ENVIRONMENTAL FOOTPRINT COMPARISON TOOL

A tool for understanding environmental decisions related to the pulp and paper industry

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS

Table of Contents

OVERVIEW OF EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS

Introduction

Water that is used and recycled in pulp and paper manufacturing processes until it can no longer be reused in the process is called wastewater*.* Wastewater is treated on-site or off-site in treatment systems. Once treated, the resulting effluents are, in most cases, discharged to surface waters. While there are some exceptions, wood products operations do not generally produce or discharge wastewater.

Wastewater treatment systems are designed to remove oxygen-demanding substances (as measured by five-day biochemical oxygen demand, BOD_5, or BOD) and solid particles (measured as total suspended solids, or TSS). Chemical oxygen demand (COD) is a measure of all oxygen-demanding substances, including those not amenable to biological treatment, and these, too, are reduced through wastewater treatment. No reasonably constant relationship exists between COD and BOD values for either untreated or treated kraft wastewaters (Bryant and Wiseman 2003). Wastewater may also contain toxic and non-conventional pollutants such as chlorinated organic compounds.

Industry Performance

There has been significant reduction in the global pulp and paper industry’s production-normalized releases of BOD and TSS since the 1970s. The evolution of BOD and TSS reductions in the U.S. is shown in Figure B1. In Canada, federal government data show reductions of BOD and TSS between 1970 and 2008 to be 97% and 90%, respectively (Environment Canada 2012). Improvements to effluent quality since the mid-1970s have resulted from a combination of wastewater treatment system improvements and in-process improvements that have reduced the load on wastewater treatment systems allowing them to operate more efficiently. Examples of the latter include

- manufacturing process control measures taken to reduce the formation and release of chlorinated organic compounds, and
- best management practices applied to prevent or contain losses of spent pulping liquor and other process streams that might interfere with treatment plant performance or contribute to the discharge of pollutants.

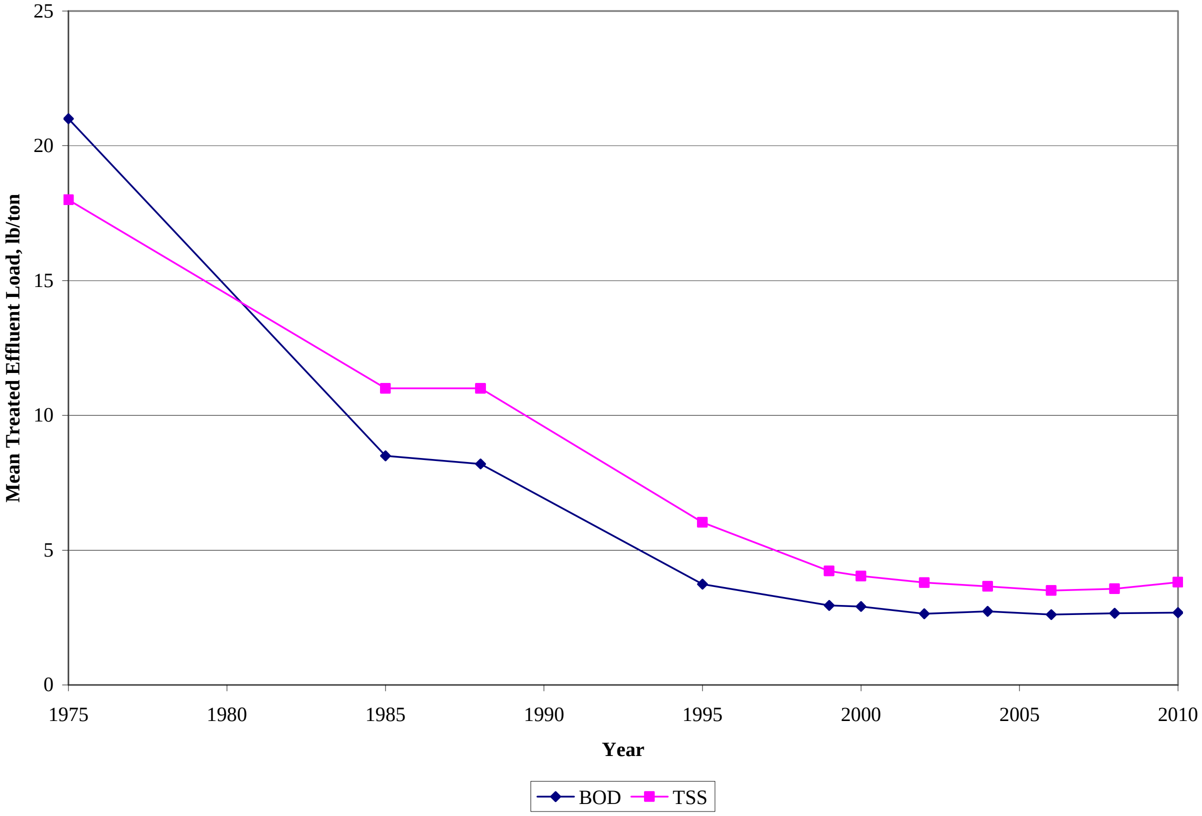

Figure B1. U.S. Industry Production-Normalized BOD and TSS Discharges (Source: NCASI 2012; AF&PA 2012)

Methods for reducing discharges to water take two general forms: a) reducing the loading of constituents delivered to the wastewater treatment system, also known as source reduction; or b) installing additional treatment system capacity or components. The potential environmental benefits and trade-offs for each method can be quite different, and for this reason, each method is presented separately in this section.

In its evaluation of appropriate controls for toxic and non-conventional pollutants, the U.S. Environmental Protection Agency expressed the view that “the most environmentally beneficial approach is to combine process technology changes which reduce or eliminate the formation of pollutants of concern with best available end-of-pipe treatment” (USEPA 1993a). As much might be said for such conventional pollutants as BOD and TSS.

