Paper Mill Sludge and Ash as Soil Conditioner

Generating 120 tons of sludge and 50 tons of ash daily, the Warren Paper Company knew it had to shift away from landfilling and head toward land use... And a private company to market the materials.

RAYMOND G. PEpin
S. D. Warren Company

PETER COLEMAN
N. C. DEPT. OF NATURAL RESOURCES & COMM. DEV.

THE INTEGRATED kraft pulp and paper mill of the S. D. Warren Company at Westbrook, Maine produces 650 tons per day of coated and uncoated printing, publishing and specialty papers. The company employs about 2,000 people at this facility.

The Westbrook mill has been generating sludges from its wastewater treatment systems since 1963 when a small primary treatment plant was started up. In 1976, a new primary and secondary treatment facility was put on-line. The conventional activated sludge process is utilized to treat 17 MGD of wastewater. Ammonia and phosphoric acid are added to provide nutrients to the biological treatment system. There are no sanitary wastes in the wastewater stream.

In January, 1982, the company started up a new biomass boiler, which produces electricity and process steam. It is one of the larger co-generation facilities in the Northeast. Approximately 2,000 tons of woodchips and 200 tons of coal are burned daily.

Currently, the Westbrook mill generates approximately 120 tons of sludge and 50 tons of ash daily. Historically, landfilling has been the preferred method to cope with solid waste management and disposal.

But the Westbrook mill is located only five miles from downtown Portland, the largest city in Maine (metropolitan pop.—200,000). As remaining landfill capacity is rapidly consumed, the availability of suitable future landfilling sites is becoming significantly diminished. The problem is made more complex by a rapidly growing public resistance to the location of landfills in their communities. At the same time, landfill operating costs are escalating rapidly.

Warren management at Westbrook is convinced that remaining landfill capacity must be managed as a very valuable commodity and utilized only when absolutely necessary. As a result, several studies were conducted by the company to test the feasibility of direct land application of sludge and biomass boiler ash for use as agricultural supplements and topsoil builders in the Westbrook area.

Demonstration Project

In June, 1982, four demonstration plots encompassing 12 acres were selected for research. The project involved direct land application of sludge and ash to various soils ranging from a very sandy soil to pure clay.

Sludge containing 40% solids was landspread on pure clay soil at a rate of approximately 150 tons per acre. Conventional farm manure spreading equipment was utilized to spread a 4-inch thick layer of sludge. Prior to landspreading, the areas were barren and would not even support the growth of weeds. Additionally, the areas suffered from severe erosion problems. The sludge was rotary tilled into the soil and the area was planted with a conventional grass seed mixture.

Within 8 weeks, a rich carpet of green grass, approximately 10 inches tall, covered the formerly barren landscape. A visual inspection of the grass roots indicated a very healthy root structure. In one cutting during the following summer, 750 bales of hay were harvested from a 9-acre portion of the demonstration plot.

Ash from the biomass boiler was spread over a portion of the demonstration plot and exhibited a favorable visual effect. This area was even more lush than the area treated with only sludge. The demonstration plots in the sand and gravel areas exhibited the same positive results, but were somewhat slower to respond.

The value of the sludge and ash as a soil amendment was further demonstrated by the growth of house plants in various mixtures of potting soil, sludge and ash as compared to plain potting soil purchased from a nursery. Several ornamental flower beds around the Westbrook mill were also treated with sludge and ash, then compared to beds without these materials. In all cases, the response of houseplants and outside ornamentals to sludge and ash addition resulted in larger and healthier appearing plants than those grown in untreated soils.

Sludge and Ash Characterization

S. D. Warren sludge contains two basis groups of materials:

Organics: Cellulose, microorganisms from

Table 1. Sludge Heavy Metals Analysis

<table>
<thead>
<tr>
<th></th>
<th>S. W. Warren</th>
<th>Maine Max. for</th>
<th>Common Value</th>
<th>Range for 100</th>
<th>Purchased</th>
<th>Purchased</th>
<th>Purchased</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sludge</td>
<td>Food Chain</td>
<td>Crops</td>
<td>Soils</td>
<td>Top Soil</td>
<td>Cow Manure</td>
<td>Poultry</td>
</tr>
<tr>
<td>Cadmium</td>
<td>2.0</td>
<td>10</td>
<td>0.06</td>
<td>0.01-7</td>
<td>1.3</td>
<td>1.0</td>
<td>1.9</td>
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<tr>
<td>Chromium</td>
<td>230</td>
<td>1000</td>
<td>100</td>
<td>5-3000</td>
<td>420</td>
<td>53</td>
<td>135</td>
</tr>
<tr>
<td>Copper</td>
<td>33</td>
<td>1000</td>
<td>20</td>
<td>2-1000</td>
<td>47</td>
<td>42</td>
<td>485</td>
</tr>
<tr>
<td>Lead</td>
<td>15</td>
<td>700</td>
<td>10</td>
<td>2-200</td>
<td>23</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Nickel</td>
<td>31</td>
<td>200</td>
<td>40</td>
<td>10-1000</td>
<td>170</td>
<td>200</td>
<td>29</td>
</tr>
<tr>
<td>Zinc</td>
<td>200</td>
<td>2000</td>
<td>50</td>
<td>10-500</td>
<td>42</td>
<td>48</td>
<td>425</td>
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<tr>
<td>Mercury</td>
<td>&lt;1.0</td>
<td>10</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

