

TECHNICAL NOTES:

FLAT-PLATE FREEZE SAMPLER FOR SLUDGE CHARACTERIZATION IN A FEEDLOT RUNOFF STORAGE POND

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ABSTRACT. *Collecting undisturbed sludge and sediment samples is difficult in saturated or near-saturated, wetland or pond environments. A sampling device was developed for sampling sludge in a beef cattle feedlot runoff storage pond. The device enabled stratified samples to be frozen to one side of its exterior surface. Dry ice and isopropyl alcohol were used as the freezing media in the sampler. The utility of the sampler was demonstrated with photographs and data delineating sediment layers by color and chemical concentrations. The sampler proved to be effective for obtaining an undisturbed, visual representation of soft sediments and sludges, and should have many uses in sediment and wetland research.*

Keywords. *Sampler, Sludge, Sediment, Storage pond, Lagoon, Wetland.*

The study of physical and chemical characteristics of stratified sediments has been problematic in submerged depositional environments because of difficulty in obtaining undisturbed samples. Currently, methods such as cylindrical core samplers, bomb samplers and combination liquid waste samplers are used to sample soft sludges and sediments. Modifications to these samplers have been made to adapt them for use in saturated sediments, including using vacuum (Corps of Engineers, 1950), a shutter apparatus (Sharma and DeDatta, 1985), or rubber stoppers (Nordstedt and Baldwin, 1975; Hamilton and Rosser, 1994) on the end of a cylinder. These samplers have proven satisfactory for obtaining disturbed grab samples. However, they are inadequate for characterizing thin-layered, stratified sediments, and do not work well with loose, saturated sediments.

Freeze sampling techniques have been used successfully to sample gravel bed sediments from the bottom of streams and rivers (Carling and Reader, 1981; Petts et al., 1989; Thoms, 1992). In these cases, frozen sediment samples were collected by injecting carbon dioxide into a hollow rod driven into the gravel bed. Durnford et al. (1991) used a modified core sampler to freeze floating fuel products in saturated soils.

The purpose of this note is to illustrate the utility of a simple freeze-sampling device for sampling thin-layered sediments in a saturated or near-saturated environment.

SAMPLER DESIGN AND OPERATION

A schematic of the sampler is shown in figure 1. The design involved a hollow rectangular device which, when filled with dry ice, froze sediment to one side. The body of the sampler was constructed of 2.4-mm thick stainless steel, and had dimensions of 1 m in length, 0.15 m in width, and 0.038 m in depth. The tip of the sampler was angled away from the sampling face at 30° (measured from the face of the sampler) to minimize sample disturbance during insertion into the sludge. The interior of the sampler was divided into two zones. The larger zone, 2.1 cm in thickness, held the dry ice. The smaller zone, 1.0 cm in thickness, was filled with a foamed-in polystyrene insulation to keep sediment from freezing to the back of the sampler. The sampler was fabricated at the University of Nebraska Biological Systems Engineering machine shop. Welding was done in short segments then allowed to cool to prevent warping of the stainless steel. Total fabrication cost (labor and materials) was about \$300.

Use of the sampler consisted of five steps:

1. Small blocks of dry ice about 1.8 cm thick were placed into the sampler and the cap was attached.
2. The sampler was pushed into the sediment by hand with the push pipe. The sampler was then filled with isopropyl alcohol using a funnel and plastic tubing (fig. 1) to provide more uniform heat transfer from the dry ice to the sampler face.
3. After 15 min (at a sample thickness of about 2 cm), the sampler was pulled from the sediment using the pull ropes (fig. 1).
4. Unfrozen sludge was scraped from the sample and remaining unfrozen sludge was removed with a tap water spray.
5. Individual layers were subdivided by color, then bagged and frozen for future analyses.

The sampler was used in the bottom of a runoff holding pond at a beef cattle feedlot at the U.S. Meat Animal

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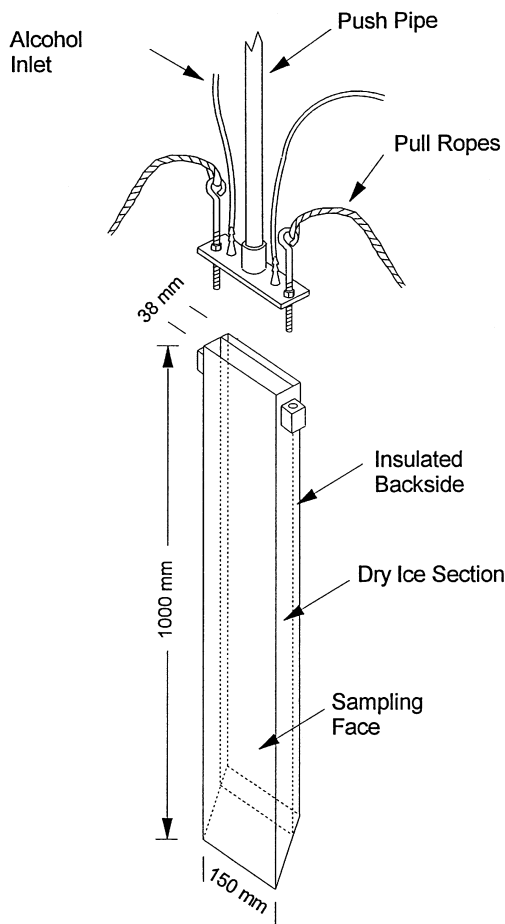


Figure 1—Schematic of flat-plate freeze sampler. The sample was frozen to the outside of the sampler.