Environmental Significance of BOD and TSS

The dissolved oxygen (DO) content of a waterbody is among the most important water quality characteristics necessary for protecting fish and aquatic life. Low DO levels can induce fish kills and reduce reproduction rates in aquatic biota. Industrial and municipal wastewater discharges, as well as stormwater runoff associated with urban, industrial, agricultural, and silvicultural sources, contribute oxygen-demanding substances (measured as BOD) to receiving streams and can diminish dissolved oxygen levels.

Suspended matter discharges (measured as TSS) may also be implicated in the depletion of DO, as well as other adverse aquatic impacts. Suspended matter, if settleable, can blanket the stream bed, damage invertebrate populations, block gravel spawning beds and, if organic, remove dissolved oxygen from the overlying water column. Suspended matter that does not settle may obstruct transmission of light into the water column, impairing aesthetics, as well as diminishing photosynthetic activity and the abundance of food available to fish and aquatic life.

History of Regulation of BOD and TSS Discharges

Historically, regulatory limitations on mill discharges of BOD and TSS were unevenly established on a site-specific basis in response to perceived local water quality imperatives. In the U.S., the regulatory landscape was altered in 1972 with a national legislative mandate that required the uniform application of technology-based standards except where water quality needs compelled even greater stringency. Significant improvement in effluent and receiving stream quality followed.

Regulatory standards responsive to the 1972 legislative mandate were adopted in 1977. They were derived on the basis of the average of the best existing performance by well operated plants within each production category. The best performing population of mills represented about 30% of the industry at the time (Ryan 2003). Deliberations involved consideration of the cost-effectiveness of alternative treatment practices, as well as a balancing of numerous engineering factors and non-water quality related environmental impacts including energy trade-offs. EPA has twice reviewed these initial standards for BOD and TSS, most recently in 1998 (*Federal Register* 1998). In each case, the original standards were left essentially unchanged for existing sources, a judgment based upon cost versus effluent reduction benefits.

In Canada, uniform standards were similarly enacted in 1992 to replace earlier (1971) regulations that had not required broad application of secondary biological treatment. By 1995, these types of secondary treatment systems were installed and operating at virtually all pulp and paper facilities in Canada.

Effluent limitations for BOD and TSS in North America have been largely driven by the demonstrated performance of external treatment systems. This stands in contrast to countries such as Sweden, where regulators going back to the 1970s had pressed the pulp and paper industry to adopt internal process changes rather than end-of-pipe treatment common in North America (Harrison 2002). The initial in-process focus gave the Swedish industry the advantage of having to treat smaller raw waste loads when biological treatment systems were installed two decades later.

Wastewater Treatment of BOD and TSS

Conventional wastewater treatment systems are capable of removing more than 90% of BOD and virtually the entire settleable portion of TSS. Further reducing discharges to water by installing additional treatment system capability involves capital improvements and/or the addition of new technologies to wastewater treatment systems. Because pulp and paper mills treat large volumes of wastewater, treatment system upgrades frequently require substantial capital investment. Costs escalate dramatically with the application of advanced treatment measures to remove the small increments of BOD and TSS that remain after conventional treatment.

Conventional Treatment: Conventional wastewater treatment systems in the pulp and paper industry most often employ primary clarification for removal of settleable material followed by secondary treatment for removal of biodegradable organic matter. Secondary treatment processes most often involve biological treatment. The process involves biological conversion of organic matter, either to energy required to sustain the biomass, or to growth and accumulation of additional biological solids. The solids are subsequently separated from the wastewater prior to its discharge. The most common secondary treatment configurations are aerated stabilization basins (ASBs; see Figure B2) and activated sludge treatment (AST). Both are capable of achieving high degrees of treatment.

Figure B2. Photo of Conventional Wastewater Treatment via Aerated Stabilization Basin

For North American pulp and paper mills, ASBs are the most frequently applied wastewater treatment technology, representing about 60% of U.S. and nearly 30% of Canadian mills practicing on-site wastewater treatment (i.e., excluding those who discharge indirectly via a publicly owned treatment works (POTW)). The remaining direct dischargers employ ASTs. In the aerated stabilization basin (ASB) configuration, most of the biosolids generated by the process settle within the aeration basin, or in subsequent polishing ponds. To a large extent, these biosolids subsequently decompose within the basin sediments. In the alternate activated sludge configuration, the biosolids are separated in dedicated tanks. Most of the solids collected in the tanks are returned to the system as needed to sustain the process. The remainder are dewatered and discarded or burned for energy recovery.

Conventional secondary treatment performance is, in part, dependent upon the settleable nature of the biological solids essential to the process. Sustaining that settleable quality is among the more sensitive aspects of activated sludge treatment and in some cases, chemical coagulants and settling aids may be intermittently used to enhance settling as circumstances require.

Wastewater treatment systems operating at pulp and paper mills are quite efficient at removing oxygen demanding substances (i.e., BOD) and solids (i.e., TSS). At many mills, average treatment system efficiencies exceed 95%. Table B1 shows data for activated sludge treatment systems. Aerated stabilization basin treatment systems perform in these ranges as well.

Table B1. Wastewater Treatment by the Activated Sludge Process (Source: Hynninen 1998)

	BOD removal, %
Sulfate (kraft) pulp mill	92 - 98
Mechanical paper	92 - 98
Recovered fiber-based paperboard	91 - 98

Given this high level of treatment efficiency, in-plant source reductions in the amount of BOD, TSS, and other treatable substances usually have a small incremental impact on treated discharges. For example, achieving a 50% reduction in raw waste load sent to a treatment system capable of achieving 95% BOD reduction would result in only an incremental 2.5% reduction relative to the original raw waste load. Wastewater substances that are not so amenable to removal in conventional wastewater treatment systems are, however, better dealt with by manufacturing process control measures. Wastewater color associated with chemical pulping is an example.

