Greenpeace Corner: Report on Zero Discharge

Zero Discharge

Technological Progress Towards Eliminating Kraft Pulp Mill Liquid Effluent, Minimising Remaining Waste Streams and Advancing Worker Safety

By Jay Ritchlin and Paul Johnston

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Executive Summary

The manufacture of wood pulp is the single most important method for chemically converting wood into useful products, and as such is a highly important component of the global manufacturing industry in both economic and environmental terms. In certain regions, pulp and paper manufacture is a dominant industry and is responsible for a large portion of regional economic activity.

At the same time, pulp and paper manufacture can have potentially serious impacts on environmental quality and hence the health of both human and wider ecosystems. In the United States alone, pulp and paper manufacturing is recognised as one of the nation's most highly polluting industries. The US Environmental Protection Agency's 1994 Toxic Release Inventory (TRI) reported that such facilities generate the greatest quantities of polluting substances (measured in pounds per facility) of any industry sector. Each facility was reported as generating an average of 457,457 pounds of reportable toxic substances every year. In addition, these industrial plants discharge an estimated 6.01 billion pounds of other pollutants not covered by the TRI into national waterways and public sewerage systems.

There is, however, great potential for both improving efficiency and moving towards **sustainability** in this industrial sector. This paper details the state of current research and technological development in the field of ecologically responsible kraft pulp manufacture. Developments designed to mitigate and eliminate **human and environmental health impacts** are emphasised. Also explored in depth is the potential for operating **closed loop pulp mills** which discharge no wastewater into our rivers and oceans and minimise the quantity and toxicity of air pollution and solid waste.

While the authors recognise that issues such as sustainable forestry, control of consumer demand and maximising the use of recycled and alternative fibres are critical components in moving the entire pulp and paper industry onto a sustainable footing, these issues are not addressed here.

The concept of a closed loop mill aims to eliminate discharges to the aquatic environment, recycle and reuse all possible solid and liquid process wastes, and reduce air emissions to the lowest possible quantity and toxicity. Ultimately, a mill should be able to produce its primary product, with most or all of its by-products suitable for use as **secondary products**. To date, much of the by-product in existing mills attempting to go closed loop is burned as a source of energy for the mill. While this may indeed qualify as a "reuse", it is a far from ideal reuse for much of the waste-stream. Future research must continue to develop more sustainable reuse options for kraft pulping solid wastes, as well as pulping methods that result in purified by-products that can serve as feedstock for other manufacturing processes.

Since the discovery of highly toxic **dioxin compounds** in pulp mill effluent there has been a great deal of work on reducing the toxicity of liquid discharges from pulp mills. There have been efforts at both end-of-the-pipe control, and at eliminating precursors to known toxic compounds. Despite progress on these fronts, a variety of toxic impacts persist. Genetic damage to fish and toxicity to micro-organisms that help to break down waste are still present in secondarily treated effluent from mills employing only chlorine dioxide as a bleaching agent. The presence of resin acids and other unidentified constituents continue to present toxicity problems for all kraft mills, regardless of bleaching chemicals. Ecosystems near pulp mills which meet relatively tough existing environmental regulations continue to experience significantly reduced diversity in the plants and animals able to live near them. These facts emphasize the need to pursue closed loop strategies.

Additionally, the effects of mill process changes on workers and local communities has rarely been factored into the mainstream debate on best routes forward. Exposure to bleaching chemicals, process gasses, emissions from treatment ponds, and bacteria and fungi on wood chips and sludge all directly impact the health and safety of the people working in the mill and the people who live near by. Decisions on how to make an ecologically responsible pulp mill must take these issues into account.

This paper reviews the literature on a wide variety of factors that will influence the overall impact of a pulp mill on its total environment. An attempt is made to draw conclusions about which **pathways** the research and practical experience indicate are the best ways forward to a kraft pulp industry with the lowest possible negative influence on its surroundings. Areas addressed include: effluent toxicity, air emissions, sludge and solid waste, raw material utilisation (i.e. energy usage, chemical consumption, wood yield and paper quality), bleaching methods, capital, conversion and operating costs, and worker and community health and safety. Current progress on closed loop mills is reviewed and evaluated with a particular look at non-bleach plant improvements, non-process element control to manage the build-up of recycled chemicals that can harm mill equipment and product quality, bleaching chemical choices and effects on mill equipment. Finally, looking to future improvements in the industry, emerging work on alternative pulping methods is discussed and a summary of next steps and gaps in existing research is presented.

A different quality and quantity of information is available for each area reviewed. **Effluent toxicity** has been, and continues to be, extensively researched. While the most advanced mills in the world may have similar final effluent toxicity, those employing only oxygen based bleaching chemicals continue to have the lowest toxicity on a full spectrum of toxicity parameters.

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As important as this area of study is under existing circumstances, closed loop operations will eliminate all toxicity to aquatic environments by eliminating all discharge into them.

The characteristics of **air emissions**, on the other hand, have not been well documented, nor have there been adequate comparison studies between various mill types. The current regulatory standards are inadequate. Existing data suggest that oxygen based closed loop operations will have either no difference in air emission impacts, or an improved one. However, this conclusion warrants further testing, especially as emissions to air will continue as a major output of closed loop mills.

