WATER CYCLE WITH ZERO DISCHARGE AT TUMUT PULP AND PAPER MILL NEW SOUTH WALES - AUSTRALIA

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Abstract

The Tumut Visy Pulp and Paper Mill is one of the cleanest mills in the world, reflecting Visy Industries' commitment to sustainable manufacturing.

Visy Industries have developed a new Pulp and Paper Mill in Tumut, NSW – Australia, which showcased innovative environmental and sustainable energy technologies, including the biggest continuous biomass energy facility in Australia.
Construction of the mill began in 1999 and was complete it by 2001. Total investment in the project was AUD$435 million.
The Tumut Mill used extensive industry experience and many well-known companies in the paper industry to engineer an advanced mill concept with zero levels of effluent leaving the site. Careful project planning included steps to minimise raw water intake, maximise reuse opportunities and reduce effluent.
The Tumut Pulp and Paper Mill produces 300,000 tonnes of unbleached kraft pulp and paper board per year, from around 800,000 tones of pine plantation pulp logs and forest waste plus recycled paper, cardboard and sawmill residues, using advanced cleaner production technology and achieving significant reuse.
Per tonne of pulp, it is one of the most resource efficient and pollution free operations in the world.
Its raw water consumption (4.61 m^3/tonne of paper) and effluent discharge (1.53 m^3/tonne of paper) are believed to be the lowest in the world.
Treated effluent is irrigated on a 110 ha farm, around the Mill producing fodder for cattle. Sludge and other waste products, form a combined agricultural fertiliser for the farm to improve soil characteristics and provide nutrient for sustainable cropping.

Keywords: activated sludge, effluent irrigation, SBR effluent treatment, unbleached kraft pulp, zero effluent

1.0 Introduction

As a major investment in its commitment to sustainable manufacturing, VISY has built a plantation pine kraft pulp and paper mill at Tumut in New South Wales – Australia.

VISY have been around for more than 50 years and for the past 20 years, the company has built its business substantially from other peoples "waste", mainly through paper recycling. Since 1979 VISY has built 10 paper recycling machines in Australia and the USA at a combined cost of well in excess of $1 billion.
Paper fibres gradually weaken, as they are recycled over and over again, potentially affecting paper quality, so to be truly sustainable, the waste paper recycling industry required new fibres in the 'recycling loop'. This ensures that the range of end products Visy can offer will both meet and create new market demands. Rather than rely on outside forces to ensure a continual supply of virgin fibres, the Tumut Mill allows to maintain the recycling loop indefinitely by producing essentially virgin plantation fibre-based paper to mix with ongoing recycled stock. It also provides tougher light weight papers for some special

applications such as ‘microflute’, which is replacing thousands of tonnes of high wet strength papers that cannot be recycled in Australian systems.
The Visy Tumut Mill (Figure 1) supplies a wide range of kraft paper grades for both domestic and export markets, enabling Visy to offer customers the optimum in high performance packaging with superior print surface.

Figure 1: Visy Pulp and Paper Mill, Tumut

Previously, Visy imported more than 35,000 tonnes per year of virgin Kraft fibre to put into its six recycling mills in Melbourne, Brisbane and Sydney. Now, Visy has ceased Kraft fibre imports to its mills, and is supplying 100% of its own board plants’ recycled and virgin content paper needs as well as exporting to a wide and growing number of overseas customers.

Paper from the Tumut mill contains an average of 20% domestic and commercial recycled paper and 80% of the fibre is from pine forest thinning and saw mill industry in the area. These thinnings are by-products of the timber industry and used to be treated as waste material.

2.0 General Description

The Tumut mill has applied extensive industry experience to engineer an advanced mill concept with zero levels of effluent leaving the site. This has been possible due to wastewater from mill being used to support an environmentally sustainable irrigation scheme.
The mill consists of the following main areas:
The Site **-** the mill is set on approximately 1,100 hectares that are carefully managed for their paper manufacturing, sustainable farming, biodiversity and European and Aboriginal heritage values.
Since Visy’s activities at the site started in 2000, more than 60,000 trees have been planted. The farm is also used for cattle grazing and irrigated cropping.
Woodyard **-** the woodyard includes log handling, debarking, chipping, storage and conveying of wood chips to the ‘digester ‘ and bio-mass fuels to the ‘power boiler’.

