DREDGED MATERIAL RESEARCH PROGRAM

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EVALUATION OF THE ELUTRIATE TEST AS A METHOD OF PREDICTING CONTAMINANT RELEASE DURING OPEN-WATER DISPOSAL OF DREDGED SEDIMENTS AND ENVIRONMENTAL IMPACT OF OPEN-WATER DREDGED MATERIAL DISPOSAL

VOL. II: DATA REPORT

by

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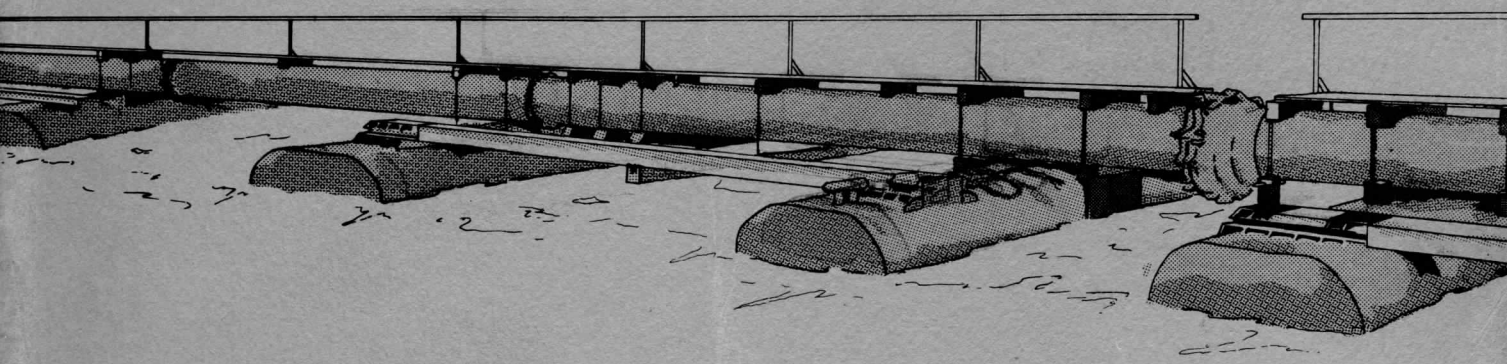

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The U. S. Army Corps of Engineers and the U. S. Environmental Protection Agency developed the elutriate test for the purpose of predicting the release of chemical contaminants from dredged sediments upon open-water disposal. This study was conducted to evaluate the factors influencing the results of the elutriate test and the reliability of this test in predicting the release of contaminants during actual dredged material disposal operations. Sediment

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20. ABSTRACT (Continued).

samples were taken from waterways located at or near Duwamish River-Elliott Bay-Puget Sound, Washington; San Francisco Bay, Mare Island, Rodeo Flats, and Oakland Harbor, California; Los Angeles Harbor, California; Galveston Bay Entrance Channel, Galveston Channel, Texas City Channel, Houston Ship Channel, and Port Lavaca, Texas; Mobile Bay, Alabama; Apalachicola, Florida; Wilmington, North Carolina; James River, Virginia; Perth Amboy, New Jersey; Bay Ridge, New York; Newport, Rhode Island; Norwalk and Stamford Harbors, Connecticut; Foundry Cove, New York; Menominee River, Michigan: Upper Mississippi River near St. Paul, Minnesota; and the U. S. Army Engineer Waterways Experiment Station Lake, Vicksburg, Mississippi.

These samples were subjected to the standard and modified elutriate test in order to examine the influence of various factors on the results of the test. In addition, field studies were conducted at Elliott Bay-Puget Sound, Washington; Galveston Bay Entrance Channel Disposal Area, Texas; Mobile Bay, Alabama; Apalachicola, Florida; James River, Virginia; New York Bight; and the Upper Mississippi River near St. Paul, Minnesota, in which comparisons were made of the results of the standard and modified elutriate tests and water column concentrations during disposal operations. These studies showed that the standard elutriate test, involving 30-minute mixing and one-hour settling, is a reliable test for predicting the potential release of contaminants associated with hydraulically dredged sediments that are dumped in open water. The standard tests should be conducted with compressed air. The air bubbles, in addition to mixing the solution, also keep the system oxic, thus simulating the conditions of importance for water column organisms at the dredged material disposal site.