Effects of Decreased Release of BOD/COD & TSS

General Overview

The U.S. Environmental Protection Agency, as part of the extensive and systematic analyses that accompany its rulemaking, has examined the merits of more aggressive manufacturing process measures and unconventional external treatment approaches. The agency concluded that going beyond what is now required by its best conventional technology (BCT) and best available technology (BAT) requirements could not be justified by the relative effluent quality benefits.

There are potential environmental trade-offs in going beyond current regulatory requirements. These potential trade-offs must be reconciled with the incremental water quality benefits associated with further small reductions in discharges of BOD and TSS to receiving streams.

Opportunities for Improvement and Challenges to Further BOD/COD and TSS Reduction

Internal process measures at both integrated and non-integrated mills are capable of improving raw waste loads. Tertiary treatment can be applied to further reduce BOD/COD and TSS; however, it carries with it the potential for environmental trade-offs that may not justify the additional increment in effluent quality. Conventional wastewater treatment practices remain the workhorse in reducing BOD and TSS discharges to receiving waters.

In-Plant Reduction of Wastewater Discharges: In-plant source reduction necessitates changes in the wood, pulp, and/or paper processing systems to reduce the loss of usable raw or intermediate materials, thereby reducing the need to treat these materials in wastewater treatment systems and, assuming treatment efficiency remains constant, reducing discharges to water. Such opportunities are mill-specific. A detailed review of alternative process options is beyond the scope of this document, but literature on the topic is available (USEPA 1993b; NCASI 2012).

In their consideration of options that comprise the best available technology (BAT) for bleached kraft pulp mills, the European Commission (EC) gave recognition to the European industry’s historic focus on process-integrated measures (Suhr 2000; IPPC 2001). Among them were the measures shown below that have potential benefits for raw waste load reduction.

- Dry debarking of wood
- Modified (extended) cooking
- Closed-cycle brown stock screening
- Highly efficient brown stock washing
- Elemental chlorine-free (ECF) or totally chlorine-free (TCF) bleaching
- Some, primarily alkaline, process water recycling from the bleach plant
- Purification and reuse of condensates
- Effective spill monitoring, containment, and recovery system
- Sufficient black liquor evaporation plant and recovery boiler capacity to cope with the additional liquor and dry solids loads due to collection of spills, etc.

The effect of these various options on wastewater quality and other environmental measures is qualitatively characterized in Table B2.

Table B2. Effects of Application of In-Plant Reduction of Wastewater Discharges (Source: IPPC 2001)

Techniques to Consider in the Determination of BAT	Effects on the Consumption and Emission Levels (Cross-Media Effects)				
	Chemical Consumption	**Energy**	**Emission to Water**	**Emission to Air**	**Solid Waste**
Dry debarking	n.e.	↑ in debarking	↓ COD, ↓ TSS, ↓ flow	n.e.	n.e.
Extended modified cooking to a low Kappa Continuous (c) or batch (b)	↑ in cooking ↑ lime demand ↓ in bleaching	(↑) cooking (c), ↓ cooking (b) (↑) evaporation, (↑) lime kiln	↓ COD ↓ AOX	↑ odor	n.e.
Closed screening	n.e.	n.e.	↓	n.e.	n.e.
Oxygen delignification	↑ in O_2-stage ↓ in bleaching	↑ O_2-stage, ↑ white liquor oxidation, ↑ caustic.& lime kiln	↓	n.e.	(↑) dregs
Ozone bleaching	↑ in O_3-stage ↓ in bleaching	↑ O_3-stage, ↑ O_3 generation ↓ in bleaching	↓	n.e.	n.e.
ECF bleaching technique (vs. TCF)[1] (at same incoming low Kappa)	(↑/↓)	(↑/↓)	↑ AOX, ↑ ClO_3^- -	↑ Cl_2	n.e.
TCF bleaching technique (vs. ECF)[1] (at same incoming low Kappa)	(↑/↓)	(↑/↓)	(↓ COD) ↓ AOX ↑ N Chelat.	n.e.	n.e.
Part closure of the bleach plant + increased evaporation	↑ bleaching	↑ evaporation	↓	(↑)	(↑) dregs
Collection of almost all spillage	n.e.	↑ evaporation	↓	n.e.	n.e.
Efficient washing and process control	↓ bleaching ↓cooking	↑ washing (electr.)	↓	n.e.	n.e.
Stripping and re-use of condensates	↓ bleaching	↑	↓ COD, N	↓ odor	n.e.
Buffer tanks for concentrated liquids	n.e.	n.e.	↓	n.e.	n.e.
Aerobic biological treatment	(↑)	↑	↓	n.e.	↑
Chemical precipitation	↑	↑	↓	n.e.	↑

NOTES: n.e. = no (or negligible) effect; ↑ = increase; ↓ = decrease; (↑/↓) = may or may not have an effect/little impact depending on the conditions.

[1] Assumed that there is efficient wastewater treatment.

EPA identified a similar array of options in its consideration of best available technology for bleached kraft mills. Though the agency's focus was on reduction of toxic and non-conventional pollutants, they nevertheless acknowledged the coincident BOD reduction benefits associated with the application of ECF bleaching and best management practices for containing liquor losses.

Effects of Decreased Release of BOD/COD & TSS

General Overview

Even greater improvements were anticipated with the application of other process modifications that advanced measures that further closed up the fiber line, improved water reuse within the bleach plant, and recycled bleach plant effluent. A common thread here is the capture of pulping liquor solids and other wood extractives that if lost to wastewater would add to raw waste load. To the extent that they are routed back through the liquor recovery system, they represent a source of cooking chemicals and energy (NCASI 2012).

