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Processing Contaminated Dredged Material From the Port of New York-New Jersey

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ABSTRACT: Shipping activities in the Port of New York-New Jersey are currently threatened by restrictions on dredging of navigational channels and private berthing areas because of concerns about the environmental effects caused by ocean disposal of the dredged material. Current proposals for solutions to the problem include ocean disposal of uncontaminated material, use of confined disposal facilities (both upland facilities and containment islands), subaqueous borrow pits, and processing and treatment for contaminated materials. A project to produce a complete "treatment train" for processing and decontaminating dredged material is described. The work is divided into several phases: treatability studies of commercial and nonproprietary technologies at volumes of 19 liters (bench scale) and up to 19 m^3 (pilot scale); specification of a treatment train; and implementation of a large-scale facility that can process 76,000—382,000 m^3 of dredged material per year. The goal is to achieve operational status for the facility by the end of 1999.

Introduction

Contaminated sediments in fresh and estuarine waters are a major problem worldwide. The basic reason is the realization that dredging operations required for the maintenance of navigable waterways, private berthing areas, and different types of construction operations generate large volumes of contaminated sediments, which must be disposed of in an environmentally acceptable way. Contaminated sediments can be handled by use of confined disposal facilities, subaqueous borrow pits, or through decontamination of the sediments. The cleaned sediments can be returned to the ocean, placed in a landfill, or reused in various types of beneficial applications. In practice, local and national regulations restrict the permissible disposal avenues.

Much effort has been devoted to study of the various elements of a sediment decontamination treatment train, including dredging, physical separation, treatment processes, and final disposal. Ancillary topics such as understanding contaminant distributions in sediments, sediment transport, and biotoxicity effects related to marine disposal of treated materials are also of importance. For example, in Germany, federal standards have been developed (Köthe 1995a, b) for end disposal

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TABLE 1. Summary of contaminants in select New York-New Jersey Harbor sediments (Chen 1994).

Contaminant	Newark Bay	Arthur Kill	Newtown Creek
2,3,7,8 TCDD (ppt)	130	39	9.9
OCDD (ppt)	5,494	3,016	15,369
TCDD/TCDF TEQ (ppt)	197	61	224
Total PCBs (ppm)[a]	0.92	1.16	2.86
Anthracene (ppb)	1,400	880	5,820
Benzo (a) anthracene (ppb)	3,070	1,460	6,190
Chrysene (ppb)	3,100	1,630	6,050
Total PAHs (ppb)[a]	32,550	19,120	59,380
Total Herbicides and DDT (ppb)[a]	145	1,219	420
Arsenic (ppm)	9–17	17–25	5–33
Cadmium (ppm)	1–2	1.5–3	1–20
Chromium (ppm)	175	161	305
Copper (ppm)	105–131	178–304	61–770
Lead (ppm)	109–136	111-261	68–554
Mercury (ppm) total	2–3	2–4	1–3
Nickel (ppm)	33-40	20–60	12–140
Silver (ppm)	2–4	2–5	2–3
Zinc (ppm)	188–244	230–403	104–1,260

[a] National Oceanic Atmospheric Administration.

criteria. In the Port of Hamburg (Netzband 1994; Detzner 1995), a sediment-processing plant has been constructed to help in the dewatering of sediments and reduction of contaminated material volume through physical separation. In the United States, the United States Environmental Protection Agency (USEPA) has completed a pilot-scale demonstration project, Assessment and Remediation of Contaminated Sediments (ARCS), to test different types of decontamination technologies intended for use on freshwater sediments found in the Great Lakes region (United States Environmental Protection Agency 1994).

A related United States Environmental Protection Agency and United States Army Corps of Engineers (USACE) project (Water Resources Development Acts of 1992 and 1996, WRDA) combining elements of these two examples is presently in progress in the Port of New York-New Jersey. In brief, the Port is faced with an operational crisis brought about by regulations that reduce the amount of dredged material considered suitable for ocean disposal in the coastal Atlantic Ocean. Currently there are limited alternative options and, as a result, the continued economic operation of the Port is threatened. The WRDA project is intended to demonstrate decontamination technologies for sediment treatment and to create a viable treatment train capable of processing sediment volumes on the order of 382,000 cubic meters per year by the end of 1999. It can be seen that the work entails a merging of applied and basic research and development activities with a parallel need to accomplish full-scale design and construction of operating facilities. This will require development of an effective operational public-private partnership to deal with the diverse challenges of the project. The present status of the project is summarized here.