Pulping - wood chips are mixed with 'white liquor' and cooked in a 'digester'. The cooked chips form a slurry, which is washed and refined to provide the quality of pulp required on the paper machine.
Recovery - the residue chemicals used in the cooking and lignin extracted from wood form 'black liquor' which is recovered and recycled. During the recovery process the 'black liquor' is fired in a recovery boiler producing steam. The molten chemicals (green liquor) from the bottom of the Recovery Boiler furnace are recovered and re-processed in the 'causticising' area to produce 'white liquor'.
Power Boiler – biomass fuels are used in the fluidised bed boiler to produce steam needed in various areas of the process
Paper Machine - the paper machine produces high quality kraft liner. The latest technology is applied to maximize the mill's productivity.
Co-Generation - steam generated from both boilers is used to generate 'green' power that makes up two thirds of the mill's requirements.
Waste Water Treatment Plant - the WWTP of the Mill is a Sequencing Batch Reactor (SBR) with Biological Nutrient Removal (BNR) Activated Sludge Process. This operation completes all unit process steps within the same reactor, eliminating the need for both secondary clarifiers and sludge recycle system.
Irrigation – the treated effluent from the mill is irrigated on 110 ha through five Centre Pivots and one Soft Hose Traveller Irrigator.
Environmental Management Systems - the mill is subject to strict environmental regulations, with continuous recording of many emissions, annual independent compliance audits, and annual reporting of performance to the environmental and planning authorities as well as the Visy Community Consultative Committee. The site has achieved certification to ISO 14001, and has received several awards for its environmental management performance.

3.0 Water Cycle of the Mill

3.1. Raw Water Supply

Fresh water supplied to the mill is sourced from the Tumut River through a 375 mm DICL (Ductile Iron Cement Lined), bitumen coated, 14.6km long pipeline. The water is pumped from the river and boosted up at the mill site into the Raw Water Dam with a capacity of 190 Mega Litres, located 63 m above the mill.
During the off peak energy time, the water is pumped into the mill and into the Raw Water Dam at the same time and during peak energy time, the water is supplied to the mill using the same pipeline, through gravity (only), from the dam. There is one fresh water intake pipeline connection towards the mill.

3.2. Filtration System

There are two filtration units in the water distribution system. One at the river pumps and the second one at the mill.
At the river, there is one Automatic Brush Filter (800 micron) and at the mill (Figure 2) there is the pre-filtration unit with two screen filters (> 3.5mm) and a fine filtration system with three EBS screen filters (< 25 micron).

Figure 2: Filtration System at the Mill

3.3. Raw Water Distribution

After filtration, the water is distributed towards the: Reverse Osmosis Plant - filtering further down to 0.2 micron, feeding the Recovery and Power Boiler; Cooling Towers, Wet Surface Air Condenser, Paper Machine (Figure 3).