Internal process measures of the potential benefits of raw waste load reductions are not restricted to pulping operations. The European Commission addressed some in their reference *Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Pulp and Paper Industry* (IPPC 2001), as shown in Table B3.

Table B3. Effects of Application of Other In-Plant Measures to Reduce Wastewater Discharges (Source: IPPC 2001)

Techniques to Consider in the Determination of BAT	Effects on the Consumption and Emission Levels (Cross-Media Effects)				
	Chemical Consumption	**Energy (E) & Water (W) Consumption**	**Emission to Water**	**Emission to Air**	**Solid Waste**
Water Management and Minimizing Water Usage	(0)	(↓)E (↓)W	↓	0	0
Control of Potential Disadvantages of Closing Up Water Systems	↑	0	(↓)	0	0
In-Line Treatment of White Water by Use of Membrane Filtration	0	(↑)E (↓)W	(↓)	0	0
Reduction of Fiber and Filler Losses	↑	↓	↓	0	(↓)
Recovery and Recycling of Coating Color Containing Effluent	(↓)	0	↓	0	↓
Separate Pre-Treatment of Coating Wastewater	(↑)	0	↓	0	(↑)
Measures to Reduce Frequency and Effects of Accidental Discharges	0	0	(↓)	0	0
Measurement and Automation	(↓)	↓	↓	0	0
Equalization Basin and Primary Treatment	0	0	↓	0	0
Aerobic Biological Treatment	(↑)	(↑)E	↓	0	↑
Chemical Precipitation	↑	(↑)E	↓	0	↑

NOTES: The positive and negative side effects are also given. ↑ = increase; ↓= decrease; 0 = no (or negligible) effect;(↑) or (↓) = low influence depending on conditions.

Tertiary Treatment Approaches: Tertiary treatment measures have been evaluated for effectiveness in further removing BOD and removing non-settleable material, but they have not often been applied.

Chemically Assisted Clarification (CAC), as one option, involves the routine use of chemical coagulants, polyelectrolytes, and polymer combinations. Achieving relatively modest incremental improvement in the discharge levels of TSS requires large chemical additions. More problematic is the associated generation of disproportionately large quantities of gelatinous, difficult to dewater sludge, especially with pulp mill wastewaters.

Filtration is another option that has been explored. Studies by NCASI and others have demonstrated that significant reduction in treated effluent TSS and turbidity could be achieved with filtration. Performance was dependent upon the type of wastewater being treated. Consistently high performance, however, required chemical addition. The corresponding BOD reduction represented a significant portion of the residual BOD after secondary treatment. However, the fraction removed was only a minor portion of the initial wastewater BOD introduced into the treatment system (NCASI 1973).

Past attempts to improve pulp and paper mill effluent quality through granular media filtration of biologically treated effluents have not proven to be successful (NCASI 2008). Among the obstacles is management of the filter backwash that is generated when the accumulated solids that would ultimately plug the filter are flushed from it. That backwash must be routed back through treatment, resulting in an additional hydraulic load. Any portion of the solids in the backwash that remain unsettleable will impose a continually increasing "dead load" on the system. Where separated, the solids represent an additional solid waste burden. If chemicals are employed to enhance filtration, sludge volumes and management difficulty will be all the greater. Mixed media filtration was among the technologies considered by EPA in its effluent guidelines review and judged not to be cost-effective.

There are other rarely applied advanced treatment options that might be considered, such as membrane systems, ozonation, carbon adsorption, and others. Like the tertiary treatment measures described above, the incremental reductions beyond conventional practices are seldom justified based upon other environmental trade-offs and what, in most cases, is little or no water quality benefit. Equal gains, if necessary, may be more constructively achieved with internal process measures than by pushing external treatment beyond the point of cost-effectiveness. The proper balance of internal and external approaches is a very mill-specific judgment.

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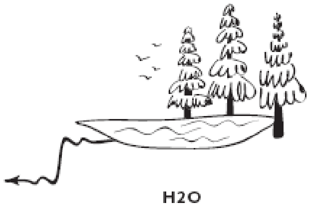


EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON WATER USE

Overview

Mills that reduce discharges to water do so using two approaches: 1) reducing the loading of constituents delivered to the wastewater treatment system, also known as source reduction; or 2) installing additional treatment system capacity or components. The latter approach generally would not have a direct impact on water usage, though economic considerations in the application of advanced wastewater treatment measures may encourage effluent volume reductions.

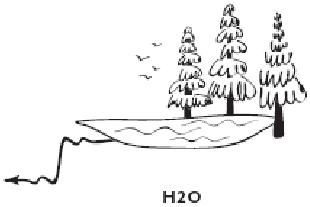
Source reduction techniques frequently include actions that can also reduce effluent volumes. Installation of improved pulp cleaning technologies and enhanced attention to pulping liquor loss control are examples of source reduction techniques that have the co-benefit of reduced effluent volumes. Such opportunities are site-specific and detrimental effects associated with reducing effluent volumes may be important (discussed in the Water section of this tool).

More information on the interactions between reducing discharges to water and effluent volumes is available at the links below.

More information

Liquor loss control and spill recovery

In-process improvements

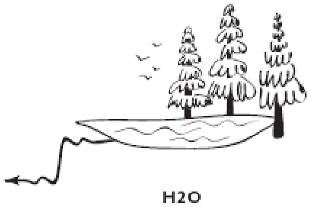


EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON WATER USE

Liquor Loss Control and Spill Recovery

A common technique for reducing the load of BOD, COD, and/or TSS sent to wastewater treatment systems is to implement pulping liquor loss control and/or recovery systems. Minimizing and/or recovering losses and spills can reduce discharges to water by both reducing the load on the wastewater treatment system and by reducing the day-to-day variability in untreated wastewater load, leading to more stable treatment system performance.

