

DREDGED MATERIAL RESEARCH PROGRAM



CONTRACT REPORT D-77-4

TRANSFORMATIONS OF HEAVY METALS AND PLANT NUTRIENTS IN DREDGED SEDIMENTS AS AFFECTED BY OXIDATION REDUCTION POTENTIAL AND pH

VOLUME I: LITERATURE REVIEW

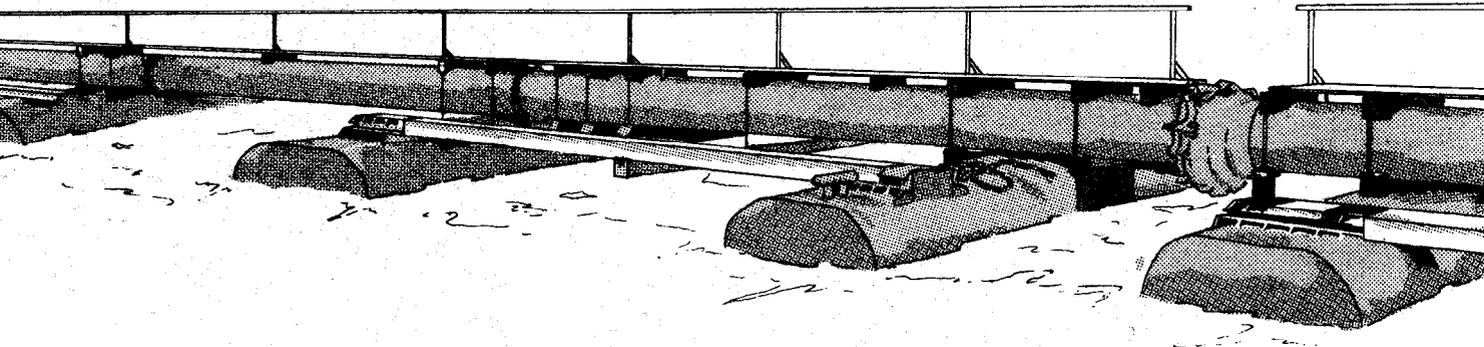
by

R. A. Khalid, R. P. Gambrell, M. G. Verloo, W. H. Patrick, Jr.

Louisiana Agricultural Experiment Station
Louisiana State University
Baton Rouge, Louisiana 70803

May 1977
Final Report

Approved For Public Release; Distribution Unlimited



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

Under Contract No. DACW39-74-C-0076
(DMRP Work Unit No. IC05)

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

**Destroy this report when no longer needed. Do not return
it to the originator.**



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

IN REPLY REFER TO: WESYV

27 May 1977

SUBJECT: Transmittal of Contract Report D-77-4

TO: All Report Recipients

1. The Dredged Material Research Program (DMRP) is a broad, multifaceted investigation of the environmental impacts of dredged material disposal and includes consideration of the development of new or improved disposal alternatives. In the early stages of the DMRP's problem definition and assessment and research program development phases, it became apparent that an understanding of the actual pollution potential of dredging and discharging of sediments required substantial state-of-the-art improvement in a number of fundamental aspects. Particularly critical were basic matters of sediment chemistry relating to physicochemical parameters such as pH, redox potential, and dissolved oxygen. These are dominant factors regulating the mobilization of chemical constituents or pollutants from dredged material discharged into aquatic or terrestrial environments. Contaminated sediments are often involved in dredging projects and during the discharge activity changes in the physicochemistry of the system can significantly enhance or retard release of contaminants from the sediment.

2. The contract report transmitted herewith represents the results of one of several research efforts completed as part of Task 1C (Effects of Dredging and Disposal on Water Quality) of the DMRP. Task 1C is part of the Environmental Impact and Criteria Development Project of the DMRP. Among other considerations this project includes determining on a regional basis the short- and long-term effects on water quality due to dredging and discharging bottom sediment containing contaminants.

3. This research was conducted (as Work Unit 1C05) to study the transformations of heavy metals and plant nutrients in dredged sediments as affected by oxidation-reduction potential and pH. Specific objectives were to review thoroughly the scientific literature concerning cause-and-effect relationships and to conduct specific laboratory investigations where data and evaluations were not available.

4. The first volume of this two-volume report includes an extensive bibliography and thorough discussion on the occurrence and chemistry of selected heavy metals and plant nutrients in relation to expected physicochemical changes during discharge of dredged material into various environments. The second volume contains reports on laboratory investigations of the effects of pH and oxidation-reduction conditions on the

SUBJECT: Transmittal of Contract Report D-77-4

distribution of toxic heavy metals and plant nutrients among selected chemical forms in sediment-water systems from four geographical locations. Particular emphasis was placed on how these physicochemical parameters might affect the chemical availability of these nutrients and toxic substances and thus reflect changes in their bioavailability.

