FIVE YEARS FULL SCALE EXPERIENCE WITH ANAEROBIC TREATMENT OF RECYCLED PAPER MILL EFFLUENT AT INDUSTRIEWATER EERBEEK IN THE NETHERLANDS

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ABSTRACT

In The Netherlands, approximately 60% of all paper production is based on recycled paper. All effluents are treated biologically before discharge to sewer or surface water. In 1983, the first anaerobic wastewater treatment plants were installed, since then the anaerobic technology has spread widely through the pulp and paper industry and especially in the recycled based paper and boards mills. Most of the installed anaerobic reactors are Upflow Anaerobic Sludge Bed (UASB) type reactors.

Industriewater Eerbeek B.V. treats the effluent of three separate mills in the same town. In order to cope with increasing BOD/COD loads, an anaerobic (UASB) reactor was installed in 1985 to expand the treatment capacity of the existing activated sludge plant. The three mills are: de Hoop (Reedpack) which produces corrugated medium/test liner, Mayr-Melnhof which produces folding box board and Coldenhove which produces specialty papers. All three mills use recycled paper and the second uses waste paper deinking. The combined production of the mills is 350,000 tons per year.

This paper deals with five years operating experience of the anaerobic reactor and the economics of the effluent treatment.

At present, a second UASB reactor has been installed to accommodate increasing loads due to future mill expansions.

KEYWORDS

Recycling, Wastepaper, Effluent Treatment, Anaerobic Process, UASB.

INTRODUCTION

Industriewater Eerbeek B.V. is a company that treats the wastewater of three shareholders. These shareholders are three different papermills located in the town of Eerbeek in the Netherlands, namely:

- Reedpack, de Hoop, papermill, with a production of 245,000 tons per year of corrugated medium and testliner from wastepaper. This mill is the major source of the BOD load to the treatment plant.

- Mayr Melnhof Eerbeek, producing 85,000 tons per year of folding box board from pressurized ground wood (40%) and deinked wastepaper (60%).

- Coldenhove Papermill, with a production of 21,000 tons per year of envelope and special cover paper from virgin pulp (50%) and wastepaper (50%).

Figure 1 shows the increase of the total production over the past 10 years, from 220,000 tpy in 1981 to 351,000 tpy in 1990.

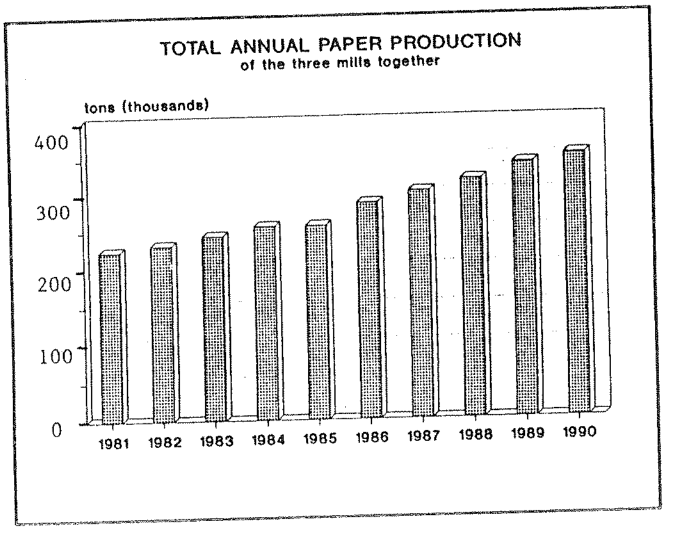

Figure 1

Over the same period, the specific BOD load per ton of paper production has increased from 6 kg per ton produced to 10.5 kg per ton produced. (See Figure 2). Figure 3 shows the specific amount of wastewater per ton of paper production, which has decreased from approximately 16 m³ per ton to approximately 12 m³ per ton produced.

These graphs explain the considerable increase of the soluble BOD concentration in the wastewater over the past 10 years.

The present wastewater characteristics are presented in Table I.

