper mills have reduced their freshwater consumption by closing up their process water circuit. This resulted in lower volumes of discharged effluent with a higher organic pollution content. The method of stock preparation is determined by the grade of the raw material and on the desired quality of the end product. Deinking processes are applied to remove contaminants like ink, waxes and plastics. In the deinking process often chemical aids such as caustic, peroxide, complexing agents and detergents are used.

The high pollution level of the effluent makes anaerobic treatment a feasible wastewater purification method. Advantages of anaerobic treatment toward aerobic treatment are mostly related to the low space requirement, the production of energy (biogas), the low sludge production and the possibility for discontinuous operation. As aerobic treatment systems alone generally have a high energy consumption and sludge production, combined anaerobic/aerobic effluent treatment is an attractive method for wastewater purification. The BIOPAQ UASB (Upflow Anaerobic Sludge Bed) is the most applied anaerobic treatment system for recycled paper mill effluent. Over 30 full scale anaerobic BIOPAQ UASB reactors have been built in the pulp and paper industry.

The UASB process

In an UASB reactor the wastewater is evenly distributed over the bottom area and flows up through a dense sludge bed of anaerobic granular sludge. The sludge converts the organic compound into biogas (mainly methane and carbon dioxide). The mixture of treated effluent, biogas and granular sludge is separated by a specially designed three-phase-separator located at the top of the reactor. While the biogas is removed from the reactor, tranquillity is restored and the granular sludge will settle back in the reactor. Finally, the treated effluent overflows the weirs of the effluent collection system on top of the reactor. Figure 1 shows a schematic of the BIOPAQ UASB system.

Description of the effluent treatment plant

Industriewater is a company that treats the combined effluents from three different paper mills. The three papermills are De Hoop (SCA), which produces corrugated medium/testliner, Mayr-Melnhof, which produces folding box board and Coldenhove, which produces specialty papers. All

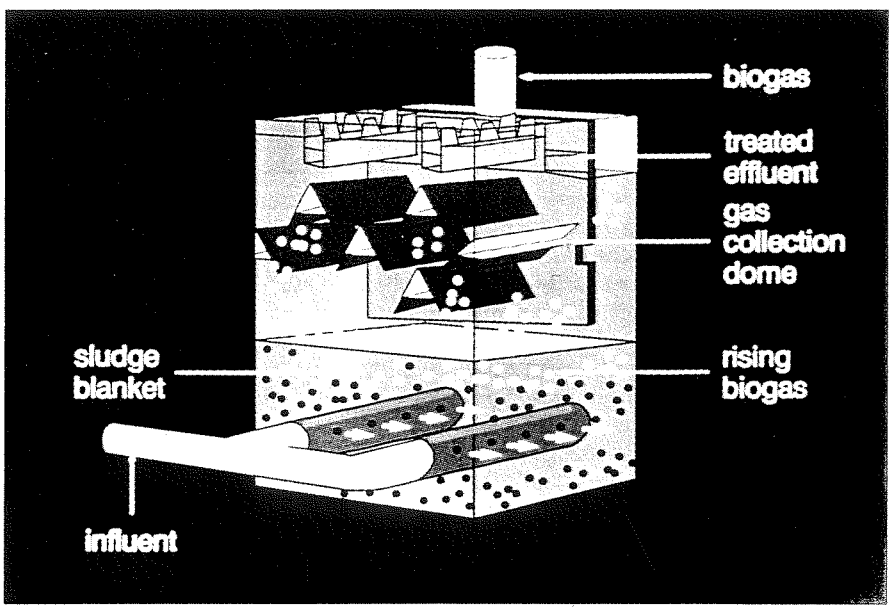

Figure 1. Schematic of BIOPAQ UASB reactor.