5. From the literature review, it was concluded that changes in the physicochemical nature of sediments could enhance release of toxins or biostimulants; however, too few investigations have been conducted to draw broadly applicable conclusions regarding the effects on water quality. The laboratory investigations demonstrated that physicochemical changes during aquatic disposal resulted in little change and subsequent release of chemical constituents; however, when upland discharge methods were used, long-term and gradual changes in the physicochemical parameters occurred that could significantly affect toxic metal availability. It was further concluded that a thorough evaluation of the physicochemical nature of a dredging and discharge activity should be conducted prior to selection of a discharge alternative.

6. The information and data published in this report are contributions to the further understanding of the complex nature of sediment, water, and chemical/biological interactions and establish a baseline from which to develop meaningful evaluations for the selection of an environmentally compatible disposal alternative. It is expected that the methodology employed in this study and the resultant interpretation of the chemical interactions will be of significant value to those persons concerned with CE dredged material permit programs.



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

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Contract Report D-77-4	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) TRANSFORMATIONS OF HEAVY METALS AND PLANT NUTRIENTS IN DREDGED SEDIMENTS AS AFFECTED BY OXIDATION REDUCTION POTENTIAL AND pH; Volume I, LITERATURE REVIEW	5. TYPE OF REPORT & PERIOD COVERED Final report (In 2 volumes)	
	6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) R. A. Khalid, R. P. Gambrell, M. G. Verloo, W. H. Patrick, Jr.	8. CONTRACT OR GRANT NUMBER(s) DACW39-74-C-0076	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Louisiana Agricultural Experiment Station Louisiana State University Baton Rouge, La. 70803	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DMRP Work Unit No. 1C05	
11. CONTROLLING OFFICE NAME AND ADDRESS Office, Chief of Engineers, U. S. Army Washington, D. C. 20314	12. REPORT DATE May 1977	
	13. NUMBER OF PAGES 238	
14. MONITORING AGENCY NAME & ADDRESS (If different from Controlling Office) U. S. Army Engineer Waterways Experiment Station Environmental Effects 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)		
Chemical analysis	Heavy metals	Plant nutrition
Dredged material	Nutrients	Sediment analysis
Dredged material disposal	Oxidation	Trace metals
	pH	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
<p>This report, which includes a bibliography of 414 references, discusses literature on the occurrence and chemistry of selected trace metals and plant nutrients in sediment-water systems. The effects of pH and oxidation-reduction conditions on metal and nutrient chemistry were stressed where this information was available. The toxic and nutrient elements included are lead, cadmium, mercury, arsenic, selenium, copper, zinc, manganese, iron, nitrogen, phosphorus, and sulfur. The report also reviews the scope and limitations (Continued)</p>		

20. ABSTRACT (Continued)

of various selective chemical fractionation procedures developed to determine the chemical forms of trace metals and nutrients in soil and sediment-water systems.

This review determined that many laboratory studies simulating the transport of reduced sediments to an oxygenated environment have reported some release of toxic metals and biostimulants and others have shown no release of many elements. However, too few studies of actual dredging and dredged material disposal operations have been completed to draw broadly applicable conclusions regarding the effects of dredging on water quality. Where dredging activities have resulted in minimal change in metal ion concentration, it may be that some regulating processes influenced by oxidation-reduction reactions tend to be activated as others are inactivated. Because of the numerous potential interactions of dredging and dredged material disposal with surrounding ecosystems, it is suggested that some site-specific evaluation of possible adverse environmental impact should be conducted for each proposed dredging project.

Though adsorption and release reactions in disturbed sediment-water systems are frequently not of the magnitude predicted from metal-ligand solubilities and thermodynamic considerations of simple aqueous systems, it is apparent from the literature that pH and redox potential do influence the availability of metals and plant nutrients by affecting regulatory processes. Studies of the effects of redox potential and pH in sediment-water systems should therefore be useful in determining the nature of the regulatory process involved and the sediment-water characteristics which may contribute to significant release of metals and nutrients to benthic and aquatic organisms.

THE CONTENTS OF THIS REPORT ARE NOT TO BE USED FOR ADVERTISING, PUBLICATION, OR PROMOTIONAL PURPOSES. CITATION OF TRADE NAMES DOES NOT CONSTITUTE AN OFFICIAL ENDORSEMENT OF APPROVAL OF THE USE OF SUCH COMMERCIAL PRODUCTS.