In some cases, the practices employed have the co-benefit of reducing effluent volumes through direct recovery of losses (e.g., collection of liquor spills into the liquor recovery system), and through the avoidance of water used to clean up spills (e.g., wash-up of fiber, paper coating, or lime spills).



EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON WATER USE

In-Process Improvements

One technique for reducing the load of BOD, COD, and/or TSS sent to wastewater treatment is the application of improved efficiency of pulp or paper processing. Techniques vary widely and are facility-specific. Generally, such methods result in improvements in raw material utilization and thus the loss of fewer materials that contribute load to the wastewater treatment system. Some of these techniques yield a concurrent reduction in water use and thus have the co-benefit of both load and flow reduction. Examples include upgraded heat recovery systems, improved pulp washing or screening systems, and others. Again, the viability of in-process load reduction techniques having co-benefits in water use reduction is very mill-specific.

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON ENERGY USE

Overview

Wastewater treatment systems require substantial inputs of electrical energy. Depending on mill type, wastewater treatment systems can consume between 1 and 7% or more of the electricity used by the mill. The primary use for electricity in wastewater treatment operations is for the pumping, mixing and aeration necessary to support biological treatment of wastewater.

To the extent that reductions in discharges to water would necessitate installation of additional treatment system capacity or components, electrical consumption would be expected to increase. Reduced discharges brought about by source reduction activities within the mill could result in either increases or decreases in energy usage and would be mill- and project-specific with respect to net energy use. Generalizations cannot be made.

More information

Energy use for wastewater treatment

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON ENERGY USE

Energy Use for Wastewater Treatment

Collection and treatment of process wastewaters typically requires the use of pumping systems to transport wastewater from process areas throughout the mill to the wastewater treatment system and between wastewater treatment system components such as clarifiers, biological treatment tanks, and residuals management systems. Aerobic biological treatment systems, which are used to treat wastewaters at the vast majority of mills worldwide (IPPC 2001), require adequate mixing in the reactor basin and a supply of air or oxygen to support biologically based degradation of organic wastewater constituents. A considerable amount of electrical power is required for pumping, mixing, and supplying the air or oxygen needed to support biological treatment.

Rough estimates of electrical use at wastewater treatment systems, as a percentage of total mill electrical use, can be made by comparing literature values for energy consumption by mill type (Nygaard 1997; Williamson 1999) with energy requirements for wastewater treatment (NCASI 1998). Table B7 summarizes some of these estimates.

Table B7. Relative Amount of Mill Electricity Consumption for Wastewater Treatment Systems

Mill Type	Percent of Total Mill Electricity Usage Consumed in Wastewater Transport and Treatment Systems
Kraft pulping integrated with fine paper	4.8
Mechanical pulping integrated with newsprint	1.3
Deinking integrated with tissue	7.2
Non integrated paper, paperboard, tissue, pulp drying	4 to 7

A reduction in the relative amount of energy consumed during wastewater treatment can be achieved through a reduction in the load to the treatment system. A common technique for reducing the load of BOD and/or TSS sent to wastewater treatment systems is by implementing spent pulping liquor loss control and/or recovery systems. Minimizing and/or recovering liquor losses can reduce discharges to water by both reducing the load on the wastewater treatment system and by reducing the day-to-day variability in untreated wastewater load, leading to more stable treatment system performance (NCASI 2012). The recovery and use of raw material, either in the product or process, or for fuel value, will offset energy associated with acquiring and processing replacement raw materials, and thus would be a co-benefit of source reduction.

Some source reduction methods involve the substitution of one chemical for another. An example is the replacement of chlorine in chemical pulp bleaching with chlorine dioxide. In doing so at kraft pulp mills, untreated wastewater loads of AOX, BOD, COD, and color are reduced (see the Chlorinated Compounds section of this tool for more information). However, the energy required to manufacture chlorine dioxide is much greater than that needed to produce chlorine on an oxidizing power equivalent basis. In this case, the source reduction activity has an environmental trade-off with respect to energy consumption and associated greenhouse gas emissions.

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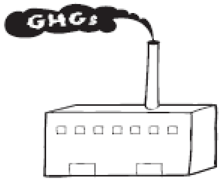

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON GREENHOUSE GAS EMISSIONS

Overview

Efforts to reduce discharges of BOD/COD and TSS to water can involve either changes within the mill’s production areas and/or the addition of wastewater treatment system capacity or components.

Changes within mill production areas that are undertaken with the objective of reducing discharges to water would not be expected to affect greenhouse gas emissions directly. However, to the extent that such changes may impact energy use at the mill, greenhouse gas emissions can be affected. Energy co-benefits and trade-offs are discussed under the Energy section of this tool.

Reduction of discharges to water that are achieved by installing additional treatment capacity or components would not be expected to impact greenhouse gas emissions, except as related to the increased use of energy to supply the new or upgraded wastewater treatment systems. The installation of tertiary treatment systems that generate additional amounts of residuals (e.g., flocculation systems for color or chemical oxygen demand removal) do have the potential to increase greenhouse gas emissions. This would occur in the case where the residuals were managed in landfills or by other means. where carbon in the residuals is converted to methane rather than carbon dioxide. Methane is approximately 25 times more potent as a greenhouse gas than is carbon dioxide.

CHLORINATED COMPOUNDS

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON CHLORINATED COMPOUNDS

Overview

Environmentally important chlorinated compounds associated with pulp manufacture can derive from some bleaching and brightening systems. Reduced discharge of biochemical oxygen demand (BOD), total suspended solids (TSS), and chemical oxygen demand (COD) can accompany process measures taken to reduce the formation and discharge of chlorinated compounds. These types of process changes, however, do not alter the treatability of wastewaters subsequently discharged.

Follow the link below for more information on the interactions between reducing chlorinated compounds and effluent quality.

