New rules for the paper game

Australia earns $370 million a year from export woodchips, yet spends treble that amount on imported pulp and paper. How can we redress the balance without harming the environment?

Emilia Tagaza

Computerised data storage and electronic mail were to have heralded the paperless office. But contrary to expectations, paper consumption throughout the world shows no signs of abating. In fact, consumption, especially of printing and writing papers, continues to increase.

World demand for paper and board is now expected to grow faster than the general economic growth in the next 15 years. Strong demand will be underpinned by the growing industrialisation of South-East Asia, the re-emergence of paper packaging, greater use of facsimile machines and photocopiers, and the popularity of direct-mail advertising.

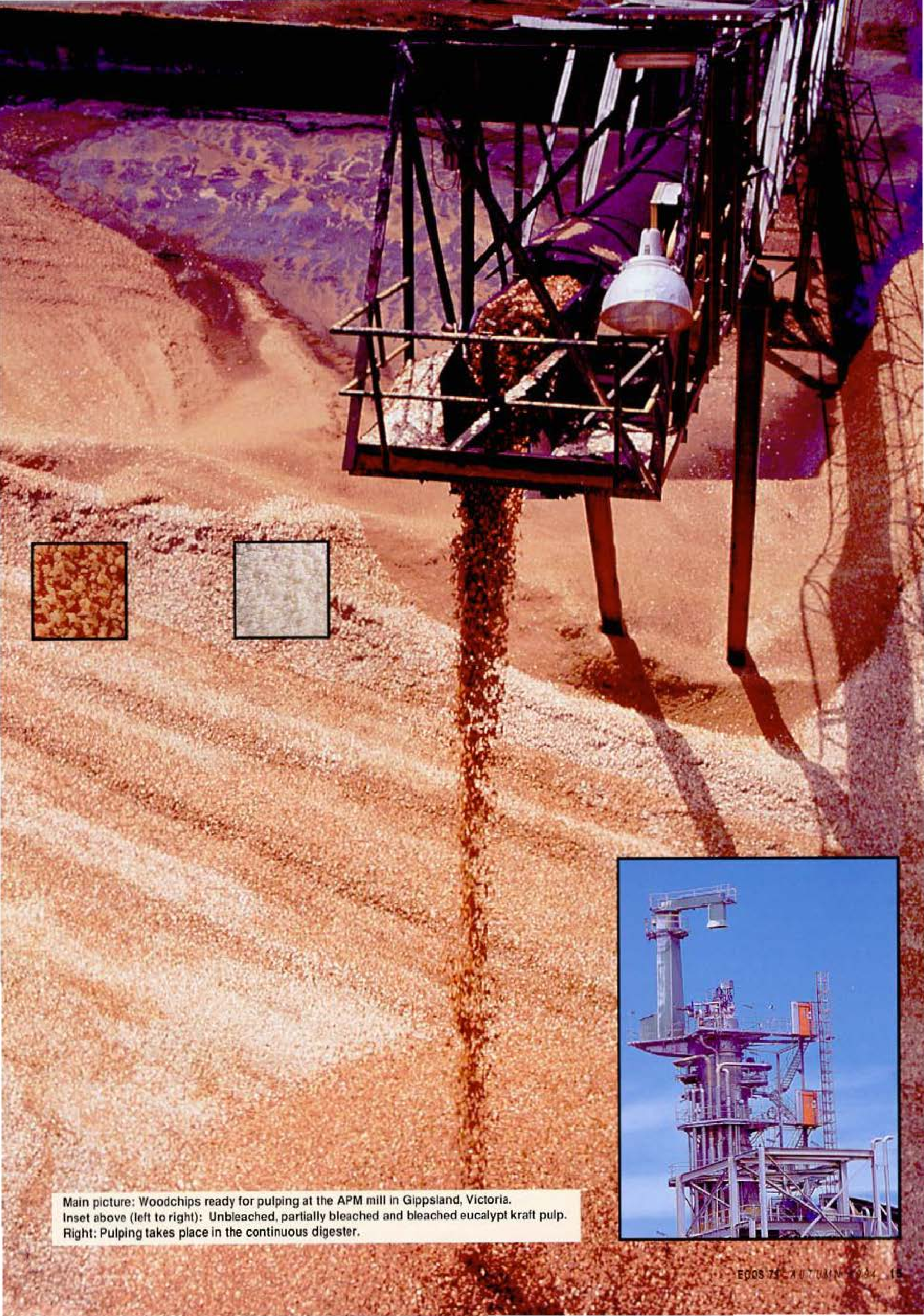
The Pulp and Paper Manufacturers Federation of Australia forecasts that by 2007, world paper and board demand will reach 455 million tonnes, compared with 241 million tonnes in 1991.

