

PAPER MILL SLUDGE: FEEDSTOCK FOR TOMORROW

EVEN THOUGH paper mill sludge is a relatively homogeneous material removed from the wastewater stream during the pulp and paper-making process, recovery projects were virtually unheard of until the late 1980s. Today, that has decidedly changed. Much of it is still being landfilled, but an ever increasing amount is being either put back into the production of paper or otherwise being utilized.

Documentation is provided by the National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI), which has periodically surveyed the paper industry about solid waste management practices for more than 20 years. The latest survey shows that in 1995, its members — roughly 70 percent of the papermaking industry — generated just under 3.9 million tons of sludge. Of that amount, around 25 percent is managed by utilization projects, which include recycle/reuse, beneficial use and land application. About 50 percent is landfilled or lagooned and the other 25 percent incinerated, but that still is a dramatic improvement. The 1979 NCASI survey showed that approximately 86 percent of the sludge generated by its members went to either landfills or lagoons, 11 percent was incinerated and only three percent was recovered by recycling or land application (see Table 1).

With land application leading the way, paper companies are finding many more uses for their sludge.

Jim Glenn

Lightweight pea-sized aggregate for use in concrete and two kinds of fuel pellets are some by-products being made from pulp and paper mill sludge.

Table 1. Paper mill sludge management trends

Method	1979 (%)	1988 (%)	1995 (%)
Landfill/lagoon	86	74	50
Incineration	11	18	25
Land application	2	6	12
Beneficial use	>1	1	7
Recycle/reuse	>1	1	6

Source: National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI)

"The first thing that prompted the push to utilization was the cost of landfilling," says Amy Schaffer, Senior Director of the Industrial Waste Group for the American Forest and Paper Association. "Then companies realized there actually were possibilities." Clearly the most popular option is land application and NCASI notes that the amount of sludge being land applied has increased over 600 percent from 1979 to 1995.

Because sludges from paper mills typically have excellent moisture holding properties and also are a significant source of organic matter that improves the makeup of soils, they are well suited for use in both land reclamation and agriculture. In Ashland, New Hampshire, White Mountain Resource Management evolved out of the corporate world of BFI and has focused its attention on organics recycling since its inception in 1995. White Mountain acts as a third party operating company, contracting with generators to manage their organic residuals. Among the materials that they manage are municipal biosolids, wood ash and paper mill sludge. Customers have included seven wood ash generators in the Northeast, several wastewater treatment facilities in New Hampshire and Vermont, and a paper mill in Maine. "We are ag oriented," says Ned Beecher of White Mountain. "Most of the biosolids and about half of the ash we manage go to farms."

However, the company has taken a different approach with the paper mill sludge it manages, utilizing the "short paper fibers"

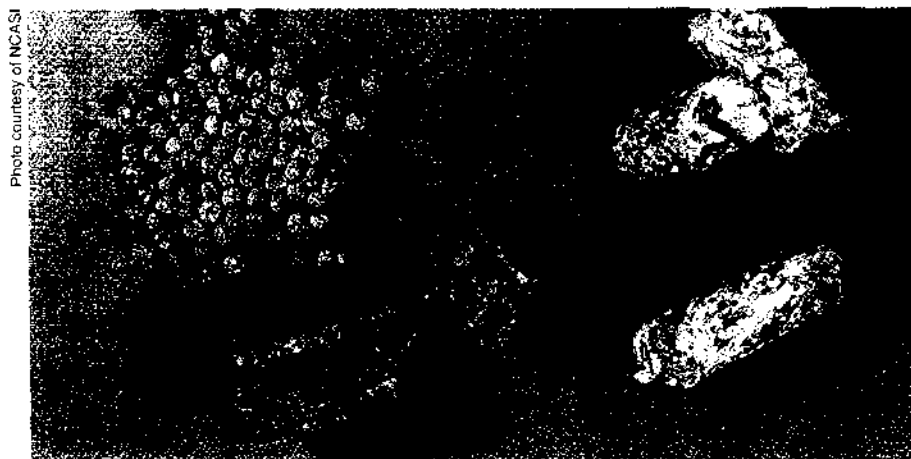


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in gravel pit reclamation. "We do what we call topsoil manufacturing," says Andrew Carpenter of White Mountain, explaining its approach of blending the primary sludge from a recycled fiber mill with biosolids and other ingredients. White Mountain brings in the ingredients and does the blending on site. "It's a low tech operation," says Carpenter. "The material is mixed, usually with equipment that's available at the site, like a front-end loader. We usually use a bulldozer to apply it." The blend of material varies from site to site, based on what the soils are like, but the basic formula aims for a final carbon:nitrogen ratio of 30:1.