More information

AOX removal

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON CHLORINATED COMPOUNDS

AOX Removal

AOX (adsorbable organic halide) removal efficiency during conventional wastewater treatment is not affected by process modifications such as low to moderate levels of ClO_2 substitution in the bleach plant (Barton and Drake 1993), or the installation of oxygen delignification and complete ClO_2 substitution (Hasagawa and Barton 1997). Though the specific mechanisms of AOX removal may vary with the configuration of waste management systems, well-treated effluent levels tend to be proportional to influent levels, as illustrated in Figure BX below. Apart from process changes that alter bleaching practices, reducing the discharge of BOD and TSS to treatment would not be expected to have a significant impact on either the potential to generate or to discharge chlorinated organic compounds.

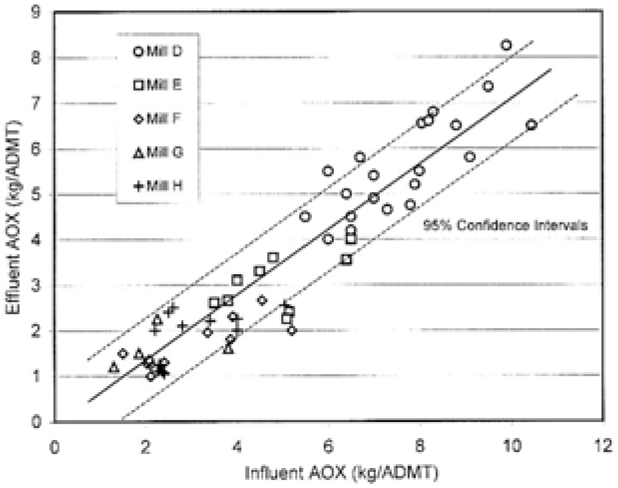

Figure BX. Relationship between Influent and Effluent AOX for Wastewater Treatment (Source: Bryant et al. 1992)

Reduced discharges of BOD/COD and TSS to water might also be approached with the installation of additional treatment system capability or components. Anaerobic/aerobic sequences for enhanced AOX removal have been explored, as have the merits of aerated stabilization basins (ASBs) with longer retention times and high rate activated sludge systems having longer sludge residence times. Removal mechanisms that have been suggested include volatilization, precipitation and settling, sorption on separated biomass, and chemical and biological degradation (Eckenfelder 1999). Specification of optimal design and operating conditions to maximize AOX and conventional pollutant removal remains elusive. It is possible that some tertiary treatment systems (e.g., flocculation for removal of dispersed solids or dissolved/colloidal organic compounds (such as color) may have co-benefits in reducing AOX. Because the approach to upgrading treatment system capability or adding treatment components is site-specific, associated reduction in chlorinated compound discharges or compromises in conventional pollutant removals, if any, will also be site-specific. At present, there do not appear to be full-scale treatment systems in use that are expressly designed for removal of chlorinated compounds.

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Hasagawa M.M. and Barton D.A. 1997. The effects of oxygen delignification, complete chloride dioxide substitution, and biological treatment on bleached kraft mill effluent quality. *Water Science and Technology* 352: 1-6. http://dx.doi.org/10.1016/S0273-1223(96)00909-2

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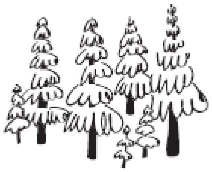
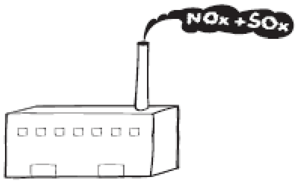


EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON LAND AND WOOD USE

Overview

Efforts to reduce discharges of biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solids (TSS) are unlikely to have significant impacts on land and wood use. These parameters are relatively insensitive to reductions in discharges to water; however, advances in wood delignification may increase pulp yield to an extent that wood requirements may decrease (or production increase with no change in wood requirements).



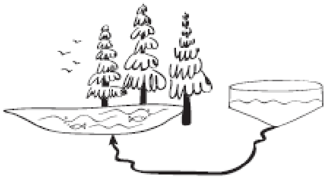
EMISSIONS TO AIR

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON EMISSIONS TO AIR

Overview

Efforts to reduce biochemical oxygen demand (BOD) or total suspended solids (TSS) discharges to water either through source reduction methods or by installation of additional treatment system capacity or technology would not be expected to have an effect on emissions to air.

Emissions to air might increase as a result of water use reductions and in some cases the associated reduction in effluent volume might be expected to have a co-benefit in reducing discharges to water (BOD and TSS). The relationship between water use reduction and emissions to air is described in the SOx and NOx section of this tool.



EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON DISCHARGE TO WATER

Overview

Effluent discharge limitations derived from national technology-based standards for biochemical oxygen demand (BOD), total suspended solids (TSS) and toxic pollutants have had a prominent role in improving water quality in North America. In spite of this progress, along with a sustained effort to impose more stringent discharge limitations where required, water quality impairment persists in some areas. Industrial point sources continue to contribute to that impairment, but are only one of many possible contributors.

In the vast majority of cases, current industrial effluent limitations for BOD and TSS are sufficient to meet associated water quality objectives. More stringent limitations may be called for where water quality needs dictate, but in general, additional reduction in BOD or TSS beyond current industrial effluent limitations will not have a substantial effect on receiving environments.

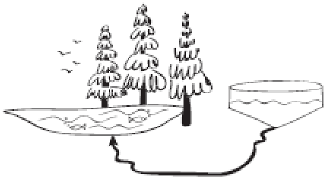
Mill contributions to water quality impairment are sufficiently isolated that any remaining concerns are typically pursued on a company- and mill-specific basis.