The pulp and paper industry has not been badly affected by the electronic technologies that promised a paperless society. But what has radically altered the industry's structure is pressure from another front – a more environmentally-conscious society driving an irreversible move towards cleaner industrial production.

The environmental consequences of antiquated pulp mill practices and technologies had marked this industry as one in need of reform. Graphic descriptions of deformed fish and thinning populations, particularly in the Baltic Sea where old pulp mills had discharged untreated effluents for 100 years, have disturbed the international community.

Until the 1950s, it was common for pulp mills and other industries to discharge untreated effluent into rivers and seas. The environmental effects were at the time either not understood, or regarded as an acceptable cost of economic prosperity in an increasingly export-oriented world economy. But greater environmental awareness has spurred a fundamental change in attitude in the community, in government and in industry itself.

Since the early 1980s, most of the world-scale pulp mills in Scandinavia and North America have modernised their operations, outlaying substantial amounts to improve production methods. Changes in mill design and processes have been aimed at minimising the environmental effects of effluent discharge while at the same time producing pulp with the whiteness and strength demanded by the international market. The environmental impetus is taking this industry even further, with



Main picture: Woodchips ready for pulping at the APM mill in Gippsland, Victoria.
Inset above (left to right): Unbleached, partially bleached and bleached eucalypt kraft pulp.
Right: Pulping takes place in the continuous digester.

the focus now on developing processes that may even eliminate waste-water discharges.

But the ghost of the old mills continues to haunt the industry today. In Europe, companies face a flood of environment-related legislation. In Germany, companies are now being held responsible for the waste created by their products.

Pulp mill shelved

Australia has no established export-pulp industry. The country earns $370 million a year from exporting about five million tonnes of woodchips, but pays 1.3 billion for its annual import of one million tonnes of pulp, paper and paper products. A bleached eucalypt kraft mill has attracted the most commercial interest as a way of adding value to these resources.

In 1989, environmental concerns resulted in the shelving of what was to be the country's first world-scale pulp mill. The proposal, by joint venture partners Noranda Forest and North Broken Hill Peko, was for a mill at Wesley Vale in Tasmania, producing 440 000 tonnes of eucalypt pulp using the bleached kraft process.

The then Prime Minister, Bob Hawke, said the government needed to look at the environmental effects of such a huge mill and to develop operational standards for future mills. The Canadian partner was not prepared to hold its investment for an indeterminate time while these guidelines were being developed and withdrew the proposal. In December 1989, the government issued environmental guidelines based on the best information available. These set strict standards on waste emissions from all future mills, specifically bleached eucalypt kraft mills.

Research into enhancing these environmental guidelines is being coordinated by the National Pulp Mill Research Program (NPMRP). This is a concerted research effort by the pulp and paper industry, Federal and State governments and the science community.

More than 30 research projects are designed to ensure that the 1989 pulp mill guidelines are kept up to date with improving technology. Importantly, the program aims to 'Australianise' the guidelines so that state-of-the-art, cleaner production methods and monitoring procedures are adapted to suit Australia's unique environment.

The 1989 guidelines are largely based on research in the northern hemisphere, where the raw materials and the environment are different. For example, most bleached kraft mills overseas use softwoods such as pines and spruces or Northern Hemisphere hardwoods such as aspen and birch as feedstock. This means that the effluent produced by future Australian mills using eucalypts, a hardwood with rather different properties to the Northern Hemisphere woods, may require different methods of treatment and processing.

Most international studies on the environmental effects of pulp mill effluents have been done in areas where climatic conditions are different to those in Australia. The species present in waters studied overseas are different to those in Australia and may therefore have different reactions when exposed to pulp mill effluents.

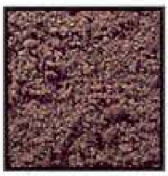
Gilliane Tedder

The properties of Australian eucalypts differ from Northern Hemisphere hardwoods. Different methods of treatment and processing are therefore needed.