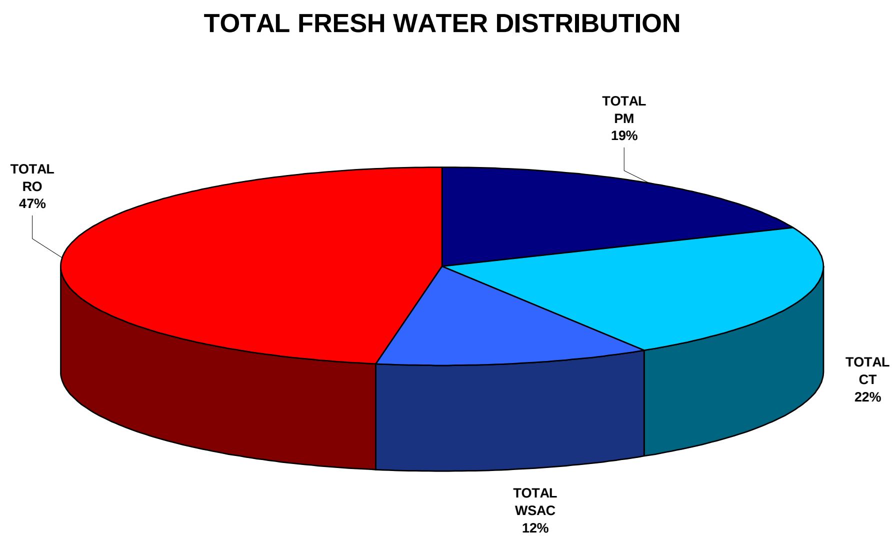

Figure 3: Fresh Water Distribution Chart

3.4. Effluent

During the process and operation the Mill produces the following effluents:

a) Mill Effluent discharged from the mill: *Excess Clean Condensate* with COD between 250-1000mg/L, *Cooling Water Bleed* with COD between 80-650mg/L, *Wet Surface Air Condenser Bleed* with COD between 50-100mg/L, *Boiler Blow Down* with COD between 0-25mg/L, *Micro Filtration Rejects* with COD between 0-25mg/L (Figure 4)

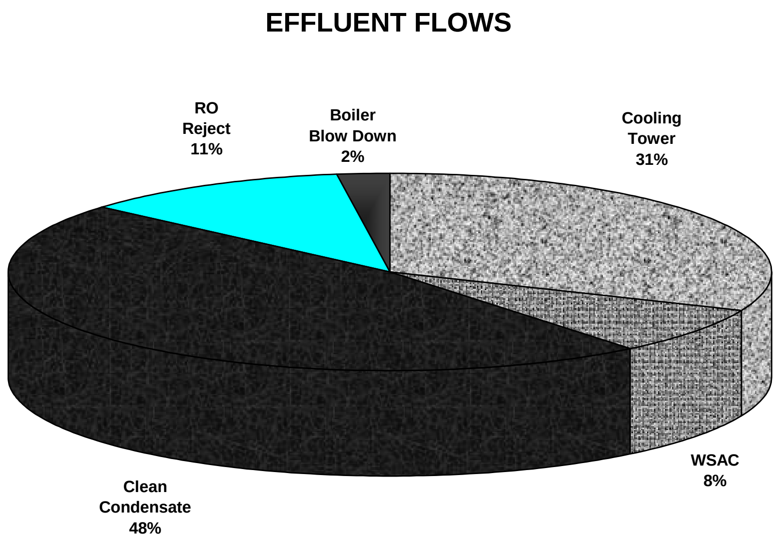

Figure 4: Mill Effluent Distribution Chart

b) Domestics Sewage is collected from the administration building and control room and diverted to the Sewage Pit, from where is pumped through a screen filter into Cooling Pond B. This is the only nutrient addition source to the wastewater treatment plant.

c) First Flush Dam the run off/stormwater from the Woodyard area is collected separately into this dam to settle. Because the Chemical Oxygen Demand (COD) content can be high, 50-5000mg/L, this water is added under controlled circumstances to Cooling Pond A and B. A floating aerator is situated in the dam and can be activated to add oxygen to reduce the COD content and to eliminate odour problems.

Most of the effluent is reused in the process and only the remaining effluent - clean condensate - is treated at the Wastewater Treatment Plant (WWTP) and then it goes to onsite irrigation.

4.0 WasteWater Treatment Plant

The WWTP of the Mill it is a Sequencing Batch Reactor (SBR) with Biological Nutrient Removal (BNR) Activated Sludge Process (Figure 5).
This operation completes all unit process steps within the same reactor, eliminating the need for both secondary clarifiers and sludge recycle system. Also, the aerator mixer system used for the defusion of oxygen can both aerate and mix without the need for additional equipment.

It is designed to run automatically. The program allows the system to match aeration power supply to process oxygen demand and provides automatic alarm response, too.