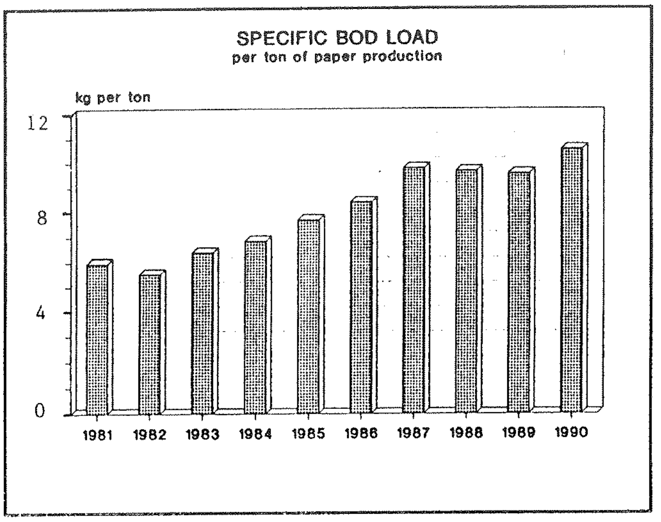

Figure 2

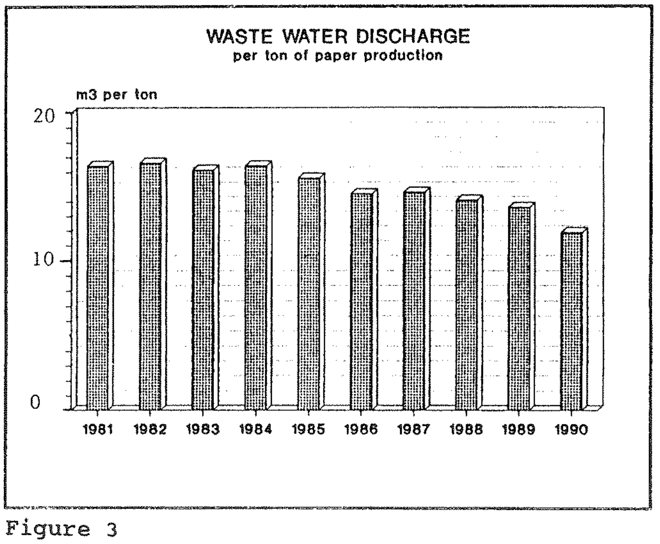

Figure 3

TABLE I: Present Wastewater Characteristics

Mill	Flow m^3/d	Soluble COD ppm	Soluble COD kg/d	Soluble BOD ppm	Soluble BOD kg/d	Settl. Solids kg/d
De Hoop	5000	2800	14000	1600	8000	2000
MME	5900	850	5000	350	2000	14000
Coldenh.	1400	140	200	70	100	1000
Total	12300	1560	19200	820	10100	17000

The temperature of the wastewater is rather constant and ranges from 28°C in winter to 32°C in summer. The wastewater contains a sulfate concentration of approximately 140 ppm.

Since 1978, an activated sludge plant has been operated to purify the wastewater to surface water standards. In 1985, the plant capacity was increased by installing anaerobic pretreatment.

DESCRIPTION OF THE PRESENT PLANT

A schematic layout of the wastewater treatment plant is given in Figure 4. The three different wastewater streams, discharged by the mills, flow by gravity through an independent sewage system to the treatment plant, where the combined wastewater is received in a collection sump.

Two screw pumps lift the wastewater to create a gravity flow to the primary clarifier after first passing through a rotating screen to remove large solids and through a pre-aeration step to remove odorous components. The clarifier was originally installed to treat a much larger flow than exists today. The pre-aeration tank is covered with a compost filter to prevent air containing H_2S from entering the atmosphere. The clarified wastewater is then pumped into a BIOPAQ Upflow Anaerobic Sludge Blanket Reactor (UASB reactor). Incoming flows above a certain level are directed to an equalization tank. The volume of the UASB reactor is 2200 m^3. In the reactor, the dissolved organics are converted mainly into biogas (approx. 80% methane, 19% carbon dioxide and 1% H_2S) and into granular biological sludge.