The NPMRP is looking at all the stages of cleaner production at bleached eucalypt kraft pulp processing, from pulping and bleaching to effluent treatment, marine dispersal and environmental monitoring.

Pulping

Pulp is the porridge-like mass of plant fibres from which paper is made. Paper makers choose the type of plant fibre and the processing methods, depending on what the end product will be used for: whether it is a sturdy packing box, a smooth sheet of writing paper or a fragile tissue.



In wood, which is the source of about 90% of the world's paper production, fibres are bound together by lignin, which gives the unbleached pulp a brown colour. The pulping stage separates the wood into fibres so they are suitable for paper making. Pulping can be done by mechanical grinding, or by chemical treatment in which woodchips are 'cooked' with chemicals, or by a combination of both methods.

Kraft pulping is the most widely used chemical process for producing pulp with the strength required by the high-quality paper market. It is now usually carried out in a continuous process in a large vessel called a digester (see diagram). Woodchips are fed from a pile into the top of the digester. In the digester, the chips are cooked in a solution called white liquor, composed of caustic soda (sodium hydroxide) and sodium sulfide in water. The chips are cooked at high temperatures of up to 170°C for up to three hours. The pulp is then washed and separated from the spent cooking liquor which has turned dark and now appropriately called black liquor.

An important feature of kraft pulping is a chemical recovery system which recycles about 95% of the cooking chemicals and produces more than enough energy to run the mill. In a series of steps involving a furnace and tanks, some of the black liquor is transformed into energy, while some is regenerated into the original white cooking liquor.

The recovery system is an integral part of production in the pulp and paper industry. The pulp that comes out has little lignin left in the fibres. Bleaching removes the last remaining lignin and brightens the pulp.

Dr Geoff Irvine, from CSIRO's Division of Forest Products, says most modern mills have modified their pulping processes to remove as much of the lignin as possible before the pulp moves to the bleaching stage.

Mills have been applying a number of strategies, such as more effective chemical usage and temperature profiling, to reduce the amount of bleaching required. All the cooking and washing liquors from the pulping stage can be cycled through the chemical recovery process in the plant. It is at the bleaching stage where most eventual pulp mill effluents are formed because the most widely used bleaching chemicals produce corrosive chloride salts. These salts prevent the effluents from being added to the chemical recovery system.

Effluent discharge from the Australian Paper Mills plant in Gippsland is treated through a series of aerobic and anaerobic ponds.

'When you reduce the amount of effluent produced in the process, you achieve cleaner production,' Irvine says.

Irvine heads a team under the NPMRP that is investigating how extended delignification can be applied to the pulping of both mature and plantation eucalypt woodchips.

Bleaching

Bleaching with chlorine-based compounds is still the best way to achieve high brightness while maintaining pulp strength. But it is chlorine, specifically chlorine gas (elemental chlorine), which has caused the pulp and paper industry to suffer a poor environmental report card.