Research Center near Clay Center, Nebraska. Sediments in the pond had accumulated since 1974. Sediment depth varied from 1.0 to 1.5 m. Wastewater depth in the pond at the time of sampling was about 0.1 m. The sampling sites were accessed by walking on wood pallets to prevent sinking into the soft sludge.

Sediment color was determined using Munsell soil color charts and a Minolta CR-300 electronic tristimulus color analyzer. Photoscanned images of freeze samples were prepared using Aldus Photostyler software. Color slides were scanned with a Nikon Coolsan film scanner and 16 bit Nikon GPIB scanner board mounted in an IBM compatible personal computer. The photoscanned images were converted to grayscale for this article.

Sediment samples were analyzed for Total Kjeldahl Nitrogen (TKN) using the Kjeldahl method with a CuSO_4 catalyst and H_2SO_4 acid digest (APHA, 1992), and for Bray Phosphorus (NCR-13, 1988).

DISCUSSION

Figure 2 illustrates distinct layers in a sample taken near the center of the pond. This layering was used to subdivide the sample for chemical and physical analysis. Also shown in figure 2 are the resultant TKN and P concentrations. Isolating the sediment layers by color and thickness resulted in TKN concentrations ranging from 2200 to

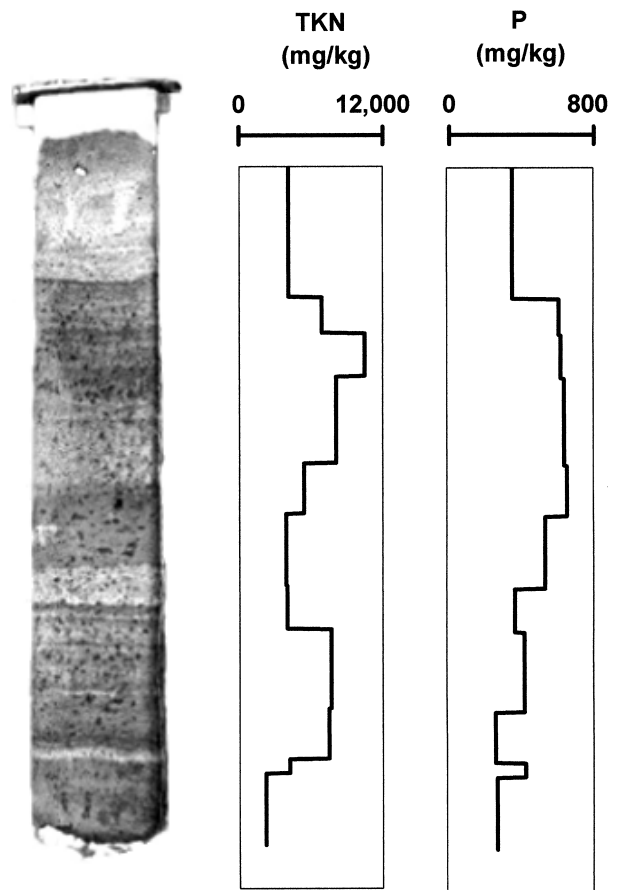


Figure 2—Charts showing variability in TKN and P concentrations with depth for sample collected near center of pond.

10 500 mg/kg and P concentrations of 280 to 660 mg/kg. Such data is useful for projects where sludge from storage ponds are land-applied and nutrient levels or other constituents must be accurately known.

Figure 3 shows profiles provided by the sampler for different locations in the pond. The lines drawn between samples A, B, and C connect layers of similar color and thickness. Because these layers were also located at similar depths beneath the sludge surface, it is thought that they were deposited during the same time period. Sample D, taken near the inlet, consisted of coarser, darker sediments with less distinct layering than samples A, B, and C taken on a transect across the center of the pond. The freeze sampler enabled the pond to be characterized by layer for its chemical and physical properties as a function of accumulation of sediment over its 22-year history. The data and information obtained with the freeze sampler was beneficial to the understanding of solute movement in the sludge and soil beneath the sludge (Parker, 1996).

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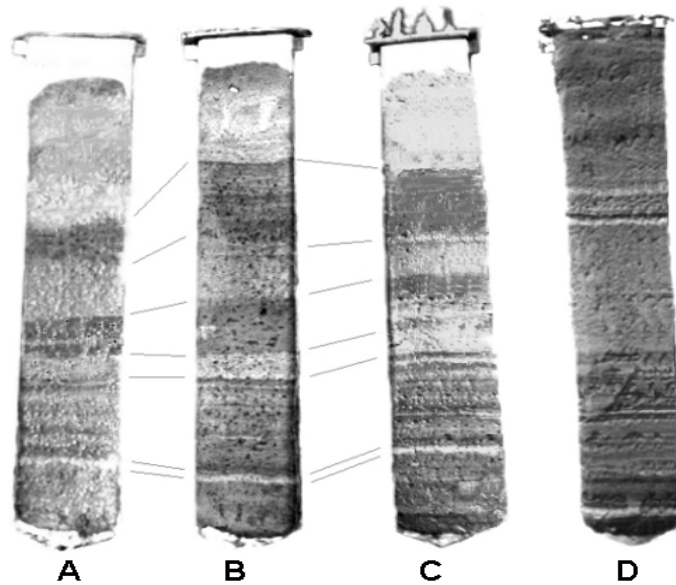


Figure 3—Images of sediment samples collected with the freeze sampler. Samples A-C were taken in a transect across the center of the pond, while Sample D was collected near the inlet to the pond.

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