



Research Brief #1

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An Investigation of Chemical Transport from Contaminated Sediment through Porous Containment Structures

Progress

During the first year of this three-year project which started in 1992, the researchers at Louisiana State University and the U.S. Army Corps of Engineers Waterways Experiment Station have concentrated on: developing the analytical capability to measure chemicals and dissolved organic carbon (DOC); designing, building, and using a column for sediment leaching experiments; and, developing a numerical model to simulate the significance of contaminant material seepage due to changes in water levels.

Analytical Capabilities

Since the project's start, the researchers have significantly improved their analytical capabilities. They are using a high-performance liquid chromatograph (HPLC) with an automatic sample-injector to characterize what chemicals and how much are in the sediment. They have also

added a total-organic-carbon analyzer with an automatic sampler. This analyzer allows the researchers to constantly measure the changes in carbon levels in the pore water, which indicates the flow of contaminants through the sediment.

Experimental Column

The researchers designed and constructed an experimental column based on those used at the U.S. Army Corps of Engineers Waterways Experiment Station. The column's design allows the researchers to collect large volumes of leachate water while maintaining low pore-water flow rates. Thus they can achieve a rapid experimental turnaround and realistic flow rates. They use the column to collect fundamental sorption, desorption, and leaching-rate data on sediment and CDF dike materials.

Since October, researchers have used a freshwater sediment from Bayou Manchac, Louisiana, to conduct

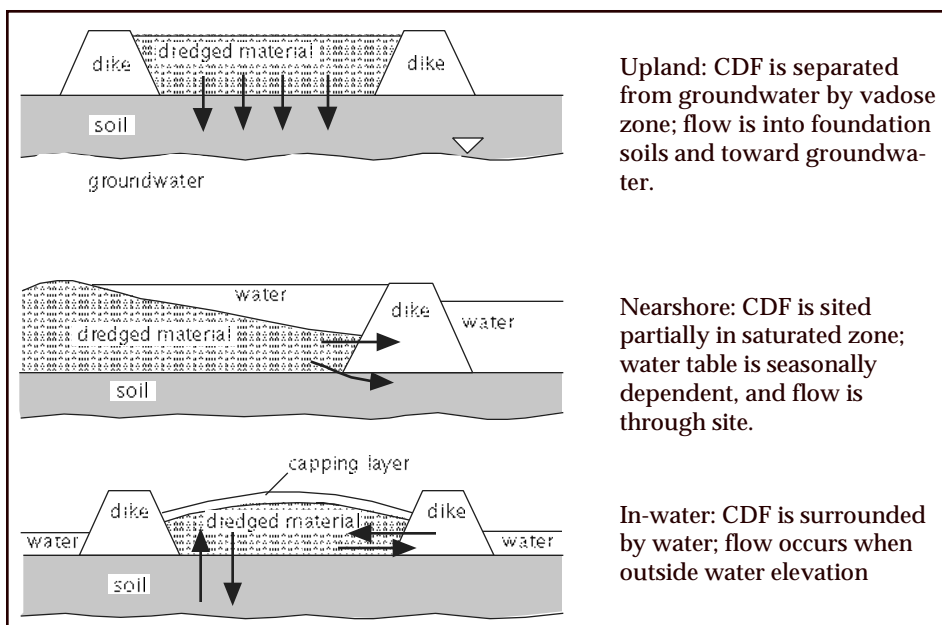
Summary of the project

Dredged sediments are sometimes placed in diked-in disposal areas, called Confined Disposal Facilities (CDF). Some of these are designed to be porous, allowing water to leak out but holding contaminants in. Some are considered to be impermeable, but even these are never 100 percent leak-proof. Although contaminants that aren't very water soluble tend to cling to sediments, tidal influences, waves, or the action of pumping water in and out can create the potential for some contaminants to leak out.

How big a problem is this?

It's not clear that leakage is an important problem. The main objective of this research is to provide a better basis for estimating contaminant release rates from in-water and near-shore CDFs used for the disposal of contaminated dredged materials. The focus is on contaminant release during inactive periods when dredged material is not being added to the CDF.

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Upland: CDF is separated from groundwater by vadose zone; flow is into foundation soils and toward groundwater.

Nearshore: CDF is sited partially in saturated zone; water table is seasonally dependent, and flow is through site.

In-water: CDF is surrounded by water; flow occurs when outside water elevation

The three transport processes being considered are

- transient in-dike seepage caused by water-level changes;
- seepage and dispersion associated with tidal or wave action;
- attenuation by the dike walls as a result of sorption and filtration.

These processes are being investigated experimentally using model sediment and dike materials, as well as representative CDF construction and fill material.

experiments on flow uniformity and organic-carbon leaching. The researchers measure the DOC in the effluent in order to estimate the chemical mobility of colloidal organic carbon. Although a permeable CDF dike wall would be expected to act as a good particulate filter, colloidal organic carbon could carry significant quantities of non-water-soluble organics through the dike walls.

During an initial set of experiments, the researchers monitored DOC movement while passing water over a sediment layer in small cells. They used the amount of DOC measured in the effluent water to define the flux from the sediment and developed a model that described this process. They also looked at the effect of sand layers above the sediment, reasoning that the sand acts like a particulate layer that collects on the dike walls, which might reduce the flux. The experiments were conducted so that sediment transport processes controlled the flow rate. The results show a clear and consistent picture of DOC migrating in the sediment.

In order to define the chemical migration associated with the colloidal carbon, the researchers have explored the use of solid-phase extraction cartridges to speciate colloiddally bound and non-colloiddally bound (dissolved) chemicals. Using pyrene as a model hydrophobic organic compound, researchers attempted to determine the amount of pyrene in the water phase that had dissolved and that had sorbed to DOC. The DOC in sediment pore water includes a broad range of chemical species, however, and no treatment method has thus far been completely successful at separating dissolved and DOC-bound contaminants.

Numerical Model

The remainder of the first-year efforts focused on developing a numerical model of in-dike seepage

caused by water-level changes and chemical transport. One objective was to develop a model that can identify the potential significance of contaminants seeping through CDF dike walls.

Preliminary modeling using commercial software suggests that, under the simulation conditions, much less contaminant may be lost due to seepage from a CDF than due to evaporation. To accurately evaluate the seepage-related losses and the conditions under which such losses may be significant, the researchers developed a two-dimensional finite-element model that evaluates the flow in a CDF dike wall. They also developed a finite-element convection-dispersion transport model that uses the anticipated flow to predict chemical movement. Using this model, they examined the contaminant seepage associated with water-level changes between the inside and outside of a CDF. As a benchmark to test the model, they acquired data from a permeable-wall CDF in Chicago. The researchers are now evaluating the model's ability to predict the behavior observed in the Chicago CDF.

Proposed Work

The second year's focus is on completing these studies and defining a subsequent direction. The first step is to complete the work using the numerical model. If the completed model confirms that evaporation is a more significant cause of contaminant loss from CDFs than seepage, the project may be redirected toward studying evaporation. The researchers will conduct experiments to simulate various conditions based on relative water level, dike permeability, and other data that have been collected from CDFs in the Southeast and Great Lakes areas. In addition, they will continue doing experiments using columns to evaluate how contaminants move in actual dike materials and to determine appropriate limitations for numerical modeling.



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