(1) Quarterly average since 1976 (2) Maine DEP Regulations
(3) "Fate and Effects of Trace Metals in Sewage Sludge When Applied to Agricultural Land" EPA - 670-2-74-005.
(4) Dana Perkins, Portland Water District

BioCycle

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Table 2. S. D. Warren Sludge Cumulative Heavy Metal Loadings:

<table>
<thead>
<tr>
<th>Metal</th>
<th>Maine Limit</th>
<th>Tons/Acre to Reach Limit</th>
<th>Years of Application @ 20 Tons/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>2.5-10</td>
<td>600-2400</td>
<td>30-120</td>
</tr>
<tr>
<td>Copper</td>
<td>125-500</td>
<td>1700-6800</td>
<td>90-360</td>
</tr>
<tr>
<td>Nickel</td>
<td>50-200</td>
<td>700-2800</td>
<td>36-152</td>
</tr>
<tr>
<td>Lead</td>
<td>500-2000</td>
<td>15,000-60,000</td>
<td>750-3000</td>
</tr>
<tr>
<td>Zinc</td>
<td>250-1000</td>
<td>600-2400</td>
<td>30-120</td>
</tr>
</tbody>
</table>

Annual Cadmium Limit = 120 tons per acre/year

Table 3. Economic Value of By-Products To Landowners

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Local Cost $/Lb.</th>
<th>Nutrient Content Sludge lb/ton</th>
<th>Nutrient Value Sludge $/ton</th>
<th>Nutrient Content Ash lb/ton</th>
<th>Nutrient Value Ash $/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>$0.33</td>
<td>21.4</td>
<td>$7.06</td>
<td>1.0</td>
<td>$0.33</td>
</tr>
<tr>
<td>Phosphorus (P₂O₅)</td>
<td>$0.26</td>
<td>5.3</td>
<td>$1.38</td>
<td>11.0</td>
<td>$2.85</td>
</tr>
<tr>
<td>Potassium (K₂O)</td>
<td>$0.18</td>
<td>1.6</td>
<td>$0.29</td>
<td>52.4</td>
<td>$9.43</td>
</tr>
<tr>
<td>Calcium (CaCO₃)</td>
<td>$0.02</td>
<td>397</td>
<td>$7.94</td>
<td>367</td>
<td>$7.35</td>
</tr>
<tr>
<td>Magnesium (MgCO₃)</td>
<td>$0.05</td>
<td>9.2</td>
<td>$0.46</td>
<td>49.3</td>
<td>$2.46</td>
</tr>
<tr>
<td>Organic Matter</td>
<td></td>
<td>920</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total *</td>
<td></td>
<td>$17.13</td>
<td></td>
<td></td>
<td>$22.43</td>
</tr>
</tbody>
</table>

Typical Application Rate
- Sludge - 20 tons/acre $342.60/acre
- Ash - 10 tons/acre $224.30/acre

Maine has established cumulative heavy metal loading limits based on soil cation exchange capacity. These are shown in Table 2 along with the total number of tons that would have to be applied per acre and the number of years of application at a typical rate of 20 tons per acre per year to reach these limits. This data shows that heavy metal buildup in soils should not be a problem with this sludge. The sludge contains moderate amounts of the primary nutrients (N, P, and K) as shown in Table 3 and almost 50% organic matter. It is, therefore, considered a soil conditioner which will reduce but not necessarily eliminate the need to add fertilizer.

Pulp and paper mill sludges are typically very low in heavy metals, and the S. D. Warren sludge is no exception. Table 1 compares the sludge heavy metals to applicable regulations and common materials such as topsoil, cow manure and poultry manure. All heavy metals are well within established guidelines and comparable to other agricultural supplements.

Inorganics: Lime, clay, calcium carbonate, titanium dioxide and trace elements.

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The average composition of S. D. Warren ash is shown in Table 4. It is being promoted as a replacement for limestone.