"Short paper fibers work great in reclamation because of how they retain moisture and control erosion," says Beecher. Currently, White Mountain uses most of the nearly 5,000 tons of primary sludge it manages for the paper company in gravel pit reclamation, but it also is working it into landfill cover and roadside bank stabilization jobs.

While all of these applications are geared to using the moisture retention and erosion control properties of the sludge, White Mountain believes that the sludge, which has a substantial portion of clay associated with it, can also be used as a barrier layer in landfill caps. "It's an idea that has gotten a good response so far," says Beecher. "But because it's new, the regulators have some concerns."

MEAD MENDS MINELAND

Mead Paper Company has been working for years on uses for its paper mill sludges. "We've looked at all sorts of alternatives," says Derk Kroskop of Mead. "To date, we've had the most success in mine reclamation."

Mead started down the road to full utilization with sludge from its Chillicothe, Ohio plant about 10 years ago. Located amid the coal mining region of southeastern Ohio, the vast acreage that needed improvement provided Mead with a substantial opportunity to use the 500 to 600 wet tons/day produced at this facility. "I didn't think we could operate without a landfill, but it can be done," says Kroskop.

Early in the process, Mead worked with university researchers to provide the data necessary to show that using the sludge to rebuild mine soils provided an overall benefit to the environment. That was necessary to get regulatory approval from the Ohio EPA, and to convince landowners that it was worthwhile to specify use of paper sludges when reclaiming strip mines.

Unlike many paper companies, the Chillicothe plant manages and operates its own utilization projects. At first, sludge was applied under contract to the Ohio Department of Natural Resources at abandoned mine sites. Because those jobs were limited by available state funds, not all sludge from the plant was utilized. According to Joe Lawson, who manages the program for Mead, the big break came about five years ago when the Ohio EPA approved paper

mill sludge for use as a soil amendment. Now, virtually all of the output from the plant goes to reclamation projects, with about 75 percent used at active sites and the remainder going to the abandoned mine reclamation program run by the state. "Right now we have more demand for the sludge than supply," says Lawson. "We have two large coal companies that take all that we have available."

After a site is approved by the Ohio EPA, sludge is hauled to the location and then company crews do the application work and seeding. The entire cost, including postapplication mowing, is borne by Mead. "We save roughly 50 percent of landfill costs," says Lawson. "All of our private work is done within 40 miles of the plant."

Mead operates seven paper mills in the U.S., and although the objective is to develop alternatives to landfilling sludge, that is

tion sites. Even the availability of potential sites doesn't always translate into projects. In Mead's case, although there are more than 400,000 acres of abandoned strip mine lands that need reclaiming in its area, Ohio's reclamation budget doesn't provide sufficient funds.

For the Great Northern paper mills in Millinocket and East Millinocket, Maine, it isn't the state budget that is the problem, but rather the budgets of local potato farmers. "The big years for land spreading were 1995 and 1996," says Bob Deabay of Great Northern. Unfortunately, the farmers had a bad year in 1996 and couldn't afford to share the costs of the program in 1997, so it was cheaper for Great Northern to landfill the sludge.

The company started to work earnestly on a land spreading program in the early 1990s. The first couple years were devoted to pilot studies that showed farmers how paper mill sludge helped improve yields, especially in dry years, when water retention properties came to the front. By 1995, Great Northern was land spreading 55,000 cubic yards (cy) of sludge and, in 1996, that increased to almost 70,000 cy spread at five farms. But when hard times hit in 1996, the farmers didn't have money to spend for transporting and spreading sludge in 1997. "Maybe things will be better next year," says Deabay.

THE COMPOSTING ALTERNATIVE

At its Hawk Ridge facility in Maine, BFI Organics has been composting paper mill sludge along with municipal biosolids for more than 10 years. With roughly 20,000 tons of sludge going into the process each year, the company is one of the larger composters of paper mill sludge in the country. Much of the paper sludge composting taking place is being done at public facilities, rather than by either the paper companies or private third parties.