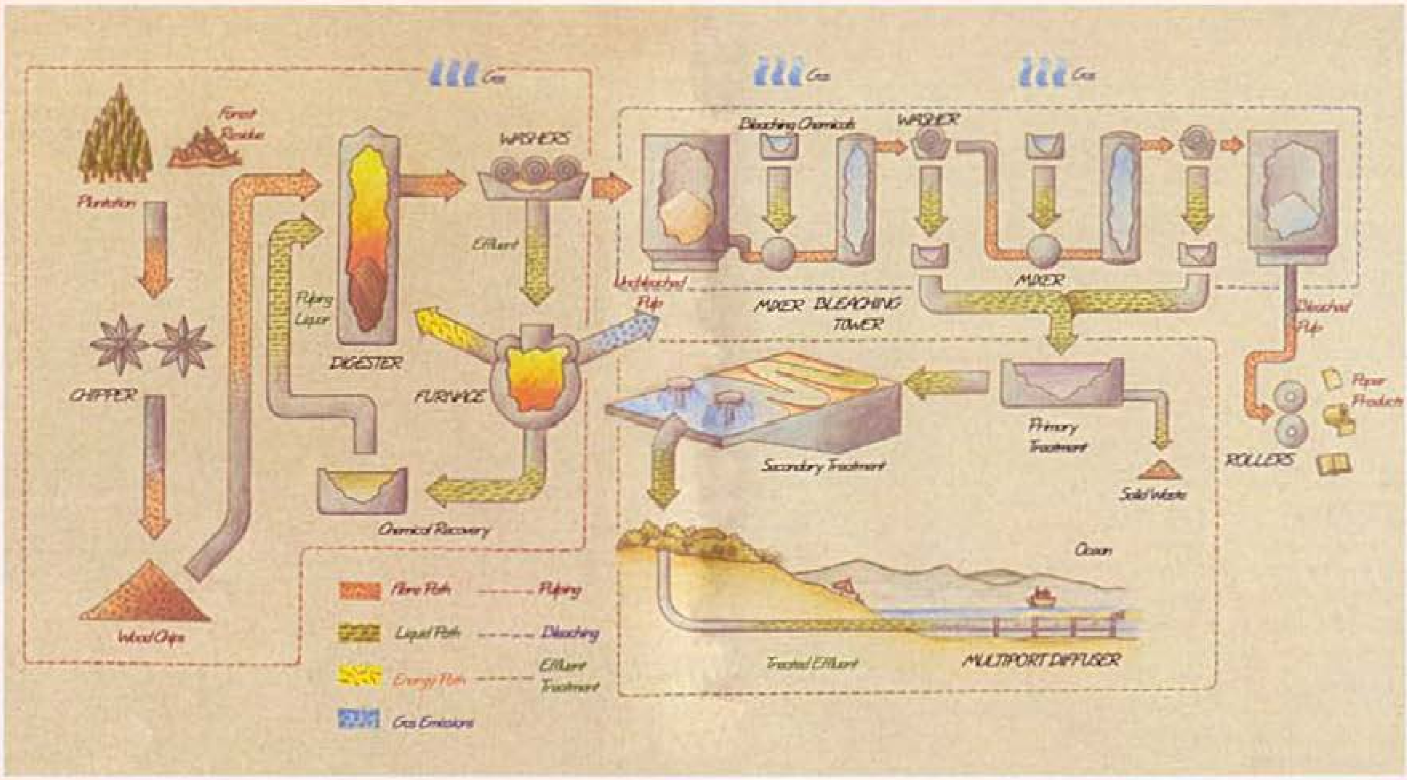
Reactions between chlorine gas and organic wood compounds produce organochlorines, the environmental villain blamed for the environmental damage around old pulp mills. Organochlorines are potentially hazardous to the aquatic environment if present in high concentrations.

During the past decade, there has been an intense drive towards reducing the formation of organochlorines during the bleaching stage. Changes in this direction have been rapid, and include longer cooking in the pulping stage to reduce the need for later bleaching, improved washing processes, and modifications to the bleaching stage itself.

Bleaching is carried out in a sequence of chemical treatments and washings. The first treatments are designed to remove the lignin remaining in the pulp. These first steps do not increase the pulp's brightness sufficiently. The later treatments are designed to remove the remaining colour and so increase brightness.

In older technology, the first treatment used chlorine gas to remove the residual lignin. This was followed by an extraction stage where dissolved lignin was leached out in an alkaline solution. Many modern mills now use chlorine dioxide to substitute chlorine gas in the first treatment stage.

Effluent from chlorine dioxide bleaching contains fewer organochlorine compounds, and those compounds that are present are generally far less toxic than those formed with chlorine gas. In Europe, the change to



From plantation to paper: an overview of the chemical pulping process.

chlorine dioxide is virtually complete and ECF pulp (elemental chlorine-free) is widely available in the market.

Also in Europe, the move towards TCF pulp (totally chlorine-free) is gaining momentum. Demand for TCF pulp has risen considerably during the past few years. At a conference in South Carolina in the United States, managing director of the Confederation of European Paper Industries, David Clark, said between 250 000 and 300 000 tonnes of printing and writing paper in Europe could claim to be TCF. By 1992 the amount had jumped to about two million tonnes, or almost 10% of the total printing and writing paper production in Europe.

Dr Peter Nelson, of CSIRO's Division of Forest Products, says that TCF pulp does not have the strength and brightness of chlorine-bleached pulp. However, it serves a niche market which could grow further. The industry has therefore made a tremendous effort to develop TCF bleaching techniques.

Nelson leads a NPMRP team that looks at using non-chlorine agents to bleach eucalypt kraft pulp. He says that non-chlorine bleaching may ultimately result in a closed-cycle mill where all waste-waters from the bleaching process are recovered and recycled. This becomes possible when bleaching processes do not produce corrosive salts, as chlorine beaching does.

