DREDGED MATERIAL RESEARCH PROGRAM

TECHNICAL REPORT D-78-20

A STUDY OF LEACHATE FROM DREDGED MATERIAL IN UPLAND AREAS AND/OR IN PRODUCTIVE USES

by

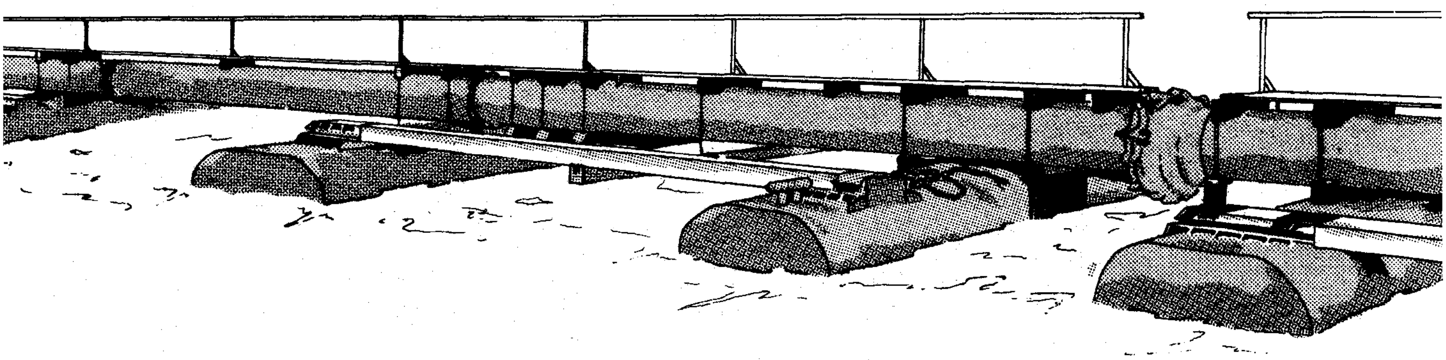
James L. Mang, James C. S. Lu
Ronald J. Lofy, Robert P. Stearns

SCS Engineers
4014 Long Beach Boulevard
Long Beach, California 90807

June 1978

Final Report

Approved For Public Release; Distribution Unlimited



Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

Under Contract No. DACW39-76-C-0069
(DMRP Work Unit No. 2D02)

Monitored by Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
P. O. BOX 631
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESYV

31 July 1978

SUBJECT: Transmittal of Technical Report D-78-20

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of Work Unit 2D02 of Task 2D, Confined Disposal Area Effluent and Leachate Control, of the Corps of Engineers' Dredged Material Research Program (DMRP). Task 2D was a part of the Environmental Impacts and Criteria Development Project, which in part was concerned with establishing a data base and developing mitigative measures for different modes of dredged material disposal. The work units in Task 2D deal more specifically with the environmental impact of effluents and leachates produced from the confined land disposal of dredged material.

2. Work Unit 2D02 involved the generation of leachate from 16 large plexiglas lysimeters under different environmental conditions. The major objectives of the study were: (a) to assess the potential adverse impacts on groundwater of leachates generated from dredged material in land containment areas; (b) to determine which major environmental variables (e.g., pH and oxidation-reduction conditions), or combinations of the major measurable variables, might have synergistic or attenuative influence on the mobility of various contaminants; (c) to assess how dredged material leachates are modified upon passage through oxidized surface soils lying beneath a disposal area; and (d) to determine what influence recently emplaced dredged material might have on the physicochemical conditons in the underlying soil profile, and how the resultant changes might affect contaminant mobility in the leachates and also the generation of mobile contaminants from the soil. The study more specifically looked at the influence of different types and levels of organic matter on the mobility of contaminants (especially trace metals) by: (a) using dredged material from five different locations (environments) with each having a different organic content; (b) choosing two interacting soils that contained both qualitative and quantitative differences in organic matter content; (c) leaching certain lysimeter columns with a landfill leachate that contained a high level of soluble organic carbon; and (d) leaching certain columns with a characterized fulvic acid solution, which should represent worst-case conditions at a solid waste disposal site or conditions in a soil of high organic content (e.g., marshland disposal). The influences of alkaline groundwater conditions and acidic rainfall on contaminant mobility were also assessed.