More information

Receiving water quality

Dissolved oxygen and turbidity

Association between BOD and TSS and impaired water quality



EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON DISCHARGE TO WATER

Receiving Water Quality

In the U.S., state environmental regulatory agencies have had the principal responsibility for identifying impaired waters and addressing the contributing sources of impairment. In practice, the process has been hampered by technical, scientific, and procedural challenges. Among these challenges have been

- the quality and quantity of monitoring data upon which impairment judgments are based, and
- the development and proper application of predictive tools for identifying the relative roles of contributing sources of impairment.

National inventories of impaired waters have been regularly compiled over the years, but these are not well-suited for defining trends in water quality improvements, given the inconsistencies among states in terms of how they undertake water quality assessments, and due to differing definitions of “impaired” waters. That said, the water quality inventory compiled by EPA provides the best available snapshot of water quality impairment in the United States.

Industrial point source discharges are one of roughly two dozen or more sources of water quality impairment identified by EPA for purposes of state water quality inventories. The relative prominence of one contributing source or another varies with the character of the water body, as illustrated by Table B4 summarized from EPA’s National Summary of State Information reported in January 2012. It is based upon information largely compiled in 2010.

Table B4. Relative Significance of Sources Contributing to Threatened or Impaired Waterways (Source: USEPA at http://iaspub.epa.gov/waters10/attains_nation_cy.control#prob_source)

Probable Source Group	“River” Miles Threatened or Impaired	“Lake” Acres Threatened or Impaired	“Estuary” Sq. Miles Threatened or Impaired
Agriculture	124,282†	1,817,549	3,020
Atmospheric Deposition	98,107	4,740,142	7,721
Unknown	86,761	3,258,186	5,439
Hydromodification	58,879†	905,925	2,513
Urban-Related Runoff/Stormwater	51,725	856,530	1,869
Natural/Wildlife	51,582†	1,374,576	4,225
Municipal Discharges/Sewage	51,236	794,158	4,406
Unspecified Nonpoint Source	46,985	759,087	2,607
Habitat Alterations*	32,387†	359,237	2,057
Resource Extraction	26,356	560,919	1,292
Silviculture (Forestry)	19,444†	242,583	0
Industrial	14,433	221,830	3,752
Construction	13,532	314,515	16
Other	10,167	863,640	3,630
Land Application/Waste Sites/Tanks	8,394	77,005	53

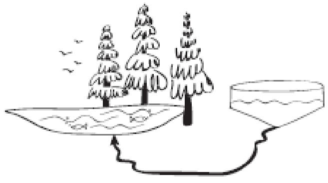
(Continued on next page)

Table B4. Continued

Probable Source Group	"River" Miles Threatened or Impaired	"Lake" Acres Threatened or Impaired	"Estuary" Sq. Miles Threatened or Impaired
Legacy/Historical Pollutants	4,915	763,320	1,469
Spills/Dumping	2,420	194,422	26
Recreation and Tourism (Non-Boating)	1,741	106,703	0
Aquaculture	318	4,620	0
Groundwater Loadings/Withdrawals	178	98,032	158
Recreational Boating and Marinas	132	126,390	1,053
Military Bases	42	2,436	--
Commercial Harbor and Port Activities	--	109,240	470

* Not directly related to hydromodification.

† Based on a separate analysis conducted by NCASI. This value is artificially high by several thousand because of unusual reporting methods in assessment data submitted to EPA by one or more states.


DISCHARGES TO WATER

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON DISCHARGE TO WATER

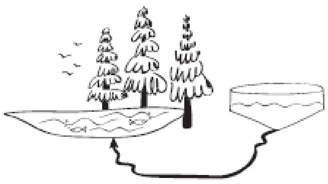
Dissolved Oxygen and Turbidity

The capacity of a wastewater discharge to diminish receiving stream dissolved oxygen is measured by its BOD. Receiving stream turbidity is a consequence of suspended matter discharges, commonly measured as TSS. Sediments, another cause of impairment, are also the result of TSS discharges and can be a legacy of historical industrial effluent discharges. However, current residual TSS discharges associated with industrial discharges that are subject to technology-based effluent limitations are largely unsettleable and tend to remain dispersed in the water column. Therefore, discussion here is focused on turbidity as a probable cause of impairment.

Assessment of a sampling of water bodies in the U.S. presented in EPA's National Summary of State Information reported in January 2012 indicates that low dissolved oxygen persists among the leading causes of remaining water quality impairments, ranking fourth (out of roughly three dozen impairment categories) for all three waterbody types. Turbidity is less of an issue except, perhaps, for lake situations. Estuaries emerge as being most vulnerable to low dissolved oxygen impacts. Table B5 identifies the proportion of surveyed waterbodies that are impaired either by oxygen depletion (low dissolved oxygen) or by turbidity.

Table B5. Relative Ranking of Sources of Water Body Impairment
(Source: USEPA at http://iaspub.epa.gov/waters10/attains_nation_cy.control)

Waterbody	Low Dissolved Oxygen		Turbidity	
	Proportion of Surveyed Waterbodies Impaired	Rank Among Impairment Causes	Proportion of Surveyed Waterbodies Impaired	Rank Among Impairment Causes
Rivers	8.0%	4	2.6%	15
Lakes	6.6%	4	5.5%	6
Estuaries	11.5%	4	0.8%	14



DISCHARGES TO WATER

EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON DISCHARGE TO WATER

Association between BOD and TSS and Impaired Water Quality

In the U.S., roughly 240 pulp and paper mills discharge treated wastewaters directly to receiving streams. There are nearly 90 such "direct discharge" mills in Canada. Their discharges tend to be large and are scrutinized by regulatory agencies as potentially significant where impact on receiving water quality has been in question. For that reason, mill discharges that have demonstrable impact on water quality in the U.S. have been largely addressed in site-specific discharge limits responsive to their contribution to water quality impairment. In Canada, the objective of the Environmental Effects Monitoring Program (EEM) is, in part, to identify and address site-specific receiving water quality issues.