Characteristics of Sediments From the New York-New Jersey Harbor

Measurements of the concentrations of contaminants found in the Port of New York-New Jersey have been made in three locations: Newark Bay and Arthur Kill in New Jersey, and Newtown Creek, a small tributary of the East River between Brooklyn and Queens in the City of New York. The results of the measurements of the surface concentrations are shown in Table 1. Independent sediment toxicity tests show that these sediments are Category 3, that is, they are not suitable for ocean disposal. The present decontamination project has used sediments from Newtown Creek for all tests to date. It is realized that the sediment physical and chemical characteristics will be variable and depend on location in the harbor. However, the contaminant levels at the locations chosen are representative of a major fraction of the contaminated materials that will be dredged harborwide in the near future. This information is included here since it is not generally available and is essential in any planning for choosing appropriate decontamination technologies. The results given in Table 1 were obtained in a project sponsored and evaluated by the USEPA (Battelle Ocean Sciences 1992; Chen 1994).

Selection of Decontamination Technologies

The guiding principles in selection of technologies for the demonstration testing were to select a range of approaches for flexibility in treating different sediment types and different levels of contamination and to make selections from existing

commercial technologies that could be extended rapidly to full-scale operation. These principles were met by soliciting proposals through a request for proposals that was circulated to approximately 150 technology development firms. Formal proposals for 25 technologies were received and evaluated by reviewers from USEPA, USACE, United States Department of Energy-Brookhaven National Laboratory (DOE-BNL), and four participating universities: New Jersey Institute of Technology, Rensselaer Institute of Technology, Rutgers University, and Stevens Institute of Technology. Seven proposals were selected for bench-scale testing demonstrations. In addition, several tests were carried out by the USACE Waterways Experiment Station, Vicksburg, Mississippi.

The selection process envisaged a developmental process that would lead from bench-scale to full-scale operations in a series of optional steps. These further optional steps proceeded from pilot-scale tests to plants operating at 76,000 m^3 and 382,000 m^3. These values are to be compared to the yearly need to process or otherwise dispose of the 2,500,000 m^3 to 3,000,000 m^3 of dredged material deemed too contaminated for unrestricted ocean disposal. A confined disposal facility, either upland or a containment island, may be used to meet some or all of these needs. Sediment processing and decontamination can be used to respond to short-term needs and is a plausible component to other dredged material alternatives for long-term needs. The magnitude of the problem suggests there is an environmental and economic requirement for operation of several large-scale facilities with varied capabilities.

Bench-scale Tests

The bench-scale tests covered technology options for mixtures with uncontaminated materials to high-temperature thermal treatments. The specific approaches follow:

Creation of a manufactured soil by addition of compost, manure, and other materials.

Solidification and stabilization by addition of portland cement, lime or fly ash, and/or proprietary chemicals to create solid aggregates.

Soil washing using proprietary surfactants, chelating agents, and high pressure collisions to remove both organic and inorganic contaminants.

Solvent extraction, a technique similar in concept to soil washing.

Thermal desorption to remove surface contaminants. The temperatures used are not high enough to destroy the organic compounds.

High-temperature thermal destruction. High temperatures can completely destroy the organic compounds and fuse the inorganic materials into a stable matrix. Three technologies were tested that used temperatures in the range from 750°C to 3000°C. The products of the testing are suitable for beneficial reuse as aggregates, cement, and glass. These products have relatively high economic values, which would help in the creation of a self-sustaining industry.

The manufactured soil approach is attractive because our initial tests have shown that the sediments pass the USEPA Toxicity Characteristic Leaching Procedure (TCLP) test (USEPA SW 846/1311), so that the soil can be disposed of on land in several ways. Bench-scale tests showed various types of grasses grew best in a soil containing 30% native sediment together with added compost and manure. However, contamination levels are reduced only by dilution and use of the final material may be restricted.

Percent contaminant reductions obtained for the other approaches are shown in Fig. 1. The values are based on the contaminant concentrations found in the end-product, including the effect of any addition of uncontaminated materials. The collection of samples, quality assurance, and quality control were supervised by the consortium of federal agencies and four university groups. The values shown in Fig. 1 are presented in a conservative way. Minimum detection limits were used in the calculation of the reduction fraction where quantitative values were not found. This resulted in an underestimate of the actual reduction.