In Oswego County, New York, the Solid Waste Authority utilizes paper mill sludge as a bulking agent for composting fish and other food processing residuals. Additionally, sludge is used as a blanket over the compost piles to help control odors and maintain moisture levels. Other public agencies that are composting significant amounts of paper mill sludge include the Oneida County (Wisconsin) Solid Waste Department and the Bluestem Solid Waste Management Agency in Cedar Rapids, Iowa.

Prior to 1995, the Bluestem compost facility, located along the Cedar River in Cedar Rapids, was used exclusively for yard trimmings. The original site, which was approximately 15 acres, had processed upwards of 25,000 tons/year of material utilizing a Scat windrow turner. Bluestem expanded the operation in 1995, when it started composting sludge from the Cedar River Paper Company. "We made a commitment to compost the sludge," says Dave Hogan of Bluestem. That commitment went a long way toward encouraging the paper

"The paper mill has been able to eliminate its landfill now that we're available," says Bart Sexton of Oneida County, Wisconsin composting project. About 4,000 tons of paper mill sludge will be composted at the site this year.



Photo courtesy of Menasha Corp.

In Michigan, Menasha Corporation teamed with Renewed Earth, a local company, to develop a compost facility that handles sludge and wood fines from its chipping operation.

sometimes easier said than done. One of its small mills in New England is using its sludge for landfill cover, but Mead still relies on landfilling at most of its other plants. "You have to look at the specific characteristics of the sludge," says Kroskopp. But that isn't the only part of the equation. "Much of it depends upon luck — and what is located near you that can utilize the sludge being generated."

LACK OF MONEY

While land application projects, whether reclamation or agriculture-based, often are the most cost-effective approach to managing paper mill sludge, they are not always an available alternative. Many paper mills simply aren't located close to land applica-

Because paper mill sludges typically have excellent moisture holding properties and are significant sources of organic matter, they are well suited for use in both land reclamation and agriculture.

CHARACTERIZATION OF PAPER MILL SLUDGE

RESIDUE removed from the wastewater stream produced by the pulp and papermaking process is generically known as "sludge." The characteristics of the sludge depend on the wastewater technology used in the mill, which can involve different physical, chemical, thermal and biological treatments. Generally, sludge is produced at two steps in the process of treating the effluent. Primary clarification is usually carried out by sedimentation, but also can be performed by dissolved air flotation. In sedimentation, the wastewater to be treated is pumped into large settling tanks, with the solids being removed from the tank bottom. These solids can range from 1.5 percent to 6.5 percent consistency, depending on the characteristics of the material. Secondary treatment is usually a biological process in which microorganisms convert the waste to carbon dioxide and water while consuming oxygen. The resulting sludge is then mixed with the primary sludge prior to dewatering and disposal.

Mills produce various amounts of sludge, depending on their raw material, process and final product. The amount of residue produced for each grade of paper depends, in part, on the source of the raw material. Mills that use recycled fiber for raw material have more residuals to dispose than mills that use wood. This is partly due to fillers in the paper that, for the most part, are not recovered. This is especially true for the tissue grades, a low-filler content grade that can use office waste (a more highly filled grade) for a fiber source.

Not only do mills produce varying amounts of sludge, but the sludges are distinctly different in composition. The sludge differs between virgin and recycled mills; however, significant variations also exist within the same categories. In general, kraft pulp mill sludge tends to have a greater sulfur content, and deinking mill sludge has a greater ash content.

Sludge from waste treatment plants is a combination of waste streams from many different processing steps within the mill. The waste used in the process — which can include effluent that is mixed from both pulp and paper mills in an integrated operation — has often passed through several of these steps before being sent to the treatment plant. Typically, the rejects from the pulper and the high-density cleaner are easily dewatered and usually disposed in the mill solid waste stream. The rejects from the other process operations (and the water removed from the rejects just mentioned, if not recycled back to the process) are generally combined and sent to effluent treatment, where some components may be recovered.

— Gary M. Scott, Said Abubakr and Amy Smith. The authors are respectively Research Chemical Engineer, Supervisory Chemical Engineer and Forest Products Technician with the USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin. This article was excerpted from the authors' paper "Disposal and Utilization alternatives for the Pulp and Paper Industry: A Review."

company to locate in Cedar Rapids.