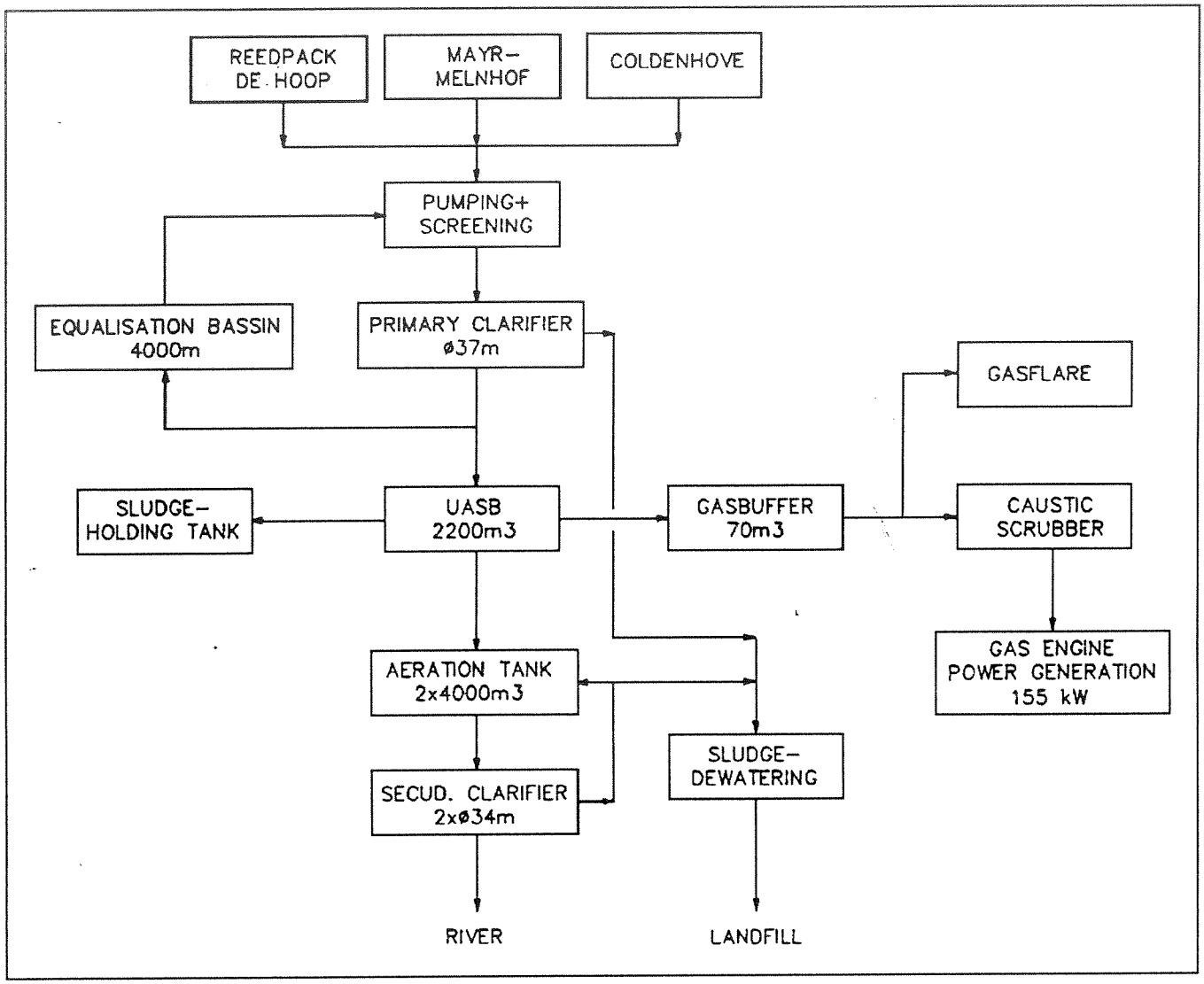

Figure 2. Schematic layout of the wastewater treatment plant at Industriewater Eerbeek.

three mills use recycled paper as raw material and Mayr-Melnhof also uses deinking wastepaper (60 per cent) as raw material. The total annual paper production of the three mills increased from 220 000tpy in 1981 to 351 000tpy in 1992. Over the same period the specific BOD load for every ton of paper produced increased from 6kg a ton to 10.5kg a ton, while the specific volume of discharged wastewater for every ton of paper produced increased from $12m^3$ a ton to $16m^3$ a ton. Since 1978 an activated sludge plant was treating the combined effluents from the mills. As the production of the paper mills increased the activated sludge plant became overloaded. In 1985 the capacity of the wastewater treatment plant was increased by installing an anaerobic UASB reactor. After primary clarification the combined effluents are treated in the anaerobic UASB reactor. The produced biogas is used by gas engines for power generation. The treated effluent from the anaerobic reactor is sequentially treated in the activated sludge. The sludge from the anaerobic reactor is stored and used for the start-up of other UASB reactors. The sludge from the aerobic system is dewatered and put to a landfill site. A schematic layout of the wastewater treatment plant is presented in Figure 2.

