Using predictive models on mill modernization projects

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Several computer models can help predict the benefits of in-mill changes on effluent and emission rates.

Emissions from the mill impact the ambient air, soil, ground water, and surface waters, as shown in **Fig. 1**. As environmental regulations become progressively more stringent, the most feasible solutions for solving environmental problems are those that deal directly with the source of the pollution. Therefore, most environmental problems of the future will be solved through mill modernization projects, which may include modest upgrades of existing pollution control systems. This concept has been accepted by most of the industry for over 20 years. The problem with its implementation has been the inability to quantify the benefits of in-mill changes on effluent and emission rates. Research into this problem resulted in the development of realistic waste treatment simulations during the early '80s. These models, coupled with source emission data and, when appropriate, environmental impact models, can be used to develop feasible solutions to environmental problems.

Types of models

The computer models used in environmental engineering can be grouped into the following categories:

- Water quality models
- Air quality models
- Treatment system models
- Manufacturing process models.

Water quality models

Typically, a mill's effluent discharge limits are technologically based and are defined by categorical standards. However, when the mill discharges into a body of water that does not meet its water quality standards, the assimilative capacity of the stream must be determined. In these cases, water quality models are used to estimate the impact of the mill's discharge on the receiving stream. A common example is a stream that does not meet its standard for dissolved oxygen during all or part of the summer.

The type of receiving water model used is dictated by the governing state agency or the U.S. Environmental Protection Agency (EPA). These models vary in complexity. The simplest model used is the desktop model developed by Streeter and Phelps in 1925. The most common model is QUAL2E, which contains a series of complex mathematical equations that must be solved using a computer.

A special type of model is the mixing model, which is used to design effluent diffusers. These models define the size and shape of the "zone of initial dilution" for various design conditions. The zone of initial dilution is the portion of the stream that initially mixes with the effluent. An example of this type of model is CORMIX2.

Air quality models

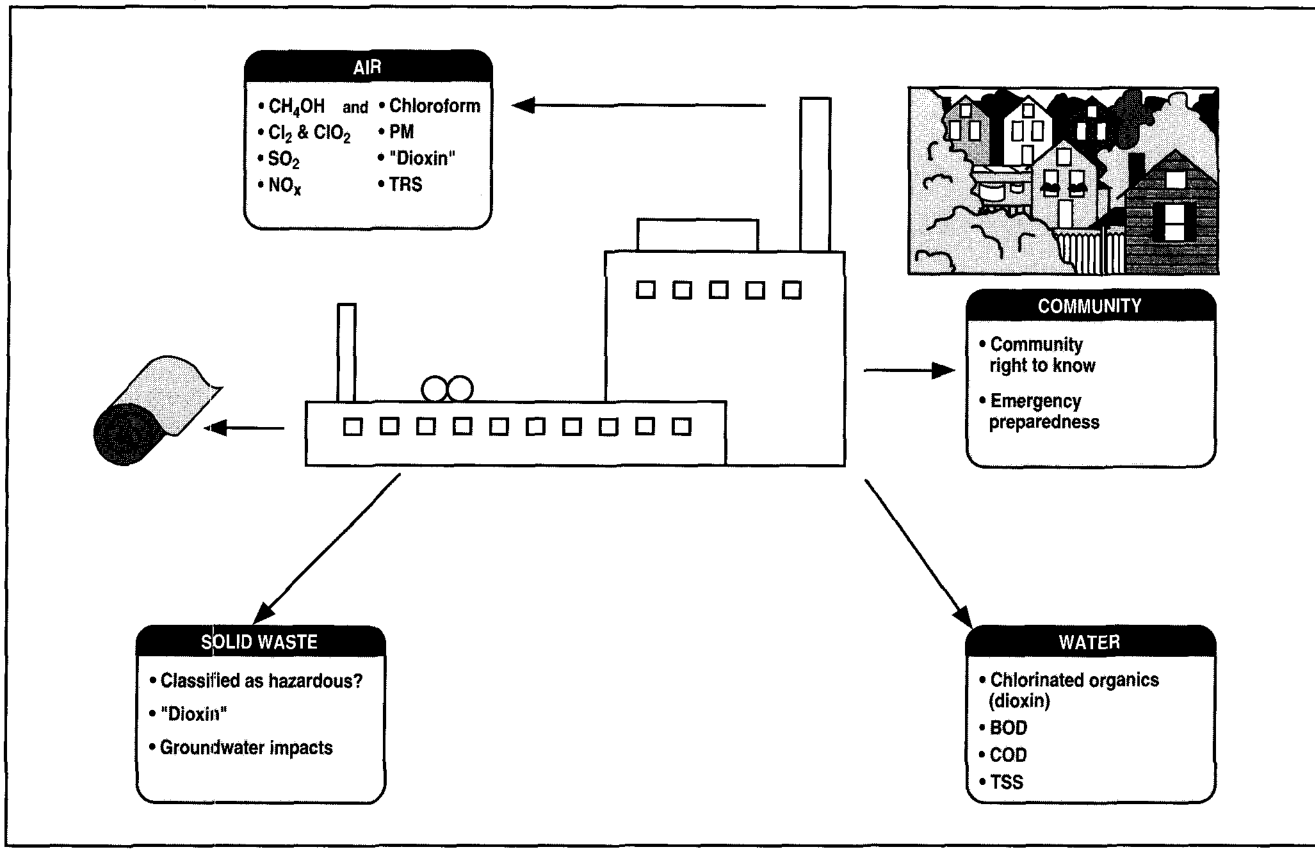
The goal of any air emissions control system is to meet ambient air quality standards. Air quality dispersion models are used to ensure that a new project does not cause these standards to be violated. For example, modeling is normally done during the Prevention of Significant Deterioration review process. Simple desktop screening models can be used to show compliance with regulations. However, this type of analysis can require the use of complex computer models that take hours to run, such as the ICST model. The type of model used normally is determined by the regulatory agency.