To accommodate the sludge and other source separated materials, Bluestem prepared and covered approximately eight acres of its composting site with "Ecostone," a recycled fly-ash product from Iowa Electric. Cedar River then decided to add a second mill, effectively doubling to 60,000 tons the amount of sludge that needed composting annually. "It's really become the centerpiece activity of the agency," says Hogan, "although it only represents about 15 percent of our budget."

Bluestem combines the sludge with yard trimmings and select industrial organics that provide nitrogen. Although the increase in materials has caused the site to be expanded, a windrow system is still used for composting.

In Wisconsin, Oneida County originally got involved in composting when it was looking for landfill cover material. Although the Solid Waste Department was interested primarily in yard trimmings, paper mill sludge offered a chance to divert significantly more

material. For Rhinelander Paper, the compost site offered a low-cost alternative to sludge disposal when its principal outlet (land application) wasn't available, such as during planting and harvesting times, and when weather makes it difficult to access the farm land.

After some experimentation in 1995, the Solid Waste Department set up a full-scale composting unit at its landfill. "The paper mill has been able to eliminate its landfill now that we're available," says Bart Sexton of Oneida County, who notes that about 4,000 tons of paper mill sludge will be composted at the site this year.

The first batch of compost from Oneida County recently has been finished and screened. With the aid of funds from the Wisconsin DNR, the county will be doing analyses on the product to determine if it contains dioxins or heavy metals, and how it performs in plant growth tests. Although the landfill has need for the finished compost as a cover material, if the compost is salable, Sexton wants to market it.

PAPER COMPANY COMPOSTING

Most paper companies seem content to allow others to do the composting, but some, such as Great Northern and the Virginia Fiber Corporation in Amherst, Virginia, have been experimenting on their own. Menasha Corporation has gone even further. Faced with encroaching development around its Otsego, Michigan mill, Menasha needed to find an alternative to its land application program, a practice it has used for more than 20 years. After several years of pilot projects, Menasha teamed with Renewed Earth, a Michigan composter, and developed a compost facility that handles sludge and wood fines from its chipping operation. In 1996, the company produced 45,000 cy of compost and expects to increase to full-scale production over the next year. Most of the compost has been sold as a growing medium for potted plants, but landscapers also are utilizing the material.

OTHER ALTERNATIVES

An increasing number of paper companies and third parties have begun to look for ways to turn paper mill sludge into other products. This takes the form of both using the sludge as a filler (for instance, in cement products) or as the principal component of a product (such as animal bedding or oil absorbent granules). Additionally, others see even more value locked in paper mill sludge and are experimenting with its use in ethanol production and high-value chemicals such as levulinic acid. While such uses can be viable, some are low-volume uses and may not fit in the plans of companies that are looking for alternatives for large amounts of sludge. "Often it's the availability of a cement plant or an entrepreneur in the area that drives a project," says Jay Unwin, manager of NCAST's Central Lake States Region and one of the principal investigators of its solid waste management surveys. Even at the corporate level, local initiative is largely responsible for the push into alternative uses. "The people at our facilities are doing such a good job that often times they know about a new use before we do," says Judy Trader, who oversees beneficial use projects for International Paper.

One means of managing at least part of a plant's sludge is either to reintroduce it into the papermaking process or reclaim it and utilize it as fiber in the manufacture of other types of paper. Speaking at the BioCycle Northeast Conference '97 in August, Gary Diadone, of the Merrimack Valley Manufacturing Partnership, noted that many paper mills, particularly smaller, specialty mills, often are not designed to maximize the use, of the fiber coming into the plant. Working with mills in Massachusetts, he's found that by introducing relatively simple modifications, the amount of fiber being disposed of can be substantially reduced. Beyond process modification, there also are ways to capture usable fibers at the end of

the pipe. Researchers at the U.S. Forest Products Lab in Madison, Wisconsin report that more than half of the recycled paper-board mills in the U.S. utilize primary sludge as fillers.