3. The results from this study show that no single mechanism can account for the migratory trends of all contaminants in dredged material or subsurface soil leachates. In the dredged material pore water, values for pH, Eh (oxidation), total organic carbon, alkalinity, and manganese generally showed a slight increase over time; the other parameters either remained relatively stable (total phosphorus, orthophosphate phosphorus, and magnesium), showed decline (total Kjeldahl nitrogen, ammonium-N, copper, calcium, sodium, and potassium), or showed highly variable trends (cadmium and zinc). Synthetic chlorinated hydrocarbons (e.g., PCBs and DDT analogs) were generally at undetectable levels. After the dredged material leachates migrated through subsurface soil profiles, there were several major changes in leachate quality. The solution pH was regulated by the pH and nature of the specific type of soil. A forest soil containing an above-average organic content tended to increase total organic carbon and decrease alkalinity and pH. Both soils used in the study acted as a generating source for soluble iron, manganese, calcium, potassium, nitrate nitrogen, and total Kjeldahl nitrogen. In general, soluble cadmium, copper, and lead were removed by the soils; sodium and ammonia nitrogen were initially attenuated, but this trend became less prevalent with long-term leaching. The migration of soluble salts (e.g., sodium and chloride ions) could be a problem in certain disposal areas containing saline dredged material. The migration of soluble (<0.45-μ filterable) phosphorus and mercury was not found to be a problem, although particulate mercury and total phosphorus were occasionally released at moderate levels. The migration of chlorinated hydrocarbons from the soils was negligible.

4. Although dilution effects alone should rapidly ameliorate any groundwater contamination problems, this study indicated that levels of ammonia and nitrate nitrogen, alkalinity, iron, manganese, total lead, and possibly zinc in the leachates from the dredged material samples used in the columns could exceed present water-quality criteria. However, many excessive concentrations (e.g., for manganese and iron) were derived from the soil as a result of changes induced by emplacement of overlying dredged material.

5. The data in this publication should be used, in context with field leachate findings, for determining the impact of land disposal on groundwater quality. It is anticipated that the results and discussion contained herein will aid those persons concerned with criteria development, water-quality monitoring, environmental impact reports, permit programs, or other regulatory functions.

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Technical Report D-78-20	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: A STUDY OF LEACHATE FROM DREDGED MATERIAL IN UPLAND AREAS AND/OR IN PRODUCTIVE USES	5. TYPE OF REPORT & PERIOD COVERED: Final report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): James L. Mang, James C. S. Lu, Ronald J. Lofy, Robert P. Stearns	8. CONTRACT OR GRANT NUMBER(s): Contract No. DACW39-76-C-0069
9. PERFORMING ORGANIZATION NAME AND ADDRESS: SCS Engineers, 4014 Long Beach Boulevard, Long Beach, California 90807	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: DMRP Work Unit No. 2D02
11. CONTROLLING OFFICE NAME AND ADDRESS: Office, Chief of Engineers, U. S. Army, Washington, D. C. 20314	12. REPORT DATE: June 1978
	13. NUMBER OF PAGES: 435
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*: U. S. Army Engineer Waterways Experiment Station, Environmental Laboratory, P. O. Box 631, Vicksburg, Miss. 39180	15. SECURITY CLASS. *(of this report)*: Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Containment areas
Dredged material
Leachates
Leaching (Soils)
Lysimeters
Waste disposal sites

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A laboratory lysimeter study was conducted to determine the composition of subsurface leachates generated from each of five different dredged materials, each combined with one of two different subsurface soil profiles. Sixteen 30-cm-diam Plexiglas lysimeter columns were consecutively filled with equal depths of homogeneous, oxidized native soil and anoxic dredged material (total profile of 60 cm). The dredged materials were obtained from land disposal areas located near Mobile, Ala. (saline silty clay), Sayreville, N. J. (saline silty loam), Grand Haven, Mich. (freshwater sandy clay loam), Seattle, Wash. (saline silty loam), and Houston, Tex. (saline silty clay). The native soils included a low organic, moderately permeable semiarid soil (Perkins loam) obtained from arable land near Hemet, Cal., and a highly organic upland sandy loam soil, obtained from a temperate coniferous forest near Lake Arrowhead, Cal.

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20. ABSTRACT (Continued).