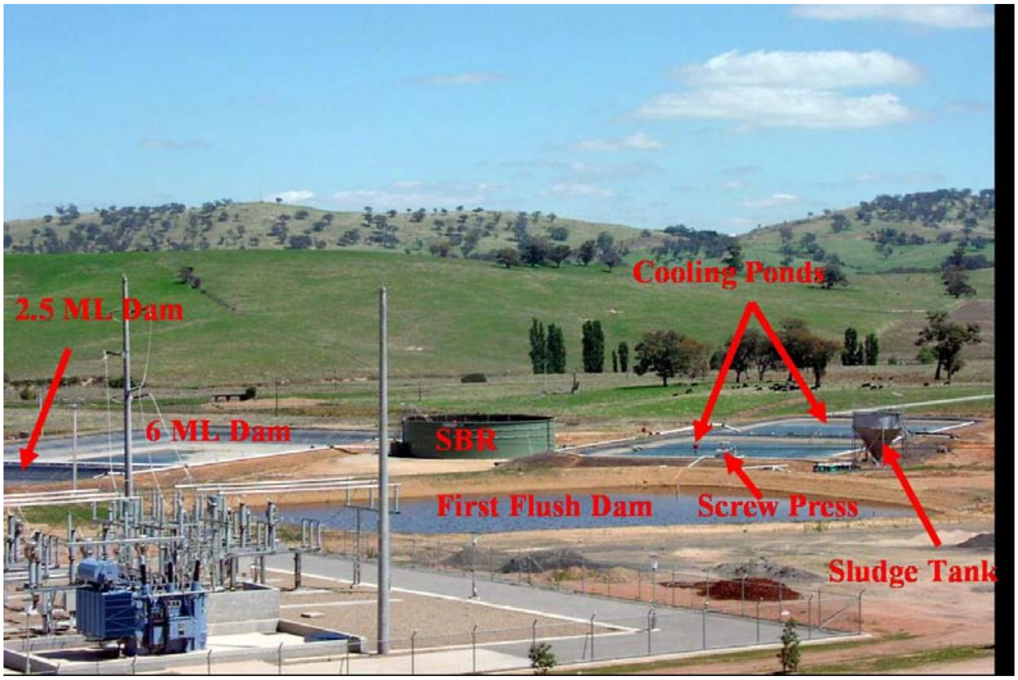

Figure 5: Waste Water Treatment Plant

The Process Design Parameters for normal Mill Operation Influent are: **BOD_5** range between 100 to 250 mg/L, **TSS** range between 50 to 300 mg/L, **SO_4** peak 100mg/L, **pH** range between 7 to 8, Maximum **Temperature** $55C^0$.

The Mill Effluents are collected in a single pipeline and sent to Cooling Pond A and B where are mixed with the sewage and the water from the First Flush Dam (if any). The Cooling Ponds were designed to cool the effluent from $55C^0 – 65C^0$ down to $30C^0 – 35C^0$.
The mixed effluent is pumped from the Cooling Ponds into the SBR. Each batch takes six hours to treat one load, which can range between $257m^3$ to $472m^3$.
One batch consists of six phases:

- ***Anoxic Fill Phase:*** the SBR is filled with raw wastewater and is distributed throughout the Influent Distribution Manifold.
- ***React Phase:*** oxygen is added through aeration until biodegradation is achieved.
- ***Spike Phase:*** making the micro-organisms to hibernate/sleep
- ***Settle Phase:*** the aerators are turned off and perfect conditions allow the biomass to settle, leaving the treated supernatant above.
- ***Decant Phase:*** treated effluent is removed by the floating Decanter.
- ***Idle/Waste Sludge Phase:*** the settled sludge is drawn from the bottom of the SBR into a Sludge Balancing Tank.

Once the SBR has been filled to the required level, controlled by a level sensor and time limit, the aerators/mixers from inside the SBR are activated automatically based on the Dissolved Oxygen (DO) amount in the SBR. These increase the amount of DO, based on the limits in the SBR, thus providing oxygen and energy for the micro-organisms to feed off - starting the treatment phase. It is important for the biological activity to remove nutrients and organic load, thus concentrating minerals into the settling sludge. The biological activity also releases carbon dioxide and nitrogen to the atmosphere.