Operational results

The characteristics of the wastewater are presented in Table 1. The temperature of the wastewater is 28–32°C, which is suitable for anaerobic treatment. Furthermore, the wastewater contains about 140mg/l sulphate.

Figure 3 shows the BOD concentration of the wastewater before and after installation of the anaerobic reactor in 1985. From Figure 3 it can be concluded that despite the increase of BOD in the wastewater the BOD concentration to the aeration system remains relatively constant. The average removal efficiencies of the anaerobic reactor are 65–70 per cent on COD and 75–80 per cent on BOD. The final effluent of the aerobic system has a BOD concentration of 5–15mg/l and is discharged into a river. The specific gas production is $0.4m^3$ biogas for every kg of COD removed. The excess sludge production of the anaerobic system is confirmed to be 0.04kg TS

Mill	Flow (m^3/d)	COD soluble (mg/l)	COD soluble (kg/d)	BOD soluble (mg/l)	BOD soluble (kg/d)	Solids (mg/l)
SCA De Hoop	6000	3000	18 000	1650	9900	440
Mayr-Melnhof	5850	990	5800	480	2800	3250
Coldenhove	1300	230	300	80	100	690
Combined	13 150	1830	24 100	970	12 800	1715

Table 1. Current wastewater characteristics.

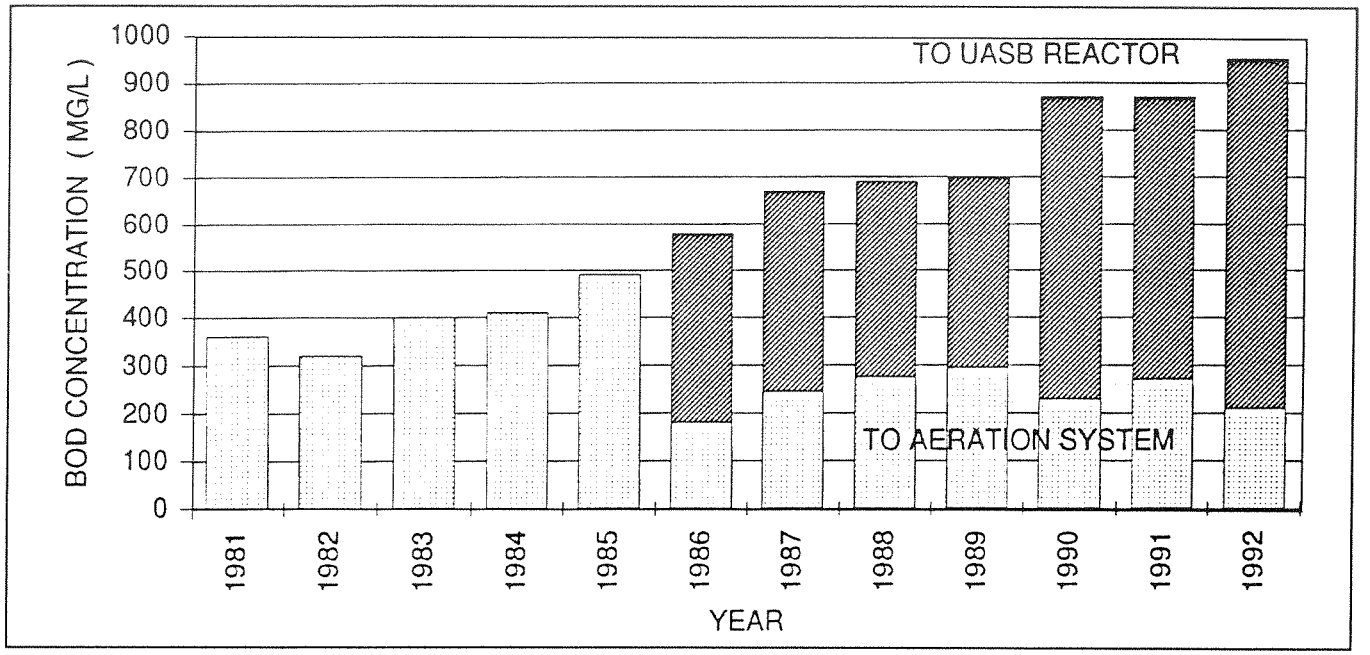

Figure 3. BOD concentrations to UASB and aeration system.