The biogas produced by the system passes through a 70 m^3 gasbuffer. After that, a part of the biogas is scrubbed for H_2S removal and utilized in a gas engine to generate 155 kW of electric power. All excess biogas is burned by a flare. Excess anaerobic sludge is sluiced periodically from the reactor and stored before it is delivered to other sites for start-up of new reactors.

The anaerobically pre-treated wastewater is post treated by an extended aeration system, consisting of two aeration tanks, each one with a volume of 4000 m^3, and two final clarifiers. The return aerobic sludge is pumped back to the inlet of the aeration tanks by screw pumps. The excess aerobic sludge is pumped to a sludge thickener and mixed with the primary sludge. The sludge mixture is dewatered on two belt presses and discharged for landfill. The final effluent, with BOD concentrations of 5 - 15 ppm, is discharged to a river.

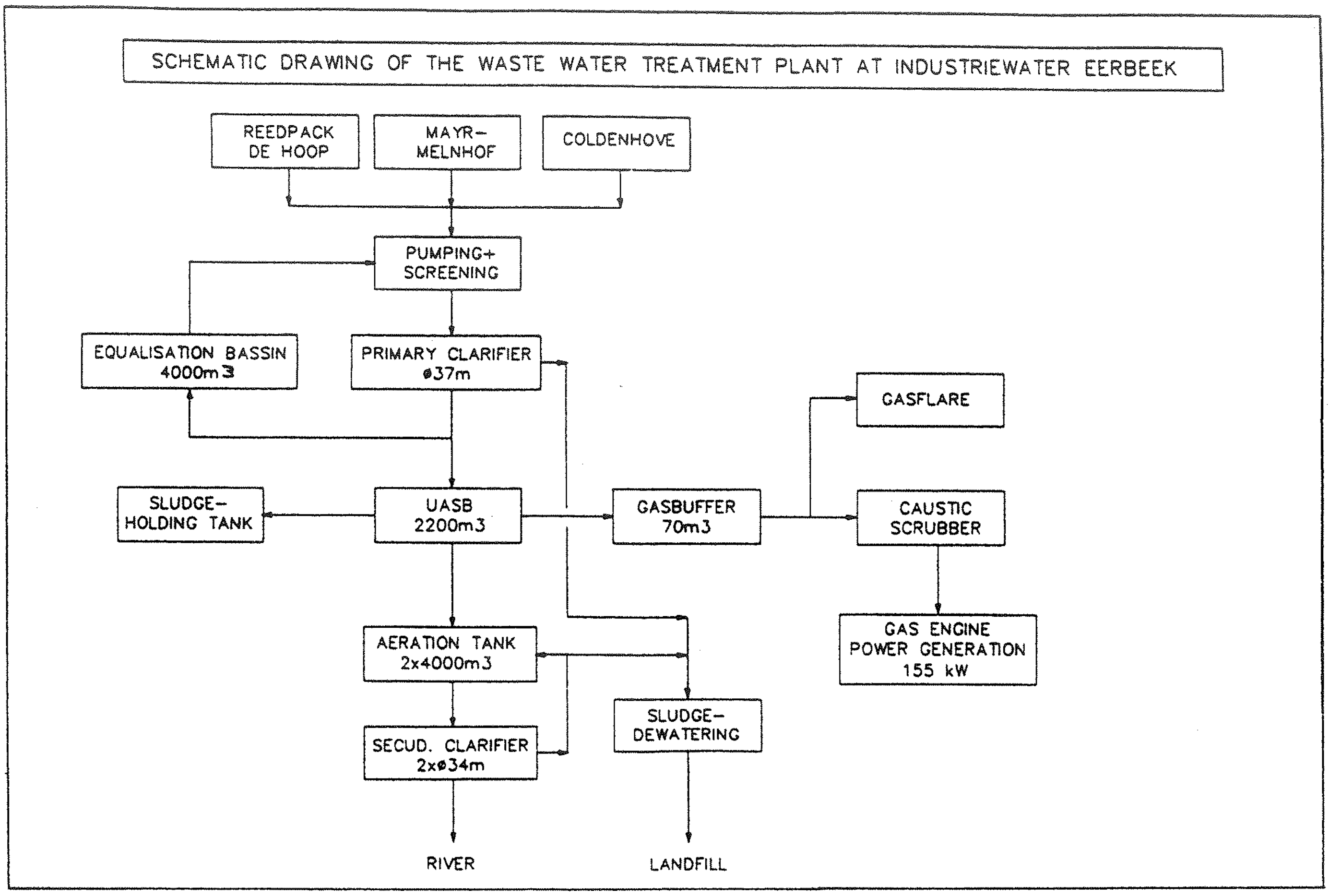

Figure 4

THE OPERATION OF THE UASB REACTOR

The principle of the UASB system is shown in Figure 5. After extensive testing and after investigation of other pretreatment systems, such as chemical precipitation and a high load two stage activated sludge system (A-B system), the UASB system was selected and installed in 1985 as a biological pre-treatment system, prior to the existing aeration plant. The tests with a 150 liter volume pilot plant had shown that a stable and reliable anaerobic treatment process with considerable COD and BOD reductions could consistently be sustained.