It is recommended that the EPA and the Corps of Engineers continue to utilize the elutriate test as a test designed to evaluate the potential release of contaminants at a dredged material disposal site involving open-water dumping or discharge of sediments.

This study has also shown that the open-water discharge of dredged sediments, including those which are highly contaminated with various types of chemical toxicants, would rarely cause an adverse effect on water quality and aquatic organisms in the disposal site water column. The rapid dilution and dispersion and intermittent nature of open-water dredged material disposal operations result in rapid reduction of the concentrations of any contaminants released to below those concentrations which are critical for aquatic life.

SUMMARY

A study has been conducted to evaluate the reliability of the elutriate test as a means of predicting the release of contaminants during open-water disposal of dredged sediment. In addition, studies have been conducted to evaluate the influence of various test conditions on the test results. Sediments and water have been collected from Duwamish River and Elliott Bay-Puget Sound, Washington; San Francisco, Mare Island, Rodeo Flats, Oakland Harbor, and Los Angeles Harbor, California; Galveston Bay Entrance Channel, Galveston Channel, Texas City Channel, Houston Ship Channel, and Port Lavaca, Texas; Mobile Bay, Alabama; Apalachicola, Florida; Wilmington, North Carolina; James River, Virginia; Perth Amboy, New Jersey; Bay Ridge, New York; Newport, Rhode Island; Norwalk and Stamford Harbors, Connecticut; Foundry Cove, New York; Menominee River, Michigan; Upper Mississippi River near St, Paul, Minnesota; and the U. S. Army Engineer Waterways Experiment Station Lake, Vicksburg, Mississippi. These sediments have been subjected to the standard elutriate test and modifications thereof. Bulk sediment analysis and analyses of the elutriates have been made for approximately 30 contaminants, including selected heavy metals, selected chlorinated hydrocarbon pesticides and PCBs, various forms of nitrogen and phosphorus compounds, and other selected parameters which could be of significance in open-water disposal of dredged sediment. Factors such as length of aeration period, length of time of sediment storage prior to elutriation, sediment to water ratio used, type of water used in the elutriate test, etc., have been examined to determine their influence on the release of contaminants during the test. The results of these studies have been compared to previously reported similar studies on sediments from Ashtabula Harbor-Lake Erie,

Bridgeport, Connecticut; Corpus Christi, Houston Ship Channel, Port Aransas, Trinity River, and Houston Ship Channel, Texas; Duluth, Minnesota, and Lake Superior; and Mobile Bay, Alabama.

Comprehensive field studies have been conducted in conjunction with elutriate test studies at Elliott Bay-Puget Sound, Washington; Galveston Bay Entrance Channel Disposal Site, Texas; Mobile Bay, Alabama; Apalachicola, Florida; James River, Virginia; New York Bight; and the Upper Mississippi near St. Paul, Minnesota, in order to compare the release of contaminants during open-water disposal of mechanically and hydraulically dredged sediments to the release found in the elutriate tests of the same sediments.

The results of these studies show that the elutriate test must be conducted under oxic conditions to properly simulate open-water disposal of dredged sediment under conditions where there is concern about the impact of contaminants on aquatic organisms present in the water column at the disposal site. It is recommended that the 30-minute mixing period specified in the standard elutriate test procedure be specified as a 30-minute aeration period in which air is vigorously bubbled through the sediment slurry. The conventional elutriate test greatly overestimates the amount of contaminants released during barge dumping of mechanically dredged sediments. A recommended modified elutriate test (plop test) has been developed for evaluation of the release of contaminants during open-water disposal of mechanically dredged sediments.

