St. Lawrence TECHNOLOGIES

INDUSTRIAL WASTEWATER

DEMONSTRATION OF A RECLAMATION TECHNIQUE FOR THE PRIMARY AND SECONDARY SLUDGE GENERATED BY PULP AND PAPER MILLS

ABSTRACT

A demonstration project was launched by Domtar Papers Inc. (Windsor, Quebec), Alliance Forest Products Inc. (Donnacona, Quebec) and the École Polytechnique of Montréal, in conjunction with Ferti-Val Inc., to study the behaviour of sludge resulting from the primary and secondary treatment of pulp and paper mill wastewater, and document the impact of its application on farmland and forestland.

Primary sludge and combined primary and secondary sludge from the Donnacona mill were employed as an agricultural soil amendment. The combined sludge from Domtar's Windsor mill was used on forestland and in the restoration of degraded sites.

The various components of these projects were monitored over a period of two years.

HIGHLIGHTS

- **Technology**
  - Value-adding paper mill sludge management technique
  - Agricultural and silvicultural soil amendment
  - Restoration of degraded soil.
- **Environment**
  - Large-scale reclamation of primary and secondary sludge generated by the treatment of pulp and paper mill wastewater
  - Rehabilitation of degraded farmland
  - Input of organic matter and fertilizer to farmland and forestland.
- **Cost**
  - Cost-effective management technique for the primary and secondary sludge generated by pulp and paper mills
  - Development of a market for pulp and paper mill sludge.

Saint-Laurent Vision 2000

Environment Canada Protection Québec Region

Environnement Canada Protection Région du Québec

FERTIVAL INC. Valorisation de matières résiduelles

Canada Economic Development

Développement économique Canada

PROJECT OBJECTIVES

1. Reclaim pulp and paper mill sludge as a soil amendment in the agriculture and forestry sectors, while respecting the environment.
2. Develop applicable codes of good practice.
3. Validate the environmental and economic interest in these practices.
4. Generate interest in these practices within different sectors.
5. Demonstrate a technique that is feasible and cost-effective all year-round.
6. Study sludge behaviour and document the impact of its use in agriculture, silviculture and degraded soil restoration.

BACKGROUND

The pulp and paper industry generates vast quantities of residuals, particularly residue resulting from the treatment of paper mill process waters. Wastewater treatment usually consists of primary treatment (settling) followed by secondary (biological) treatment. The Donnacona plant uses a mechanical fabrication process, while Domtar's Windsor plant employs the kraft process.

Pulp and paper sludge generally ends up in landfill sites, where it can constitute a major portion of the waste volumes received.

The high cost of sludge management is increasingly leading pulp and paper mills to consider reclamation as a solution. The combined sludge of primary and secondary treatment contains nitrogen and phosphorus because these two elements are necessary to biological treatment. This management approach will become more widespread over the coming years if cost-effective techniques make reclamation possible on a year-round basis.

TECHNOLOGY

The project consisted of reclaiming the residual sludge from process water treatment as a soil amendment on farm and forest land and as a mulch. For agricultural use, the rate of application of primary sludge from the Donnacona plant was on the order of 20 dry metric tons per hectare (dmt/ha).

An application rate of some 225 dmt/ha was adopted for purposes of farmland restoration, to supply the soil with a strong mass of organic matter and obtain 5% organic matter in the soil surface.

Two sites were chosen to study the restoration of degraded soil. These sites were divided into three plots of land, two test plots and one control site. Two different rates of application (225 and 300 dmt/ha) of combined sludge from the Windsor plant were used on each of these sites. One site was sown with two different ground cover mixtures, while the other site was sown with grain.

In the case of the silvicultural soil conditioner, the test site was divided into six plots of land (five test areas and one control site). Two rates of application were chosen, 135 and 180 dmt/ha of combined sludge, and spreading was performed with a conventional manure spreader. Bulldozers were used for application on farmland and degraded sites, while harrows served to incorporate the sludge into the soil.

Testing of the sludge as a mulch took place on three blocks of Christmas trees of varying sizes. Each block was composed of one row of trees with mulch and one control row.

RESULTS

Restoration of degraded soil and silvicultural soil conditioner

The combined sludge from the Windsor plant that was used in the tests performed in spring 1996 had good nitrogen concentrations and carbon:nitrogen ratios. Moreover, with the exception of cadmium (Cd), tests showed the sludge respected the criteria relative to heavy metal concentrations in municipal wastewater treatment sludge reclaimed for agricultural use.