The full-scale UASB reactor, which began operation at the end of 1985, has been designed to treat a wastewater flow of 400 m^3/h. This results in a hydraulic retention time of 5.5 hours and a volumetric load of 6 kg $COD/m^3.d$. During the first months of operation, the feeding pump capacity was maintained at the design flow rate. After a few months of operation, the flow rate was increased to 450 m^3/h and again two months later to a flow rate of 480 m^3/h. This is 20% higher than the design rate. The retention time was thus reduced to 4.6 hours, but no decrease in efficiency was observed.

Due to the fact that the incoming wastewater flow varies from 300 to 900 m^3/h, a certain amount of incoming wastewater had to be passed directly into the aerobic plant from time to time. This caused considerable peak loads on the aeration system, which was normally fed by a constant flow and steady low BOD concentrations from the outlet of the anaerobic reactor. This situation brought us to yet another increase of the flow rate, in such a way that no wastewater by-passed the anaerobic reactor any longer. The flow rate was controlled by the water level in the equalization tank and maintained at 600-650 m^3/h, sometimes with peaks to the maximum pump capacity of 700 m^3/h.

At a flow rate of 650 m^3/h, which corresponds with a retention time of only 3.4 hours, no decrease in the operation result has been observed. We feel, however, that a flow rate of 700 m^3/h with a retention time of 3.2 hours is the limit of our reactor capacity and should not be maintained during a period of more than one or two days. The volumetric load at the present time is 10-12 kg $COD/m^3.d$ which is double the design rate.