It can be seen that the high-temperature thermal technologies using temperatures higher than 750°C are extremely effective in destroying organic contamination. The lower temperature thermal desorption process is also effective but has the disadvantage of creating a sidestream of toxic materials, which must then be treated or disposed of in a separate step.

Solidification and stabilization and sediment washing were found to have less effect on the sediments. Analysis of the results suggest the treatments may change the chemistry of the contaminants and render them more susceptible to leaching. This could affect the contaminant analyses and suggests further experimentation with the specific chemicals used for the treatments is needed in order to improve performance and for evaluation of the testing procedures. The separations technologies used can also lead to recontamination of the material in the final stages of the process. We have tried to work with all the project participants to improve their technologies to the maximum extent possible.

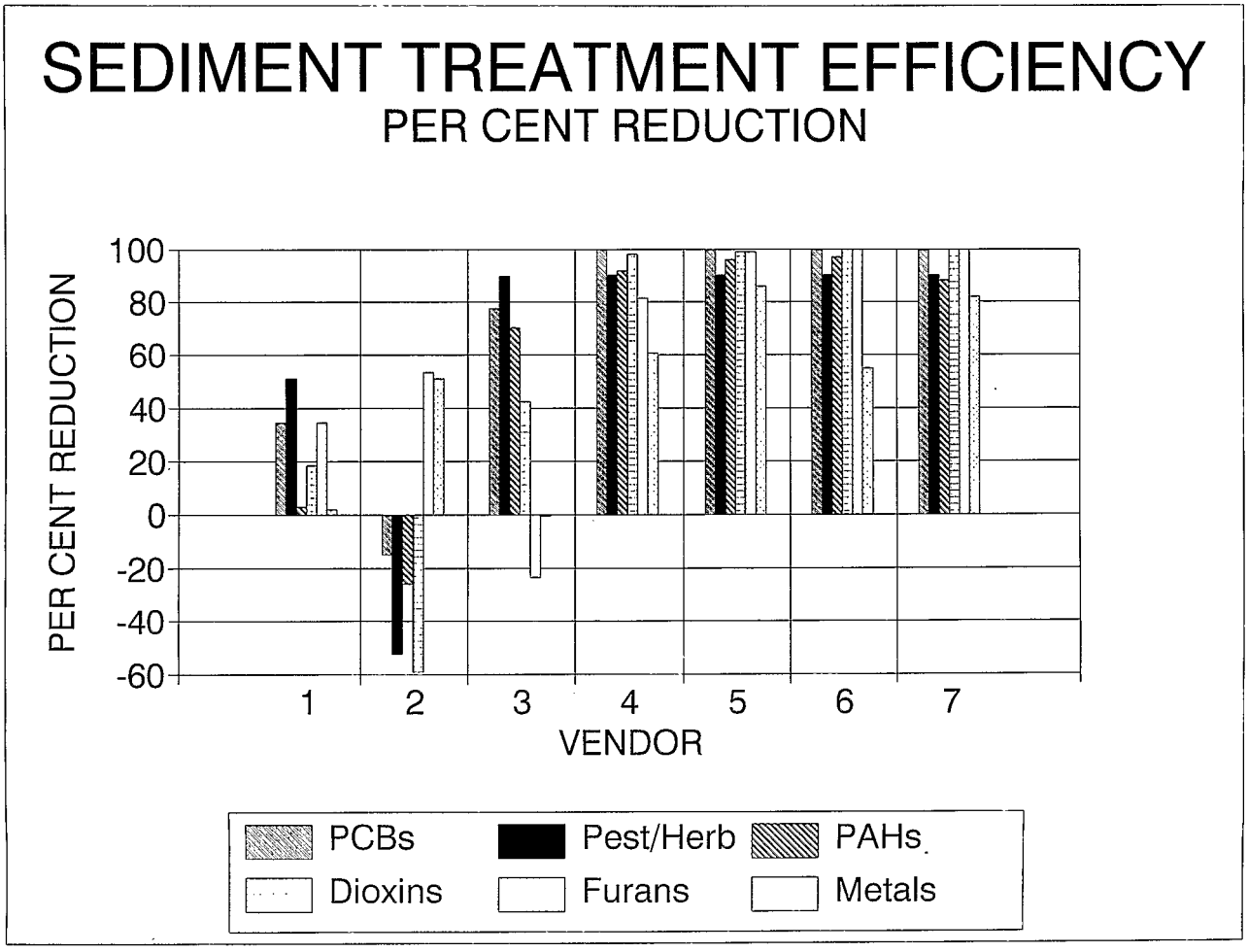

Fig. 1. The reduction of various types of sediment contaminants by seven different treatment technologies is shown. The decontamination processes are 1) solidification and stabilization using proprietary chemicals, 2) sediment washing, 3) solvent extraction, and 4) thermal desorption. 5), 6), and 7) are high-temperature thermal destruction. Several reasons for the apparent enhancement of contaminant concentrations are given in the text.

Pilot-scale Testing

Pilot-scale testing has been carried out on several of the technologies tested at the bench scale. They are manufactured soil, solidification and stabilization, solvent extraction, and high temperature treatment to produce cement and glass for beneficial reuse.

The pilot-scale tests have been completed, and analysis of the treated materials is in progress. The amount of material processed in the pilot-scale demonstrations varied from 3 m^3 to 10 m^3. The intent in this phase was to obtain more detailed information on the overall mass balance of the procedures and to obtain data to enable detailed design of large-scale facilities. It was shown that all approaches have application in the design of a complete treatment train for a commercial-scale facility. Insights were gained into the materials handling of fine-grained sediments, which will be a major part of the processing.

Related Issues

There are many issues of importance in the development of an effective sediment-processing facility, in addition to the purely technological factors. Some of the questions that are being addressed through this project are discussed in the following sections.

Risk Assessment

Risk assessment must be considered from a number of different perspectives, including: risks to the environment from disposal of the treated materials and from sidestreams produced in the processing,

risks to human health including occupational exposures, and risks from failures of components of the processing equipment. Evaluations of the first two risk categories indicate that it should be possible to define an overall approach acceptable from the environmental and human health perspectives. Equipment-dependent risk will be considered during the design process for the large-scale facility to make sure problems are addressed during the design process.