The sludge application had a significant impact on the concentration of major and minor elements, especially phosphorus (P) and potassium (K). The level of dioxins and furans at one of the sites was higher at the test areas than at the control areas, but remained well below the levels recommended by the Canadian Council of Ministers of the Environment (CCME) and the U.S. Environmental Protection Agency.

Moisture levels in the test soil were clearly superior to levels at the control sites. Amended soil also showed a significant reduction in conductivity and its ion-exchange capacity was strongly increased.

A major impact was noted in the level of nitrate in water in the vadose zone. Concentrations of sodium, Cd, iron and manganese in surface water and ditch water exceeded some provincial Environment Ministry (MEF) criteria relative to water.

Wholly satisfactory results were obtained for the seeded ground cover and grain.

Agricultural restoration

The combined sludge from the Donnacona mill applied in 1996 easily respected the criteria relative to trace elements in municipal wastewater sludge reclaimed for use in agriculture. The primary sludge applied on the site at the onset of the test period respected these same criteria.

Plant tissues were compared at the sufficiency ranges proposed by the Conseil des Productions Végétales du Québec (CPVQ). It was found that oatmeal sown in soil amended with primary and combined sludge from the Donnacona mill respected the sufficiency ranges of the CPVQ for nitrogen (N), manganese (Mg), calcium (Ca) and potassium (K), but slightly exceeded the sufficiency range in phosphorus. The oatmeal cover obtained after the application of combined sludge was deemed excellent.

Only one of six lysimeters on site measured an NO_3 concentration higher than the criterion for potable water, and this during only one of several samplings.

Agricultural amendment

The results from the first year of testing pointed to the significant increase in grain yield in 1995, in the season following the application of 20 dmt/ha of primary sludge from the Donnacona mill. Potato growing sites yielded significantly more plants during the first season after application. The yield reductions and improvements seen at these same sites in the second season following application were not significant.

The sludge application had no significant impact on the values obtained during a chemical characterization of soil at the end of the season. The sludge had no major effect on concentrations of N, P, Mg, Ca and K in plant tissue.

Silvicultural mulch

Mulch from combined sludge had an important impact on the level of minerals and trace elements in the underlying soil. It also neutralized soil pH.

The Christmas trees did not benefit from the nutrients leached by the mulch during the first season. It should be pointed out, however, that the mulch was put down in July 1996, late in the season for trees.

On the other hand, the mulch leachate did have a major impact on the levels of P, Ca and sulphur in the underlying soil, and also on its pH and cation exchange capacity. An analysis of pine needles showed that trees subject to the mulch benefitted from the nitrogen leached by the mulch during the second growing season.

POTENTIAL AND LIMITATIONS

Potential

Pulp and paper sludge is rich in organic matter and, in the case of combined sludge, nitrogen and phosphorus as well. As such, it constitutes an excellent amendment that can improve the physical and chemical properties of soil.

Paper mills generate vast quantities of this type of residual. Many plants are located in agricultural or forestry regions. The use in agriculture of combined sludge from pulp and paper mills allows farmers to reduce their fertilizer costs.

Paper mill sludge appears to have a promising future as an efficient and cost-effective means to replenish depleted farmlands, and to rehabilitate degraded soil.

Limitations

The proximity of paper mills generating such sludge remains the most important variable in establishing the cost of sludge reclamation.

An other limiting factor is the climate, which can make access to reclamation sites difficult. Managing sludge transport in such a way to ensure access to sites twelve months per year demands special attention. Various reclamation methods can be adopted at different periods of the year to lessen the climatic variable.

The use of combined sludge to rehabilitate degraded soil should be studied closely to limit the risk of nitrogen loss. To this end, a mixture combining other sludge containing higher C:N ratios should be considered.

INFORMATION

This technology data sheet is based on the results of a technology development project conducted by Ferti-Val Inc. in collaboration with the École Polytechnique of Montréal, Alliance Forest Products Inc. and Domtar Inc. The project was made possible through the technical and financial assistance of Environment Canada and the Canada Economic Development Agency for Quebec.

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St. Lawrence TECHNOLOGIES

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