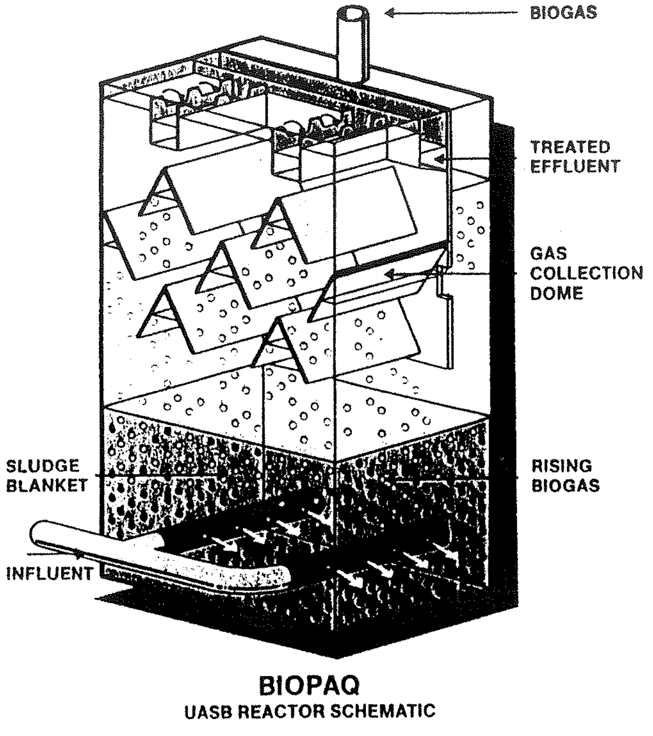

Figure 5

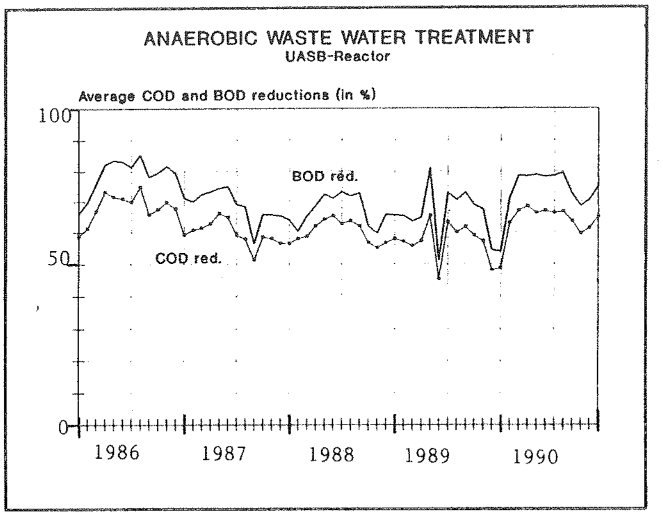

Figure 6

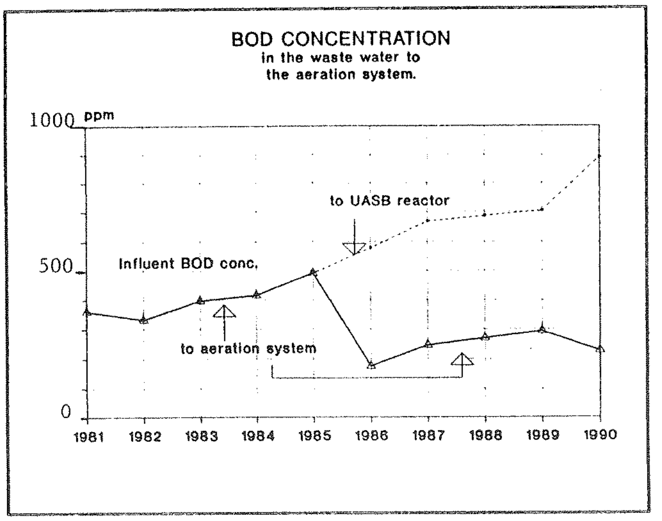

Figure 7

Figure 6 shows the average monthly BOD and COD reductions in the anaerobic pretreatment during the period 1985-1990. It should be mentioned that in the period from 1987 to 1989, the removal efficiencies have been influenced negatively by very high sulfate levels coming from one of the mills, due to acid sizing. Nevertheless, the performance of the reactor was very stable. In 1989, this mill has changed its sizing procedure and sulfate levels came down drastically. This reduced the sulfate concentration in the influent to the anaerobic reactor from approximately 500 to 140 ppm, thereby increasing the COD/SO_4 ratio from 2.1 to 11. Figure 7 clearly demonstrates the impact of the UASB reactor on the BOD concentration going to the aeration system. The increase of the hydraulic load on the anaerobic system results in a lower BOD load on the aerobic post treatment system, thus providing a very stable operation of the aeration plant and a low effluent BOD of 5 -15 ppm. As a result, it was possible to use only one aeration tank and to take the second one out of operation to save energy cost.

Figure 8 shows the specific gas production in m^3 biogas per kg COD removed. The actual biogas production is an immediate indicator of the reactor operation. A low gas production indicates low reactor activity, which can be: mechanical problems, temperature drop, toxification , or simply low inlet COD. A high gas production tells that the reactor is performing well.