Table 4. Ash Composition

| Average Value  | Antimony < 2.1 MG/KG | Arsenic 55.0 MG/KG | Barium 910 MG/KG | Cadmium 4.4 MG/KG | Calcium 73,500 MG/KG | Chromium 27.0 MG/KG | Copper 120 MG/KG | Iron 17,000 MG/KG | Lead 59 MG/KG | Magnesium 7,100 MG/KG | Manganese 3,300 MG/KG | Mercury < 0.84 MG/KG | Nickel 47 MG/KG | Potassium 26,000 MG/KG | Selenium 11.0 MG/KG | Sodium 5,400 MG/KG | Vanadium 79.0 MG/KG | Zinc 370 MG/KG | Chloride 2,500 MG/KG | Sulfate 9,500 MG/KG | Aluminum 32,000 MG/KG | Carbon 15 MG/KG | Ammonia 0.06 MG/KG | Phosphorus 0.24 MG/KG | pH 11.7 MG/KG |

The data shows that the ash, like the sludge, is also well within acceptable heavy metal limits and similar loading limit comparisons could be made. The ash has an average pH of 11.7 and high concentrations of calcium, potassium and magnesium. Tests have shown that 4 pounds of ash have the same neutralizing effect as 1 pound of agricultural limestone. The potassium and magnesium supplied with the ash make it unnecessary for the landowner to purchase more of these nutrients.

Full Scale Program Development

During the fall and winter of 1983, many local landowners became aware of the positive results from the demonstration plots. The Portland area news media was invited to the mill to observe the 12-acre plot, and some very favorable articles appeared in local newspapers. Immediately, requests from area landowners to utilize the materials as a soil amendment began to pour into the mill. State regulations for the landspreading of municipal treatment plant sludge were already in existence and called for site specific field investigations and applications for each field to be landspread. A significant commitment in time would have to be made to adequately respond to these requests.

It was then that the mill was approached by Bill Ginn, who proposed establishing a separate company to market the materials on the mill's behalf. His newly incorporated company, Resource Conservation Services, would be dedicated to the environmentally safe recycling of industrial by-products.

After nine years with the Maine Audubon Society, the last five years as Executive Director, Bill was well versed in environmental issues. He was also well known throughout the state, having organized recycling centers at municipal landfills. As Chairman of the Maine Pesticide Control Board, Ginn had made valuable contacts with the agricultural community, as well as having participated in the give-and-take of the regulatory process.

The mill entered into an agreement with Ginn, who began promoting both products. The terms "BioAsh" and "Grow-Aid," respectively, are used to refer to ash and sludge. Promotional brochures were printed and mailed to area farmers. The nutrient content and economic value of sludge and ash were emphasized in...
these mailings. Every opportunity was taken to give slide presentations at agricultural and civic meetings as well as to man booths at various fairs. Personnel from the Maine Department of Environmental Protection cooperated in developing a regulatory program based on already existing regulations for municipal sludge landspreading. The program which evolved consists of six steps:

1. At the initial contact with the landowner, the nature and practical use of the materials is explained and specific needs are ascertained. Each field to be treated is located on soils and topographic maps, and arrangements for a site investigation are made.

2. A site investigation is conducted by a certified soil scientist, who summarizes the findings in a letter, which becomes part of a site specific application. Soil types are verified and the site’s topography is described. Loading rate recommendations are made based on intended land use and soil characteristics. Spreading setbacks are maintained for such features as wells, ponds, brooks, rock outcrops and private residences. Safe locations for any winter stockpiles are determined. These areas are ideally soils of low to medium permeability, which are generally flat, but somewhat elevated from the surrounding area and accessible to large trucks.

3. A signed agreement form and an abutters’ list is supplied by the landowner. RCS then assembles the actual application. Letters of notification are sent to abutters and town officials, and a legal notice is placed in an area newspaper.

4. The S. D. Warren Company reviews all applications prior to submittal. Copies are made and sent to the Maine Department of Environmental Protection, town officials and the landowner.

5. The Maine DEP sends copies to various review agencies for comment. In the meantime, the DEP technical staff studies each site for possible problems or areas of concern. All approvals are in writing and signed by the DEP Commissioner.

6. Arrangements are made by RCS for deliveries of sludge and ash.

A typical time frame for the above steps to be accomplished is three to four months. Experience over the past year has shown that critical to successful year-round delivery is a backlog of several approved sites, which can be allocated to match individual conditions. These can change very rapidly due to rain or snow. It is also very important to cultivate the goodwill of the farmer who must often plow-out a site several times, improve access for large trucks, and pull them out when they get stuck. Because of the large volume of materials they handle, and because they are generally well equipped, large farms are the best to deliver during the difficult winter and spring seasons. Summer and fall are the most popular seasons for small landowners and part-time farmers to take delivery.

**Summary**

Acceptance of sludge and ash as agricultural supplements by local landowners has exceeded all expectations. Utilization of these by-products results in very significant cost savings, not only to the S. D. Warren Company, but also to the landowner. At this point in time, more than 75 percent of all the sludge and ash generated is being beneficially utilized by local landowners. The S. D. Warren Company, Resource Conservation Services and local landowners have worked together to convert a former liability into an environmentally acceptable asset.

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