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# Project Summary

# Field Investigation and Evaluation of Land Treating Tannery Sludges

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**Land treatment of wastewater sludges from tannery processes has been investigated during a five-year field plot study. The experimental design included eight field test plots receiving selected applications of three types of tannery sludges over a three-year period.**

**1. Two 0.2 hectare plots received beamhouse (hair-burn) sludge at two different sludge application rates (110 mt/ha and 220 mt/ha sludge). The 110 mt/ha sludge loading rate was selected to provide the assumed optimum loading of proteinaceous nitrogen.**

**2. Two total chromium loading rates (2240 kg/ha and 4480 kg/ha total chromium) were applied to two 0.2 hectare plots that received trivalent chromium-containing (chrome) sludge and to two 0.2 hectare plots that received mixed tannery (hair-burn and chrome) sludge.**

**3. A single 0.1 hectare plot received a triple total chromium loading (6720 kg/ha) of the mixed sludge, and a single 0.2 hectare control plot received no sludge addition.**

**The five-year study included analyses of sludge, soil core, plant-tissue, and soil pore and runoff water samples to evaluate the feasibility of land treatment of tannery sludges. The data generated indicated that land treatment is potentially an environmentally acceptable technology for management of wastewater sludges from trivalent chromium tanneries; however, waste application rates must be carefully controlled.**

**The applied trivalent chromium appeared to remain primarily in the topsoil without any detectable oxidation to hexavalent chromium. Transport of trace quantities of chromium in soil runoff water appeared to be associated with movement of soil particles. Application levels of tannery sludges containing hair-burn wastes will be limited by the mineralization rate of the proteinaceous nitrogen and the crop inorganic nitrogen requirements. Elevated salt concentrations of the hair-burn sludges also will require specific consideration.**

***This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

The main objective of this project was to characterize the major technical and environmental aspects associated with the utilization of land treatment technology for the disposal of tannery wastewater sludges. Tanneries in the United States primarily utilize trivalent chromium coordination compounds in the conversion of skin and hide substance into leather. Total current annual generation of chromium-containing wastewater sludges is estimated to be approximately 25,000 metric tons (dry basis).

Tannery solid wastes containing chromium have for many years been applied to agricultural soils since they

contain proteinaceous, slow-release nitrogen. Wickliff, et al. (*Water, Air, Soil Pollution* 17:61-74, 1982) published the results of greenhouse investigations on the application of trivalent chromium-containing tannery wastewater sludges to two soils. Crops utilized were tall fescue, hybrid sweet corn and bush beans. These workers concluded that tannery sludge may be applied to soils as a fertilizer amendment without adversely affecting soil chemical properties. Furthermore, the amount and frequency of sludge application should be determined by: total and available nitrogen; total salt content; total and available chromium; and soil organic matter.

However, there has not been a definitive field study which would provide data on the design, operation and closure of tannery land treatment sites. A five-year field site investigation utilizing tannery wastewater sludges was designed to provide the necessary data. The project had three specific objectives:

1. To assess potential adverse impacts of land treatment on various environmental sectors.
2. To estimate the accumulation, degradation and migration of soil contaminants.
3. To provide data for the optimization of site design, operation and closure.

## Procedure

A suitable field site was located within the Scott Creek Valley in western Santa Cruz County, California. The actual study site was located on a small, almost level marine terrace remnant lying about 115 m above the floor of the valley. The soils of the marine terraces are about 1.5 m deep with a thick, well developed B horizon; they have low permeability.

Test plots, 0.2 hectare in area, were constructed at the site with fencing, wells, berms, roadways and drainage systems. PVC pipes connected the collection boxes at the base of each test plot to concrete sedimentation vessels equipped with V-notch weirs for discharge measurement.

Two types of tannery sludges were applied to the field site test plots at four different time intervals from June 1981 until October 1983. The proper amount of each sludge was spread on the appropriate experimental plot and incorporated into the topsoil to a depth of approximately 15 cm by tilling.

Analyses of sludge, soil core, grass, and soil pore and runoff water samples from each plot were conducted throughout the project period. Parameters receiving special attention were: chromium, total Kjeldahl nitrogen, salt, and nitrate-nitrogen.

## Results

Although the project data indicated that the applied trivalent chromium remained predominantly in the plot topsoil, there was some apparent movement of trace level amounts of chromium in runoff water which appeared to be associated with movement of soil particles. Hexavalent chromium was never detected in any of the sludge, soil core, or soil pore and runoff water samples. Data from Ribgut grass tissue analyses indicated no increase in chromium at the 2240 kg/ha sludge loading level. At the mixed sludge triple loading (6720 kg/ha) level, enhancement in plant tissue chromium was suggested by the data; however, the results were considered inconclusive due to the limited number of samples analyzed.