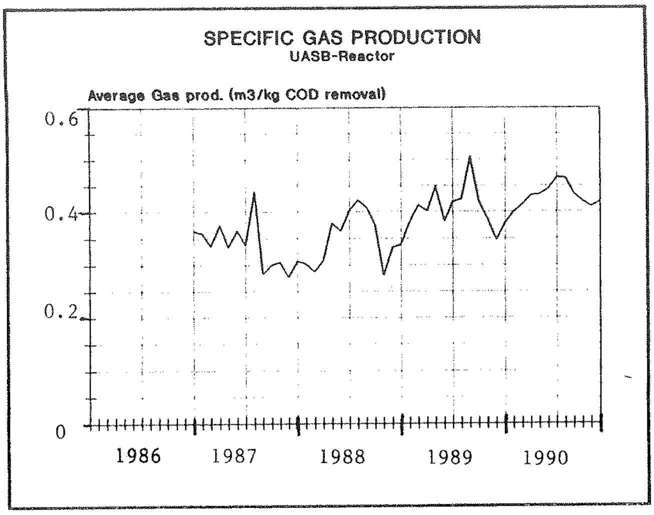

Figure 8

The excess sludge production is low compared to an aerobic system. According to our calculations, the UASB reactor produces 0.04 kg solids per kg BOD removed.

Excess anaerobic sludge is a material which is being taken care of by suppliers of UASB reactors. The sludge can be stored over very long periods and still be used as start-up sludge for newly built reactors. When a new UASB reactor is filled with granular anaerobic sludge, which has been stored during a period of 12 months or even longer, the sludge can immediately be reactivated. When it is put in contact with wastewater, gas production starts instantly and within one day a considerable efficiency of the system can be obtained.

The total excess sludge production of the entire plant has dropped drastically. Before anaerobic treatment was applied, the total excess sludge amount was approximately 0.6 kg dry solids/kg BOD load. At the present time the aerobic excess sludge amounts to 0.15 kg solids per kg initial BOD load.

PROBLEMS DURING THE OPERATION

The anaerobic UASB process has proven to be a stable wastewater treatment process which is able to cope satisfactorily with large variations in BOD. However the reactor once came down to a low efficiency, when an amount of 200 liters of biocide was accidentally dropped into the sewer in one of the mills. Gas production immediately stopped almost completely and COD removal dropped from 65 to 40%. After 4-5 days, the COD removal rate gradually increased again and finally returned to its normal level after eight days. In the meantime, the aerobic plant became up-set due to the overloading, resulting in a high sludge volume index and bad effluent quality. The recovery of the aerobic plant took much longer than the anaerobic system.

A discharge of 10 tons of antifoam agent in one of the papermills did not effect the performance of the UASB reactor when it went through, but had a disastrous effect on the aerobic plant, where oxygenation was no longer possible.

The clogging of the wastewater distribution system in the reactor resulted in short circuiting through the sludge blanket and caused low removal rates. Large solids could enter the system due to incidental by-pass of the rotating screen during peak flow and due to concrete corrosion in the pump sump. It is essential that the distribution system is accessible and can be cleaned during the operation of the reactor. In our reactor, the distribution pipes pass through the backside wall and are provided with valves. We now flush the system weekly and clean the system with high-pressure water jets every three months.

To prevent short circuiting in the reactor and to improve the contact of the wastewater with the sludge particles, the sludge bed can be whirled up easily by manipulation of the inlet distribution system (closing and opening of inlet valves).

The zone just on and above the water level is very corrosive and problems can be expected if incorrect materials are chosen for the settlers, overflow throughs, fastening bolts and nuts, and tank walls. In our case, the settler and overflow throughs were manufactured out of mild steel and covered with a high resistant coating. However, after four years of operation we discovered damage to the equipment. Extensive repairs were carried out and the reactor was out of operation during the two week summerstop of the mills. This corrosion problem accelerated our plans to extend our plant capacity with a new reactor. Instead of 1993, we built a new reactor with 2500 m^3 of treatment volume in 1990. This new reactor which was taken into operation in January 1991 has two equally sized compartments, which can be operated independently. All internals in this reactor have been made out of plastics like High Density Poly Ethylene (HDPE) and Polypropylene Copolymer. Meanwhile, the existing reactor has been taken out of operation and will be completely reworked in a similar way as the new reactors before taking it in operation in 1994.