The production of **waste fibre sludge** should end with a closed loop pulp mill. Until that time, some sludge will continue to be produced as mills increase the degree of effluent recycling they are able to accommodate. An increasing push towards landspreading of this material is being seen throughout many jurisdictions with intensive pulp production. This method of sludge disposal is an area of concern, as sludge constituents are not well identified, the sludge in any given mill is highly variable, and the fate of the sludge on land is not thoroughly researched. Well designed, independently monitored pilot projects of significant duration are necessary before this practise becomes widespread. The closed loop process will likely increase the amount of solid waste being generated in the dregs, grit, and ash of pulp mills as these waste streams become the only remaining options for the purge of chemicals and elements that can upset the process or damage equipment. While the quantity of dregs, grit, and ash in a closed loop mill will increase over current mill designs, total solid waste will be significantly reduced. Recovery of process chemicals from these purge points should be maximised. Remaining wastes will likely be committed to secure landfills. Therefore, more work on the composition and reprocessing of these waste streams is needed.

The review of **total energy consumption** is a critical element of evaluating an ecologically responsible pulp mill. A major factor in this calculation is the energy balance inherent in the various bleaching chemicals. Almost without exception, the literature indicates that oxygen based bleaching sequences have a superior efficiency over chlorine dioxide based sequences in this area. Even when combined with potential increased energy consumption in some oxygen based configurations, these mill designs are the most energy efficient available.

Wood yield and paper quality are two areas that have been frequently used by the North American pulp industry, in particular, to suggest that oxygen based bleaching sequences are neither ecologically, nor economically preferable. Many of these comparisons cite reductions in wood yield based on how the wood fibre is turned into pulp. This type of comparison is spurious and has no bearing on yield variations due to the type of bleaching used in a mill. Setting aside the yield effects of pulping processes, assertions made about yield loss due to oxygen based bleaching have been based on measurements of carbohydrate content in effluent and the resulting Chemical Oxygen Demand (COD), a standard regulatory measurement. These have suggested that there is between 0-1% increase in wood consumption for oxygen based production. These estimates, based on secondary measurements, have not been substantiated on a practical basis. The widely reported fall in yield of 6% at the Wisaforest TCF mill in Finland is thought to be due to the fact that the mill switches between ECF and TCF pulp production and as a result is not optimised for TCF production methods. Södra Cell has not seen a change in wood consumption since full conversion to TCF bleaching, in common with reports from the Louisiana Pacific mill in Samoa California after conversion to TCF. While there is undoubtedly a need to evaluate the yield aspect in greater detail, on the basis of the available evidence, yield loss does not appear to be a significant factor detracting from the overall benefits of using oxygen based bleach processes.

Similarly, claims made about **inferior pulp quality** from oxygen based sequences, while touching on an area of real concern for a small portion of the market pulp produced world-wide, seem to have been exaggerated, presented as representative of the full spectrum of bleach kraft pulp, and continually based on outdated information. As a general observation it appears that oxygen based kraft pulps show no appreciable shortcomings in quality relative to chlorine dioxide bleached products and that the unhelpful debate which has surrounded the product quality issue is of rapidly diminishing relevance both to pulp users and wider consumer markets.

The **costs** of converting an existing mill to closed loop operations are one area where there is extensive and often contradictory information in the public realm. Finding estimates that consider all relevant aspects of mill conversion and have access to enough detailed, mill-specific information is nearly impossible. In general, it appears that costs for converting an existing mill to a closed loop mill are similar regardless the type of bleaching chemicals used. The authors acknowledge that the actual cost of any conversion will be highly influenced by the state of the mill in question and we encourage the industry to open the evaluation process to public scrutiny. New, or "greenfield", mills appear to be most financially efficient when designed to optimise oxygen based bleaching and a closed-loop design.

As mentioned earlier, the health and welfare of the workers and surrounding communities has not been a regular feature of the debate over how to achieve an ecologically responsible pulp industry. This is most unfortunate because workers, especially, have often had to suffer increased workplace concentrations of hazardous chemicals as laws preventing those substances from entering the environment have been tightened. While no bleaching chemical is benign, the conclusion based on extensive available literature is that the oxygen based bleaching chemicals present the least immediate and long term hazards for workers and the general public. Additionally, the upgrades inherent in designing a closed loop mill should include other improvements, such as light gas strippers and, non-condensable gas collection systems which will remove hazardous and foul smelling pollution from the air and increase workplace safety.

Finally, we look at the current state of efforts to build and run an **actual industrial scale closed loop mill**. Efforts continue with both chlorine dioxide- and oxygen-based systems. Progress has been made on both fronts, with non-process element control (i.e., managing the build-up of chemicals which are recycled through the system), being the greatest barrier to final effluent circuit closure. For oxygen based sequences, the control of metals in the process liquor is the greatest challenge, while systems employing chlorine dioxide must have as a primary concern equipment damage from the recirculation of highly corrosive chlorides. A final solution has not been achieved for either approach. However, mills attempting to run chlorine dioxide based recycling have not been able to run at a high degree of effluent closure for extended periods. Oxygen based sequences have reached the lowest effluent flow levels and been able to run for longer periods between system purges.

The conclusion, given the best research in all of these areas, is that oxygen based, closed loop kraft pulp mills are the best route forward to a successful and ecologically responsible kraft pulp industry.