Of the various operating conditions that would likely affect the results of the elutriate test such as mixing and settling times, test water salinity, temperature, liquid:solid ratio, and type of water used, the factor that proved to be most important for many sediments is the amount of solid used in the test. For some sediments, the liquid:

solid ratio is an important parameter in determining the release of contaminants in the elutriate test. However, a consistent pattern was not found for the amount of release as a function of liquid:solid ratio for the areas studied. The 20 percent sediment of total elutriate volume currently specified for the elutriate test is probably too high for the typical conditions found in association with hydraulic dredging and open-water disposal. It is recommended that a more dilute (5 to 10 percent) sediment volume of the total elutriate volume be used. This would greatly facilitate conducting the test and more properly simulate the conditions that prevail at the dredged material disposal site, when the concern is the release of contaminants that can have an adverse effect on aquatic organisms in the disposal area water column. The 30-minute mixing period and one-hour settling appear to be appropriate, although there are situations where somewhat longer contact times will be encountered due to difficulties in obtaining a sufficient volume of filtered elutriate to perform the desired analyses. Reducing the percent sediment in the total elutriate volume will sometimes greatly help under these conditions. Normally, based on the results of this study, for many contaminants, increasing the length of the settling period by one to two hours should not significantly affect the results of the elutriate test provided that the system remains oxic during the time of settling.

Dredging site water should be used in the elutriate tests for hydraulically dredged sediments. Disposal site water should be used for the modified elutriate tests (plop tests) for mechanically dredged sediments. In those areas where there are marked salinity differences between channel surface waters and bottom waters, water with a salinity intermediate between the two, i.e., approximate average content, should be used.

The magnitude of uptake or release of the various contaminants studied appeared to be highly site specific, with little or no correlation between the physical and chemical characteristics of the sediment such as its bulk chemical content and the release of a particular contaminant in the elutriate test. It is impossible to predict with any degree of reliability the release of contaminants during open-water disposal of mechanically and hydraulically dredged sediments based on the bulk chemical content of the sediment. A possible exception is ammonia for sediments within a limited area. Even with ammonia, the reliability of such predictions is very poor and, in general, should not be used unless extensive studies have been done for a particular site which could serve as a basis for establishing a correlation between the bulk sediment ammonia content and its release in the elutriate test.

Among the heavy metals studied, manganese was the only metal that was consistently released from the sediments. Occasionally, relatively large amounts of iron were released; however, it is thought that this iron is a colloidal form and not in true solution. For the other heavy metals, copper, cadmium, manganese, zinc, arsenic, nickel, lead, and chromium, small amounts of uptake or release occurred; however, no consistent patterns were found except for zinc, which frequently showed removal from the test water.

Ammonium was consistently released from the sediments in the elutriate test. Frequently the concentrations of nitrate present in the site waters were reduced slightly as a result of elutriation.

The release of phosphorus from the dredged sediments was somewhat site specific. It appears that phosphorus release, like many other of the contaminants, is tied to the ability of hydrous ferric oxide to remove phosphate by coprecipitation reactions.

The behavior of chlorinated hydrocarbon pesticides and PCBs was also site specific, where, in general, those sites which showed the greatest oil and grease content in the sediments tended to release less of these compounds. Some of the greatest PCB releases were obtained from what would normally be considered a classical pollutional standpoint, the "cleanest" of the sediments. At several sites, monitoring programs had been conducted to evaluate the accumulation of chlorinated hydrocarbon pesticides and PCBs within aquatic organisms residing in the area of the disposal site. It has been found that even though the sediments may contain very high concentrations of these compounds, none of the sites where this monitoring has taken place have shown high concentrations in marine organisms. It is therefore concluded that dredged material disposal operations are not in general having a significant effect on the accumulation of chlorinated hydrocarbon pesticides and PCBs within aquatic organisms.

Bioassay studies on unfiltered elutriates have shown that, in general, very limited toxicity is expected from the dredged sediments upon open-water disposal. At most of the sites studied, the test organisms (grass shrimp or Daphnia) living in what is equivalent to a settled discharge from a dredging pump, survived a four-day exposure period without a significant number of deaths. In nature, the normal dilution associated with open-water disposal of dredged sediments would likely render even those sediments with the highest toxicity non-toxic to aquatic life residing in the water column at the disposal site.

A bioassay screening procedure has been developed which is believed to be much simpler and less expensive than the US EPA Corps of Engineers bioassay procedures released in July 1977 in accord with the January 11, 1977, Federal Register.