These models can be used during the early design phases of a mill project to develop strategies for avoiding costly air emission control systems, tall stacks, or construction delays.

Treatment system models

Historically, treatability studies were conducted to develop design data for wastewater treatment plants because simple desktop models often were inaccurate. In the last 15 years, realistic computer models have been developed. These models are beginning to replace treatability studies.

1. Environmental implications of a bleached kraft mill



Two types of wastewater treatment systems are used in the pulp and paper industry. Most mills use aerated lagoon systems, while the remainder use activated sludge systems. The lagoon systems generally consist of one to two partially mixed, aerated stabilization basins followed by a hold/release pond. They have hydraulic residence times of 5–20 days. Activated sludge systems consist of aerated tanks followed by clarifiers. Most of the settled sludge is recycled back to the aeration tanks. These systems have hydraulic residence times of 6–48 hours.

For aerated stabilization basins (ASBs), the National Council for Air and Stream Improvement's (NCASI) SASBV2 model normally is used. As shown in **Fig. 2**, the processes within an ASB are quite complex. The NCASI model does not account for all of these processes. Therefore, to make the model more realistic, we have upgraded it to account for the sludge beds that build up in most ASBs. For aerated sludge basins, IAWPR's SSSP model usually is used. These models solve complex equations in less than one minute that would take days to solve using desktop methods. Currently, these models are used to predict the effluent quality for conventional pollutants only (BOD,total suspended solids, NH_3, etc.). However, public domain data are available which could be used to modify these models to predict the removal of AOX, methanol, chloroform, etc.

These models are used by mills to predict the impact of mill modernization projects on treatment system performance. Their use is expected to become widespread as mills develop strategies to meet the EPA's proposed Cluster Rules.