Public Outreach

Processing of large amounts of sediment containing metal and organic contaminants will be of great concern to the public in the processing area in end-use locations. This will be true even though the sediment contaminant levels are not high enough for classification as a hazardous waste. For this reason, care has been taken to involve the public, including city, state, and local governmental officials, regulatory agencies, industry, and community groups, and to keep them apprised of progress. Much effort has been devoted at the community level to discussions of impacts on the local environment and in efforts to ensure that the communities in close proximity to the processing site will benefit from the operation.

Processing Costs

The usefulness of the processing facility is highly dependent on the total cost (including credits for beneficial use) of dredging, processing, and ultimate disposal of the treated sediments. Costs for the complete treatment train estimated by the project industrial contractors range from about \$20 per m^3 to \$120 per m^3. Sale of treated materials and resulting products, such as cement, glass products, manufactured soil, and construction aggregate, among others, will potentially sharply reduce the net treatment cost.

Disposal Criteria

Classification of the treated materials and criteria for end use are a critical part of the procedures described here. Most of the requirements are set by individual state agencies from the environmental stand point. Beneficial uses have various criteria, which are determined by the particular application.

Treatment Train

Design of a complete treatment train for sediment processing is in progress. It is based on application of the technologies described in this paper. In addition, means for dredging, dewatering, physical separation, materials transport, residuals management, and storage need to be finalized. The basis for the treatment train will rest on the employment of multiple technologies for the decontamination process.

Full-scale Project

The implementation of a full-scale project will benefit from a public-private partnership to face the complex issues of financing, siting permits, beneficial uses, continuing research and development needs, and community involvement. While this has not been done to date in the New York-New Jersey region, it is a concept that has been much discussed and used elsewhere. Preliminary discussions among USEPA, USACE, and DOE-BNL and many private sector groups are now under way in an effort to organize an effective team.

Conclusions

The results of bench-scale and pilot-scale testing of sediment decontamination technologies have shown there are several viable approaches which will be environmentally and economically acceptable. A move to demonstrations processing at the level of 76,000 m^3 to 382,000 m^3 per year is underway. Completion of this phase is projected for 1999.

Acknowledgments

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