During React Phase the “real” treatment is happening. The micro-organisms have time to achieve complete biodegradation of the effluent.
The aerators then increase the amount of DO in the SBR, Spike Phase, which fills up the micro-organisms, making them hibernate/sleep.

The aerators turn off, allowing the treated water to settle. The activated sludge (micro-organisms) settles to the bottom of the SBR, and the clear treated water remains on top.
Once the sludge is settled, the treated water is removed by the Decanter into storage dams (from 2.5 ML or 6 ML Dam into the Winter Storage Dam) or used directly for irrigation. However, it can also be sent back to the Cooling Ponds for further treatment or in some cases can be sent back into the mill process to the Spill Tank to help maintain the right water balance for the Mill.

The sludge remains in the SBR, but over time the sludge builds up and gets to a point where it can no longer maintain proper performance. The excess sludge is then pumped out into the Sludge Balancing Tank, during Idle Phase. The sludge is sprayed on the farm as fertilizer mixed with the lime mud and the lime grids.

Chemicals used for treatment are, *KOH (50%)* - used for pH control in the SBR tank. The effluent water in the SBR must have a pH range 6.5 – 8.5, because outside this range, the biomass cannot survive and treatment of the wastewater will not occur; and *Liquid Urea / Ezy N* **-** added as extra food for the micro-organisms, if the effluent coming through the process is not high in nutrients or organic load and/or after annual shut downs in order to restart the WWTP.

During the treatment samples are taken every batch to make sure that the process is performing correctly. Each sample is tested for:

- *pH* **-** it is important for the success of the treatment and of the biomass in each single phase of the treatment
- *Turbidity & TSS* - gives an idea about what is going into the SBR (sample during Fill), if the right biomass is present in the SBR so the effluent can be treated (sample during React Phase) and if the right sedimentation is happening (sample during Decant Phase)
- *Conductivity* - gives an idea of the amount of dissolved solids available in the effluent.
- *Sulphate and Phosphate* - are tested for EPA levels and for agricultural monitoring purposes
- *COD* in the Fill and Decant Phases. The Fill sample represents the amount of biodegradable matter in the effluent coming into the SBR and the Decant sample represents the COD left in the water after the treatment and indicates the efficiency of the treatment.

Table 1, summarizes the required treated effluent quality and the average treated effluent quality coming out from the reactor.

Table 1: Average Treated Effluent Quality

Parameter	Units	License Limit	Mean of Samples
Manganese	mg/L	NA	0.034
PH		5.5 - 9.5	7.3
SAR		NA	3
TDS	mg/L	NA	489
Nitrogen	mg/L	20	< 2
Phosphorus	mg/L	5	0.37
Zinc	mg/L	NA	0.178
BOD	mg/L	40	2
TSS	mg/L	45	15.7
Oil & Grease	mg/L	5	3.2

Figure 6 and 7 represents the quality of the effluent in the reactor during the treatment and after the treatment and Figure 8 shows the average Chemical Oxygen Demand (COD) in and out from the reactor.