Given the variety of industrial and non-industrial contributors to water quality impairment, identifying and equitably apportioning responsibility among potential contributors has been among the more daunting technical challenges in addressing water quality concerns.

Exhaustive site-specific technical analyses would be required to support an absolute statement about the extent to which mill BOD and TSS discharges adversely impact water quality, whether near or distant.

Lingering questions about the role of any possible mill impacts on water quality impairment in the U.S. might be gauged by examining mill locations relative to

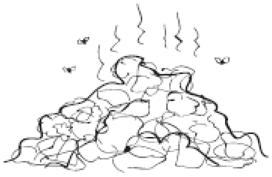
- the 5,691 water body segments identified in the National Summary of State Information http://iaspub.epa.gov/waters10/attains_nation_cy.control#APRTMDLS as impaired because of dissolved oxygen (DO) levels, and
- the 2,454 segments identified as impaired due to turbidity.

An informal NCASI staff examination of U.S. EPA data was carried out in October 2008. Results of that analysis are presented below in Table B6, which shows mill proximity to impairment situations.

Table B6. Mill Proximity to U.S. Impaired Waterways

	Immediate Mill Vicinity			Downstream of Mills		
	No. of Affected Mills	% of Direct Discharge Mills	% of Listed Segments	No. of Affected Mills	% of Direct Discharge Mills	% of Listed Segments
DO Related Impairments	19	7.0%	0.5%	73	26.9%	1.8%
Turbidity Related Impairments	9	3.3%	0.4%	26	9.6%	1.6%

It is unknown what portion of the mills noted in the above table is actually contributing to impairment. The values represent an upper bound on the number of mills whose BOD and TSS discharges might be associated with water quality impairment.



EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON SOLID WASTE

Overview

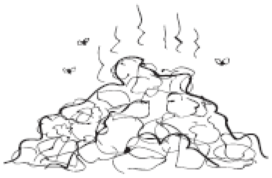
Efforts to reduce discharges of BOD/COD and TSS to water either through source reduction or wastewater treatment can have co-benefits with respect to solid waste generated during the treatment of wastewater. Reducing the losses of solid raw materials decreases the amount of primary residuals that must be managed at wastewater treatment systems. Reducing the losses of organic materials (measured as biochemical oxygen demand, BOD) will reduce the amount of biosolids generated and removed during activated sludge treatment and, to a much lesser extent, the accumulation of biomass residues in treatment pond systems.

Conversely, reducing discharges to water through the installation of additional treatment system capacity or technology is likely to increase the amount of solid residuals that must be handled and managed. This trade-off is particularly acute for tertiary treatment systems that use coagulation or physical separation techniques to remove suspended particulate, or colloidal or soluble matter from wastewaters prior to discharge. More information is provided in the links below.

More information

Effect of source reduction

Effect of incremental treatment



EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON SOLID WASTE

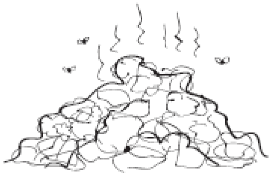
Effect of Source Reduction

Source reduction involves changes to the wood, pulp, and/or paper in-plant processing systems such that the loss of usable raw or intermediate materials is reduced. The resulting reduction in wastewater load sent to the treatment system can reduce the amount of solid waste that must be managed. This can occur in two ways: through reduction in the loss of solid materials (e.g., usable pulp fiber, filler, coatings); and by reductions in the amount of organic matter, measured as BOD or COD in effluents (e.g., by improved liquor loss control or alternate pulp bleaching practices). In both cases, the degree of solid waste reduction achieved will be mill- and treatment system-specific.

Reducing the loss of solid materials reduces the amount of these materials that must be managed in the mill primary treatment system, where settleable solids originating in the process are removed from the wastewaters. In most cases, these reductions would in turn decrease the load on residuals dewatering systems and, ultimately, requirements for their final disposal or beneficial use.

Reducing the load of treatable organic constituents in wastewater will reduce the intensity of biological treatment, resulting in a reduction of biomass grown as a result of treating organic waste. In activated sludge systems, some of the biomass grown is removed from the system and managed as solid waste (usually requiring dewatering). Reducing the organic load in process wastewaters also reduces the amount of biomass grown during treatment and thus the amount removed and managed as solid waste. For mills treating wastewaters in pond systems (i.e., aerated stabilization basins), reduced organic loading reduces the amount of biomass grown and, ultimately, the accumulation of biomass residuals in the treatment ponds. Because biomass residuals in treatment ponds are themselves degraded to a large extent in pond bottom sediments, the co-benefit to solid waste of source reduction of organic matter at mill operating treatment ponds is much less significant relative to mills with activated sludge systems.

To the extent that organic load reductions are achieved by improved capture and recovery of in-plant pulp mill process streams, there may be incremental increases in solid wastes that emerge from the chemical recovery and causticizing systems. Solid waste streams affected include green liquor dregs and slaker grits.



EFFECTS OF DECREASED RELEASE OF BOD/COD & TSS ON SOLID WASTE

Effect of Incremental Treatment

Incremental treatment to achieve greater reduction of solids (TSS) or organic matter (BOD, COD, color, or AOX) will generally increase the amount of solid residuals produced at a wastewater treatment plant. This occurs because the techniques used to improve treatment often involve the use of chemical, physical, and/or biological processes that extract additional matter from wastewaters as solid material.

Examples of tertiary treatment technologies include coagulation/flocculation (chemical), filtration (physical), and specialized biological processes. The amounts of additional solid waste generated from incremental treatment of wastewaters vary greatly with the technology and application. To illustrate, the gelatinous sludge resulting from alum-based chemically assisted clarification (CAC) treatment is often low in solids content (0.2 to 0.5% solids by weight) and difficult to dewater. Laboratory and pilot-plant data suggest that sludge quantities could range from 53 to 289 pounds per ton (dry basis) of paper production.