He says varying degrees of research, development and commercialisation of alternative bleaching agents are being undertaken by the international industry, including Australia. These substitutes include ozone, hydrogen peroxide, enzymes and oxygen.

Another NPMRP project is looking specifically at ozone bleaching of eucalypt kraft pulp. Leading this project is Dr Roger Cook at Amcor Research and Technology Centre, the research arm of Australian Paper.

Cook says the project has shown that ozone bleaching can achieve the level of brightness required by export pulp. The team is now looking at whether ozone bleaching can also achieve the strength of export pulp. The team is also conducting laboratory studies to find out the chemical characteristics of the effluent from an ozone-bleached eucalypt kraft mill.

Meanwhile, a feasibility study has begun on a proposed $1.9 billion bleached eucalypt kraft mill in Western Australia. The study is being conducted for the Western Australian government by Bunnings Ltd, which owns large blue gum plantations in the state.

The proposed project includes a chemi-mechanical pulp mill, a bleached eucalypt kraft mill and two paper plants. The kraft mill would use oxygen-based chemicals for bleaching instead of chlorine. If the project goes ahead, it would become Australia's first world-scale pulp mill and may even be one of the world's first closed-cycle bleached kraft mills.

Effluent treatment

The pulp and paper industry has spent most of the last decade trying to change the image of old mills discharging

Dr Annabelle Duncan, Dr Peter Nelson and Dr Geoff Irvine: reducing the environmental impact of the bleached kraft process.

untreated effluent into the water. Most modern mills now have treatment facilities to degrade potential pollutants of effluents before they are discharged. Primary treatment removes sludge from the effluent. The sludge is withdrawn and disposed of as landfill under strict environmental regulations.

The clarified liquid undergoes secondary treatment, in which micro-organisms such as bacteria digest the organic material in the effluent. Secondary treatment can either be done with no oxygen (anaerobic) or largely with oxygen (aerobic).

The Dutson Downs Sewage Treatment Works at Traralgon, Victoria, receives effluent from industries plus domestic sewage from the Latrobe Valley. One plant discharging waste into the system is Australia's only bleached eucalypt kraft mill at Maryvale in Gippsland, operated by Australian Paper Mills. Effluent from the mill goes through a series of anaerobic and aerobic ponds. Gippsland Water has found that the organo-chlorides in the effluent are reduced dramatically.

Dr Annabelle Duncan, of CSIRO's Division of Chemicals and Polymers, leads an NPMRP team looking at treatment of bleached kraft effluents. Her team has been investigating factors which contribute to the reduction of organo-chlorides.

Duncan says it was originally thought that adding of nutrients in the form of sewage was helping the growth of bacteria that degraded the organo-chlorides. This was found not to be the case. The important factor contributing to organochloride degradation was the use of an anaerobic treatment phase. Subsequent aerobic treatment helped to degrade the remaining organic matter of the effluent.

Effluent discharge

Once discharged into the sea, treated effluent should ideally be mixed and diluted rapidly by currents. This prevents the formation of an effluent pool around the outfall pipe. This is also why coastal sites with strong ocean currents are preferred sites for future mills.

The government's guidelines for future mills require that effluent must be diluted by at least 200 times (one part of effluent to 200 parts of water) 500 metres from a diffuser pipe.

Australia's guidelines for new pulp mills are among the strictest in the world. They ensure that mill discharges cause no known harm to the environment.

Monitoring

The fight against toxic effluent does not stop at preventing its formation and discharge by improving pulping, bleaching and effluent treatment processes. It extends to monitoring marine life where effluent is released.

Australia's guidelines for new mills are among the strictest in the world. Through limits to waste emissions, they ensure that mill discharges cause no known harm to the environment. To guard against the unknown, the guidelines also require baseline monitoring before the mill is built, then continuous monitoring of areas around the mill in case of unforeseen environmental effects. If any change is detected, modifications can be made to mill processes before there is any lasting harm.

In anticipation of world-scale mills emerging in Australia in the long-term, the NPMRP is leading research developing monitoring methods for the unique Australian marine environment. Modern, cleaner production methods and soundly-based environmental guidelines will enable industry and government to protect the environment with confidence, and allow sustainable, low-impact pulp mills to operate.

More about pulp mills

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