Figure 6: SBR – React Phase

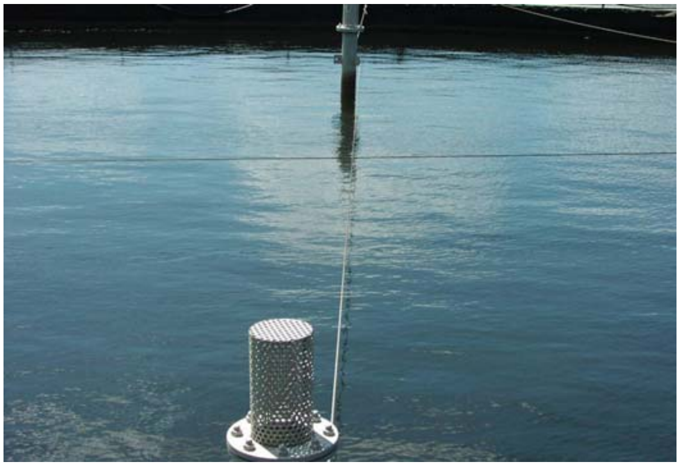

Figure 7: SBR – Settle Phase

COD IN & OUT JULY 2001 - OCTOBER 2005
Average: COD IN 226ppm COD OUT 62ppm

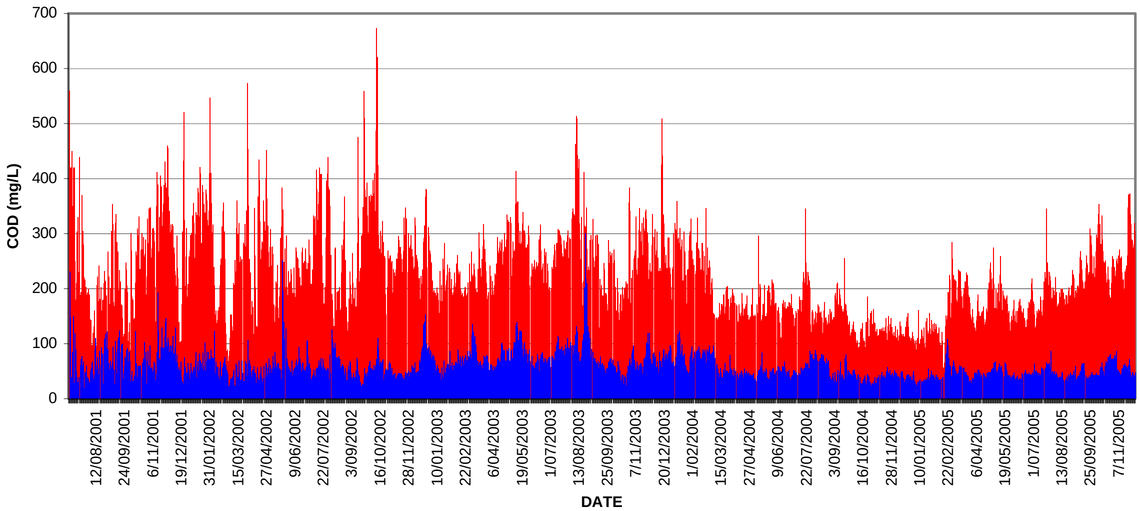

Figure 8: COD in and out 2001 - 2005

After the treatment, the treated effluent is delivered through a 225 mm uPVC pipeline through gravity to the farm into the Winter Storage Dam (480 ML capacity).

5.0 Irrigation

The treated effluent is irrigated from the Winter Storage Dam through five Centre Pivot Irrigators and a Soft Hose Traveller Irrigator on 110 hectares of land (Figure 9), irrigating oats, maize, sorghum and pasture for silage and hay production (Figure 10). The farm also incorporates around 1200 head of cattle.

Figure 9: Winter Storage Dam & Irrigation Layout

Figure 10: Centre Pivot Irrigators

6.0 Waste Management / Monitoring

The sludge from the WWTP, the lime mud from the lime kiln and the ash from the boiler is used as a combined fertiliser for the soil.
The whole operation is under a strict monitoring (soil, ground water, surface water, plant tissue, and air emissions) as per the Environmental Protection Authorities (EPA) Guidelines to protect, to establish and to maintain a sustainable environment around the Mill.

7.0 Conclusion

The Tumut Mill has received several awards, including the Rabobank Energy and Environment Award 2002, sponsored by the Australian Greenhouse Office, finalist in the Banksia Environment Awards 2002 & 2003, NSW Engineering Excellence Award 2002, and United Nations Association of Australia Award for Excellence in Water Management 2005.

The mill receives a steady stream of international visitors who come to learn more about its environmental credentials.

While the Tumut mill is continuously improving its environmental and manufacturing performance it has already been hailed as one of the world's leading examples of sustainable manufacturing in an agricultural system.

8.0 List of References

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