The primary leaching solution was distilled water (rainwater leach), which was added in pulses to simulate alternate wet-dry cycling prevalent in most land containment areas. Other leaching fluids consisted of distilled water acidified to pH 4.5 with sulfur dioxide (acid rainfall leach), hard water buffered with bicarbonate (alkaline groundwater simulation), and leaching fluids containing high organic contents (a leachate obtained from a solid waste landfill site and a characterized fulvic acid solution, to represent conditions at a solid waste disposal site or in a marsh or swamp environment). Leaching tests were performed for periods of 3, 6, and 9 months for different columns. Parameters analyzed included major elements, trace metals, PCB's, chlorinated pesticides, nutrients (nitrogen and phosphorus compounds, organic carbon), chloride, sulfides, and various gross physicochemical parameters (alkalinity, Eh, pH, conductivity).

The results from this study indicate that leachate quality may be governed by both the dredged material and underlying soil. The leachates (interstitial water) from the dredged material tended to show slight time-dependent increases in pH, Eh, total organic carbon, alkalinity, and manganese. Concentrations of soluble total phosphorus, orthophosphate phosphorus, and magnesium remained relatively stable, while soluble organic and ammonium nitrogen, copper, calcium, sodium, and potassium showed continual decreases in concentration. Cadmium and zinc trends were highly variable during the course of the leaching tests. Chlorinated hydrocarbons (PCB's and chlorinated pesticides) were generally at undetectable levels.

The soils tended to regulate the leachate pH, organic carbon, and alkalinity, and they served as a source for soluble iron, manganese, calcium, potassium, nitrate nitrogen, and total Kjeldahl (organic plus ammonium) nitrogen. Soluble cadmium, copper, and lead were generally removed by the soils. Long-term leaching tended to increase ammonium nitrogen levels in final leachates. The attenuative capacity of the soils for soluble sodium, potassium, and calcium decreased during the six-month tests, especially for columns containing saline dredged material. This suggests a potential problem for salt migration, especially through moderately permeable dredged material and subsurface soils. The migration of soluble (>0.45-μ filterable) phosphorus and mercury was not observed to create a problem for leachates, although particulate mercury and phosphorus were occasionally released at moderate levels. The chlorinated pesticide and PCB levels in final leachates were usually nil.

Since drying of the dredged material failed to occur during the wet-dry cycling studies, many of the observed fluctuations in leachate quality were probably regulated by changes in the flow rate, induced by variations in the hydraulic head. The short-term application of acid rainwater and alkaline groundwater leaches had negligible impact on leachate quality; the acid leach slightly decreased the capacity of the system for removing alkalinity and calcium, probably by dissolving calcite from near the surface of the sediment profile. The municipal-waste leaching fluid also failed to cause major impact on leachate quality, although a slight increase in total organic carbon was observed; this was probably promoted by the poor attenuative capacity of the soils for this parameter combined with a high organic carbon level in this leaching solution.

The controlling mechanisms affecting the migration of different constituents in dredged material/interfacing soil systems were found to be very complex. Solubilization could control the levels of calcium, magnesium, pH, alkalinity, phosphorus, and all trace metals in the dredged material. Calcite solubilization specifically regulated the levels of calcium and alkalinity and strongly controlled pH. For many trace metals, the increased oxidation observed in the dredged material probably regulated soluble levels through dissolution of sulfide complexes and precipitation of carbonate, hydroxide, and/or oxyhydroxide solids. The solubility differences for these new solids, which are different for each constituent, probably regulated soluble levels. However, complexation with mobile inorganic and organic compounds can greatly change the expected soluble concentrations. Adsorption, ion exchange, and dilution seemed to play dominant roles for many highly mobile species (sodium, potassium, calcium, chloride, and ammonium nitrogen) as well as for most trace metals.

In the soil system, adsorption of constituents onto solids seemed to be an important mechanism for attenuation, especially for ammonia nitrogen, cadmium, copper, mercury, and lead. Precipitation reactions in the soil could attenuate phosphorus and some trace metals as well as control pH and alkalinity levels. The mobility of constituents generally seemed to be governed by the inherent properties of the soils (especially by pH and Eh changes) and not by the nature of the leaching solutions.

Groundwater dilution effects were not incorporated into this study, and the interacting soils were emplaced in a disturbed and oxidized state. Thus, the results probably represent worst-case conditions for contaminant mobility. However, the levels of ammonia and nitrate nitrogen, alkalinity, iron, manganese, zinc, and total (particulate) lead were occasionally in excess of present criteria. The data thus strongly suggest that the groundwater and soil conditions should be carefully considered when choosing a prospective land disposal site.

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