COST OF OPERATION

Figure 9 gives an idea of the total annual costs of the entire wastewater treatment plant. These costs include all capital and operation and maintenance costs. From Figure 10, it can be learned that even though the total costs have increased, the specific cost per ton of paper production has slightly decreased. This is in spite of inflation rates and in spite of an increase in the amount of BOD released per ton of paper production. This is mainly due to savings on energy consumption and sludge dewatering.

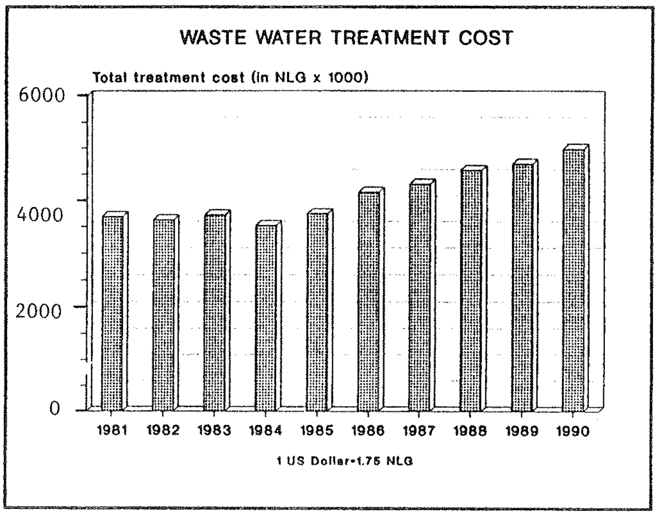

Figure 9

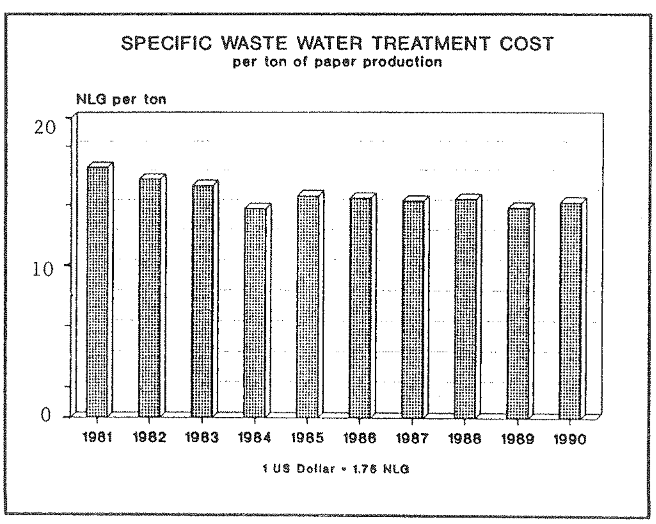

Figure 10

SUMMARY AND RECOMMENDATIONS

* The effluent from the UASB system is rather constant, thus providing a steady and low load on the aerobic post treatment system.

* In our case the UASB system does not require much attendance and maintenance.

* Biogas production is a direct and reliable indicator of the performance of the anaerobic reactor.

* Construction in two (or more) compartments is recommended.

* The use of non-corrosive materials is very essential for low maintenance cost and long lifetime.

* Good accessibility to the wastewater distribution system during operation is essential for good operation.

* To enable emptying the reactor completely (once every 3-4 years) the reactor bottom could be sloped and provided with a sump opposite the access manhole.

* Discharge of larger quantities of biocides should be avoided.

* The UASB system is a reliable and very stable wastewater treatment process, producing more power than the system requires.

* In our case the UASB system could treat much more wastewater than the reactor supplier has designed it for.

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