Studies on the water quality characteristics associated with open-water disposal involving the dumping of dredged sediments have shown that, in general, few if any significant environmental quality problems would be associated with most dredged material disposal operations. The intermittent nature of the dumping operations and the relatively rapid dispersion of any released contaminants at the disposal site creates a situation where the likelihood of significant toxicity or bioaccumulation of contaminants present in the dredged sediments is very small. The January 11, 1977, Federal Register specifies that the US EPA July 1976 water quality criteria shall be used to judge the significance of chemical contaminants released from ocean dumped dredged sediments only after consideration of mixing. Then, the chronic-based criteria would be somewhat conservative from an environmental viewpoint. The September 5, 1975, Federal Register specifies that estuarine and inland water disposal of dredged sediments shall conform to appropriate water quality criteria. It is important to note that the July 1976 US EPA Quality Criteria for Water should not be used to judge the significance of contaminant release associated with ocean dumped dredged sediments or freshwater or marine open-water disposal of dredged sediments. The July 1976 US EPA water quality criteria are based on chronic-exposure situations, where the aquatic organisms are exposed to the available forms of contaminants for a significant period of their lifetime. Dredged material disposal operations, in general, do not create chronic-exposure situations. This is especially true for dumping operations from barges or hopper dredges. In the case of pipeline disposal operations, it is conceivable that chronic-exposure conditions could be achieved. A site-by-site evaluation must be made in order to determine whether a particular disposal operation should come under chronic-exposure criteria or criteria

based on shorter times of exposure, which in general allow much higher concentrations of contaminants.

This study has shown marked differences in the potential environmental impact of various methods of dredged material disposal. The least impact to water column organisms would likely be associated with mechanically dredged sediments which are disposed of in open water. Next would be hydraulically dredged sediments dumped from a hopper dredge. This is followed, in the series of increasing environmental impact, by pipeline disposal of hydraulically dredged sediments, where the discharge point is relocated within a few hours to a few days. Next most potentially damaging would be a hydraulically dredged pipeline disposal operation where the discharge is fixed at essentially one point for a period of a few weeks to a few months or longer. The most potentially damaging situation would likely be a hydraulic dredging situation in which the dredged sediments are pumped to a confined disposal area with a supernatant detention time of a few hours or less to a day or so and where overflow waters are discharged to the nearshore areas of a watercourse. While this is the general order of increasing potentially adverse environmental impact associated with dredged material disposal, site specific conditions can reverse this order. Therefore, complete evaluation must be made for each dredged material disposal situation based on the characteristics of the dredging operation and the disposal method used without arbitrarily disregarding one or more modes.

The results of this study have shown that, in general, the elutriate test provides a reasonably accurate estimate of the concentrations of contaminants which will be released at an open-water dredged material disposal site. The bulk sediment concentrations of various contaminants have been shown to have no relationship to the release of contaminants at the dredged material disposal site or to

toxicity of the elutriate plus the sediments for a variety of waterway sediments obtained from throughout the US. The elutriate test combined with screening type bioassays appear to be the best overall dredged material disposal criteria by which to judge the significance of chemical contaminants associated with hydraulically or mechanically dredged sediments which are disposed of in open-water situations.

In general, it appears that confined disposal of dredged sediments in which there is overflow of supernatant water to the nearby watercourse may be equally and in many instances more adverse to environmental quality than open-water disposal of these sediments. It is, therefore, recommended that before any change is made from open-water disposal of dredged sediments to confined disposal in which there is no treatment of the overflow-supernatant water, a careful evaluation be made to ensure that the confined disposal method does not have equal, or greater, detrimental impact on water quality than open-water disposal of the sediments. It is recommended that the US Army Corps of Engineers and the US EPA continue to use the elutriate test and a screening type bioassay to evaluate the environmental impact of chemical contaminants present in dredged sediments upon open-water disposal. Further studies need to be done to evaluate the actual environmental impact associated with confined or on land disposal operations versus open-water disposal to ensure that the alternate, and in many cases more expensive, methods of disposal do not result in equal or greater environmental contamination than the previously used dredged material disposal method.

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