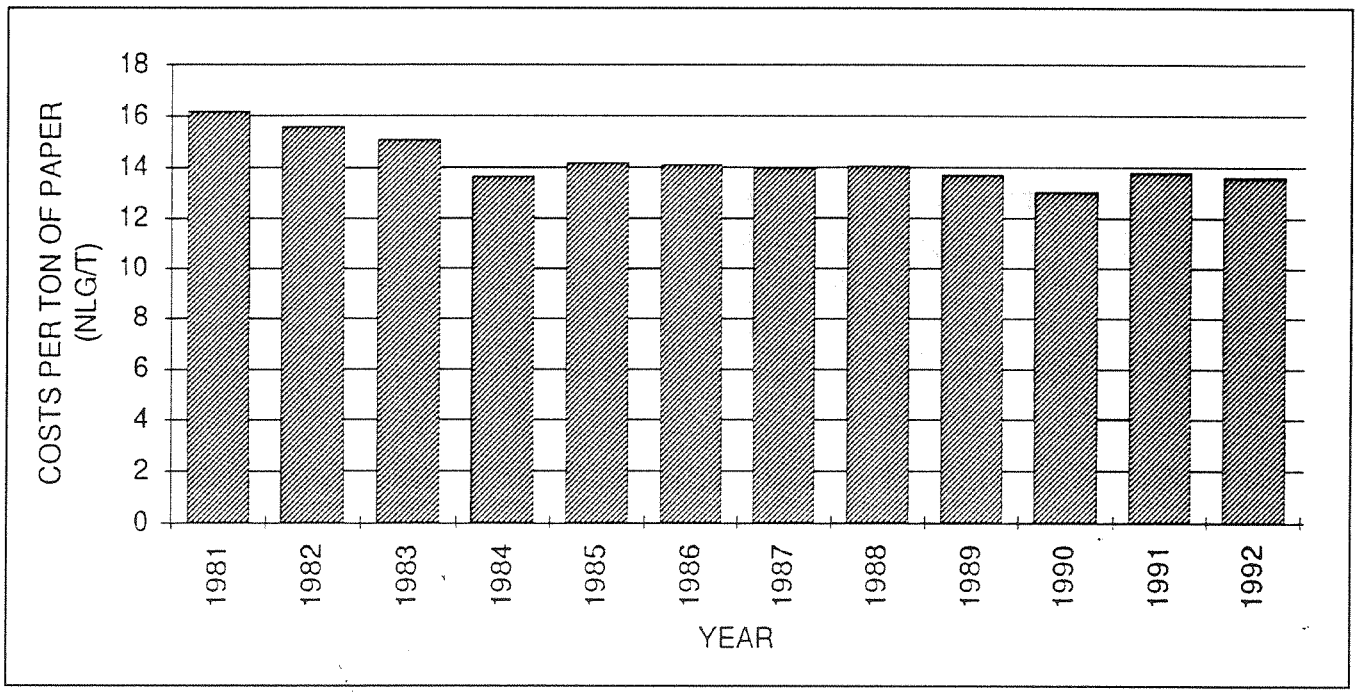

Figure 4. Specific wastewater treatment costs.

for every kg of BOD removed. This is a low figure compared to the aerobic process where the excess sludge production can be up to 0.5kg TS for every kg BOD removed. The installation of the anaerobic reactor reduced the total excess sludge production of the effluent treatment plant from 0.6 to 0.15kg TS for the initial BOD load.

Operational costs

Figure 4 shows the specific costs of wastewater treatment expressed for each ton of paper produced. The costs include all capital, operational and maintenance costs. Although the total BOD load to the wastewater treatment plant increased from approximately 4500kg a day in 1981 to approximately 12 800kg a day in 1992, the costs for wastewater treatment for every ton of paper produced was reduced from 16.2 to 13.8NLG a ton.

Anaerobic treatment has proved to be a reliable and cost-effective method to treat recycle paper mill effluent including deinking. □

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