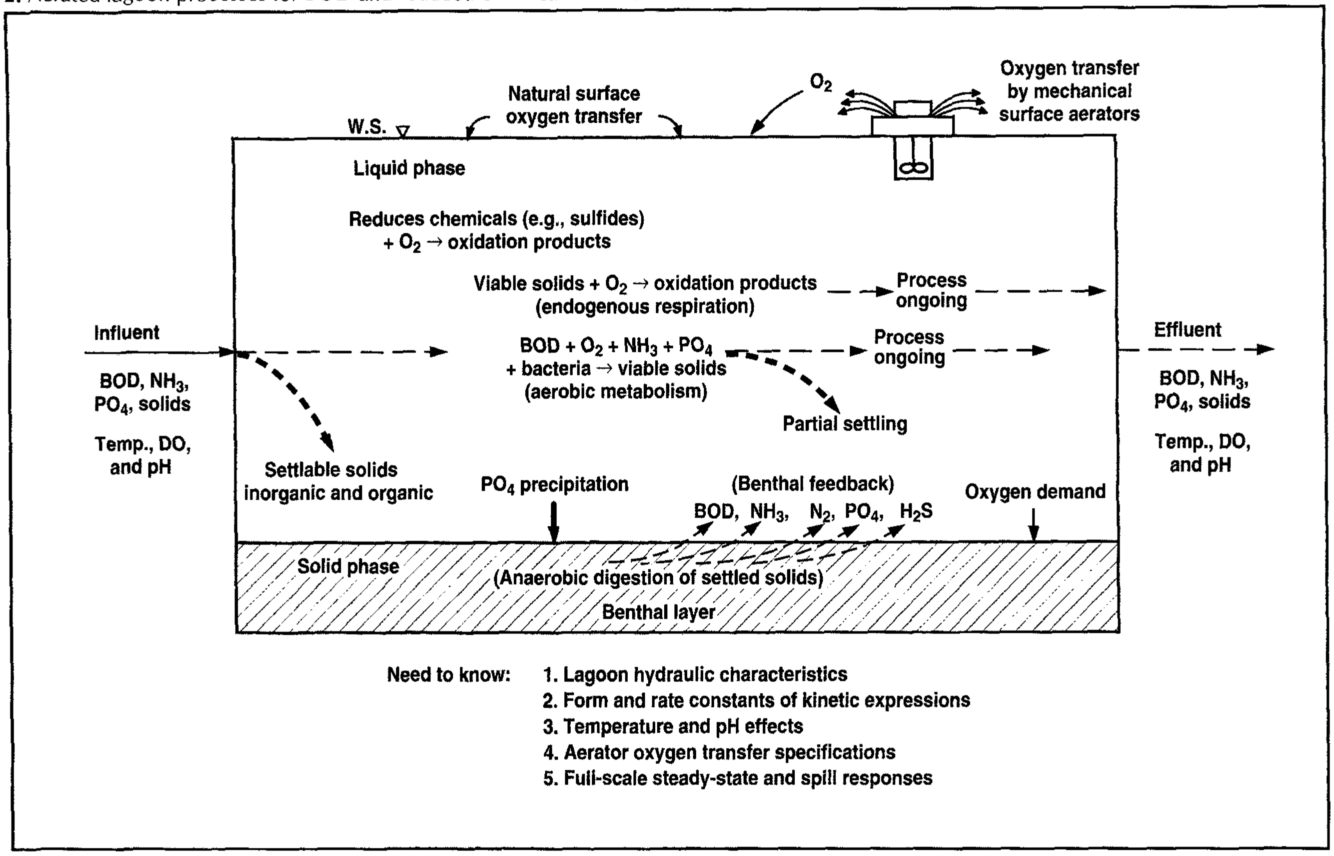
Manufacturing process models

Manufacturing models such as GEMS and MASBAL are available for conducting mass and energy balances around a process area or the entire mill. Theoretically, it is possible to use these models to estimate the pollutant emission rate from changes to the mill. For example, during the 1980s, GEMS was used to estimate the raw wastewater loadings following a mill modification. This method has several major drawbacks: losses are estimated as the difference of two process streams; small errors in estimating process streams result in large errors in estimating losses; development of these models can be costly and time consuming. These steady-state models cannot estimate losses from spills, which account for 15–33% of mill losses. Because of these drawbacks, use of these models to predict pollutant losses has lost popularity in the 1990s.

Case history no. 1

The following case history is an example of how models can be used to develop successful environmental strategies. The case

2. Aerated lagoon processes for BOD and reduced chemical treatment



involves a large bleached pulp and paper mill which discharged its treated effluent into a river that was having difficulty meeting its dissolved oxygen criteria in the summer. Various scenarios were modeled using a water quality model (QUAL2E) to estimate the acceptable treated BOD discharge for the critical low-flow summer months. From this modeling, it was determined that the mill would have to reduce its effluent BOD from 18,000 lb/day to 11,000 lb/day.

An earlier study had been conducted as part of an anticipated mill expansion. During this study, a desktop analysis was performed by another environmental consulting firm that indicated that the rate of biological treatment was limited by the availability of macro-nutrients. A subsequent treatability study showed no benefit from adding additional macro-nutrients. Their recommendation was to expand the ASB from a 7-day hold/release time to a 20-day hold/release time and increase the aeration capacity from 2000 hp to 4000 hp. This earlier recommendation was upgraded to include secondary clarifiers. The total package was estimated to cost US$ 20 million.

Under a separate project, environmental engineers used a computer simulation to model the ASB. Using this model, various ASB upgrade scenarios were developed and evaluated. Three upgrades were recommended. They were:

- The addition of eight 50-hp aerators
- The addition of ammonia and phosphoric acid during the summer months
- The addition of two baffles.

A trial following the improvement showed that the addition of the aerators improved the BOD removal across the ASB from 74% to 78%. The addition of the baffles further increased the BOD removal to 84%. With the 15% BOD removal that was achieved across the hold/release pond, the mill was able to meet the new limit. During most summers, the mill was able to average BOD values of 6000 lb/day. The total capital cost was less than half a million dollars.

Case history no. 2

The following is an example of how models can be used to determine the impact of in-mill process changes on the environment. The case involves a large market pulp mill that discharged its treated effluent into a river, causing the river to fail to meet its dissolved oxygen criteria in the summer. Water quality modeling using QUAL2E indicated that the BOD discharge would have to be reduced from 6000 lb/day to 3700 lb/day in the summer.

The mill had a very large ASB with a hold/release pond (15 days of aeration, 10 days of hold/release). Aeration and nutrients were not limiting.

Fifteen in-mill process scenarios were evaluated using the ASB model. The following projects were identified, which reduced the flow rate from 28 million gal/day to 19.8 million gal/day. These changes allowed the mill to meet the BOD limit:

- White water recycled to RCC cleaners and machine showers
- Recycle of chlorine-stage filtrate
- Recycle of accumulator hot water to lime mud washers, mud filters, and kiln scrubber.

Other alternatives were:

- Cool and reuse 9.5 million gal/day of noncontact cooling water which was being treated
- Direct discharge of 9.5 million gal/day of noncontact cooling water which was being treated.

Cost estimates were not made because the regulatory agency postponed implementation of the basic strategy.

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