As paper companies have become interested in recycling projects, the process systems needed to make them a reality have begun to evolve. For instance, the Onix Corporation of Deshler, Ohio has developed a recovery system that processes sludge and estimates that as much as 70 percent can be reclaimed as fiber for utilization at the mill or for sale as pulp to other processes. The system works in three stages: drying, primary separation and secondary

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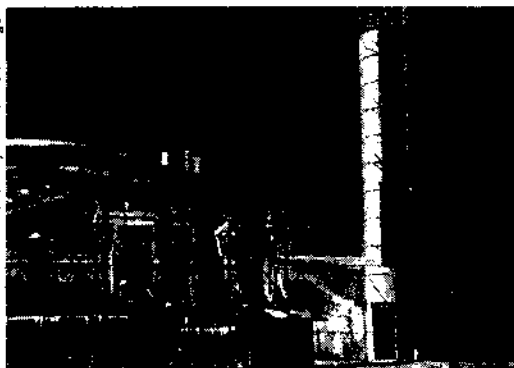
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Grantek's plant in Green Bay, Wisconsin processes paper sludge into about 40,000 tons of granules per year.

separation. Reportedly, the Onix system has been installed in at least one U.S. paper mill.

DESIRABLE PROPERTIES

Paper mill sludge would appear to have more uses than simply as a soil amendment or compost ingredient, and a number of projects have been initiated to take advantage of those properties. Currently, Thermo Fibergen is conducting a pilot at Great Northern's East Millinocket plant to determine if its patented recovery process is compatible with the plant's sludge. Fibergen pumps sludge into the recovery system, where long fibers and water are extracted and returned to the plant for reuse in papermaking. Shorter fibers and fillers such as clay which remain will be used to manufacture products such as oil and grease absorbents, cat litter and granules that are used as carriers of herbicides and pesticides.

Although Fibergen has yet to begin operating any of its systems, in July, 1996, it purchased GranTek, one of the pioneers in developing products from paper mill sludge. GranTek has been processing sludge from the Fort James (formerly Fort Howard) paper mill in Green Bay, Wisconsin since 1990. Located about a quarter mile from the Fort James tissue mill, its plant currently produces about 40,000 tons of granules per year. This continuous operation accepts sludge at 40 percent solids, dries it and then forms it into granules, which are then dried

"We save roughly 50 percent of landfill costs," says a Mead Paper Company manager in Ohio. "All of our private work is done within 40 miles of the plant."

further and screened.

Other third party operators that have developed products from paper mill sludges include International Absorbent, Inc. of Bellingham, Washington, which has been producing both animal bedding and oil absorbent materials commercially for several years. A project recently got underway at the Newstech Recycling paper mill in Coquitlam, British Columbia. At full production, that facility will process 55,000 tons of the mill's sludge annually.

Following the lead of these entrepreneurs, paper manufacturers are now starting to add product lines that make use of sludges. Marcal Paper recently began producing "Kaofin," a granule made from clay and short fibers extracted during the recycling process at Marcal's tissue mill. Marcal started developing Kaofin when ocean dumping sludge was banned in 1991, and the only immediate alternatives were expensive landfills in New Jersey and eastern Pennsylvania.

Marcal's first new product using the granules is an absorbent being marketed for industrial floor cleaning. Additionally, the company is looking at marketing Kaofin products as animal litter, as a bulking agent for composting, and as a filler in manufacturing cement products.

While the cellulose content in paper mill sludge makes it ideal for use in absorbent products, other kinds of products also are being manufactured. For instance, a local company became interested in using the sludge from International Paper's Moss Point (Mississippi) Mill as a basesheet in the manufacturing of asphalt roofing felts. After four months of trials, the plant began utilizing the sludge in its process, and from mid-1995 through the end of 1996 about 15,000 tons of the primary clarifier sludge were recovered. In other applications, Champion International's Hamilton, Ohio mill sludge and boiler ash are used as a filler in the manufacture of cement, and the West Fraser Timber's Alberta Newsprint Company supplies a Saskatchewan manufacturer with approximately seven percent of its sludge for molding egg cartons.

While as noted before, most of the work on alternatives to disposal of paper mill sludge has been by individual companies, at least in Canada, that may be changing. Paprican, the Pulp and Paper Research Institute of Canada, a nonprofit research and educational organization funded principally by Canada's pulp and paper producers, has recently embarked on a research project that may lead to the Paper Mill of the Future. As part of that work, Paprican is looking to develop advanced technologies designed to maximize the use of fiber in the mill and minimize its waste streams.

As with other industrial by-products, there probably is no "silver bullet" use that will consume all of the sludge currently being landfilled. But given enough thought and energy, in the next 10 years the NCASI survey could find the utilization percentage outweighing that of landfilling. ■



Marcal Paper's granules are extracted during tissue recycling and marketed as an absorbent for industrial floor cleaning — as well as a bulking agent.