Trivalent chromium concentrations found in the soil below the plow zone before the first and following the last sludge applications were:

| | Chromium - mg/kg | |
|---|---|---|
| Soil Depth | Background | May 1984 |
| 30 - 60 cm | 29 - 49 | 11 - 73 |
| 60 - 90 cm | 24 - 49 | 33 - 102 |

However, the chromium material balance in the top 15 centimeters of soil was not complete; as shown by the following:

| | Chromium - mg/kg | | |
|---|---|---|---|
| | Estimated | Found | |
| Plot Loading | Loading | Average | Range |
| Cr Sludge - 1 | 1100 | 640 | 590-700 |
| Mixed Sludge - 1 | 1284 | 1390 | 1240-1540 |
| Cr Sludge - 2 | 2130 | 1620 | 1380-1800 |
| Mixed Sludge - 2 | 2310 | 1190 | 1080-1300 |
| Triple Loading | 3530 | 2320 | 2010-2500 |

Sampling and analytical variability for both sludges and soils contribute to this incomplete recovery. The data obtained during the five-year study indicate a significant increase in the chromium level in the topsoil of the five treated plots.

Mineralization rates for the proteinaceous nitrogen in tannery sludges currently are not available in the literature and were not determined during this study. Soil water samples in March 1985 from the triple loaded plot had a median nitrate-nitrogen value of 42 mg/l. It is assumed that leaching problems associated with land application of tannery sludges would be eliminated if sludge application rates were limited to the optimum loading level which would provide for the nitrate-nitrogen demands of the plant growth. Furthermore, the project data indicated that the salt content of the hair-burn beamhouse sludges should be considered in loading decisions.

## Conclusions

Land treatment provides a potentially environmentally acceptable technology for management of tannery wastewater sludges from trivalent chromium tannery processes if sludge application rates are carefully controlled. The utilization of land treatment technology for management of these sludges must include the following considerations:

1. Chromium tannery wastewater sludges are characterized by a significant organic Kjeldahl nitrogen content (2 to 4.5 percent) which primarily results from the proteinaceous materials in the animal hides which are converted into leather in the tannery. Therefore, land treatment of these sludges should be guided by the mineralization rates of the proteinaceous nitrogen and by the inorganic nitrogen demands of the plants grown on the treatment site.

2. Chromium tannery wastewater sludges are characterized by significant salt contents (4 percent sodium on a dry basis from unhairing wastewater sludges and 2.7 percent from the chromium-containing wastewater sludges). Land application of these sludges may result in poor grass germination and weed intrusion; therefore, careful attention should be paid to these possible salt effects, especially when the unhairing wastewater sludges are to be applied.

3. Trivalent chromium in tannery wastewater sludges remains primarily in the topsoil after land treatment, however, there may be some limited transport of chromium in soil pore and runoff water. The transport in runoff water is assumed to be associated with soil particle movement.

4. Hexavalent chromium was not detected during this five-year field study; therefore, it is assumed that applied travalent chromium will not oxidize to the hexavalent form in this soil environment.

## Recommendations

This five-year field plot study was the first in-depth field investigation of the land treatment of chromium tannery wastewater sludges. The study results disclosed certain areas in which the project efforts could have been improved by additional prior information. The following recommendations are made for further study which would facilitate future utilization of land treatment technology for management of tannery wastewater sludges:

1. Improved sludge and soil sampling protocols which recognize the high analytical heterogeneity of the substrates should be developed.

2. Inter-laboratory analyses of sludge and soil samples by EPA Method 3050, SW846, Test Methods for Evaluating Solid Wastes, 1982, showed satisfactory agreement for total chromium and calcium. Future work involving tannery waste should restrict sludge and soil analysis to EPA Method 3050, SW846.

3. Improved agricultural practices to attain more uniform sludge incorporation into the topsoil and to secure grass or other crop growth are needed. The effect of the high sodium content of the lair-burn sludge on the weed intrusion nto the test plots also requires further consideration.

4. Proteinaceous nitrogen mineralzation rates for wastewater sludges from chromium leather tanneries were not found in the literature. Combined laboratory and field studies directed toward these mineralization rate determinations are recommended.

5. Chromium transfer from the topsoil appeared to be limited; the chromium which was transported in soil water runoff appeared to be associated primarily with movement of soil particles. Further field studies are recommended to determine the ultimate form in the topsoil of the added chromium. Dehydration of trivalent chromic hydroxide forms very insoluble trivalent chromic oxide. Soil physical chemical studies to provide data on the physical form of the chromium in the topsoil would be desirable to establish the upper permissible limit for trivalent chromium addition to topsoils.