Decontamination and Beneficial Use of Dredged Materials

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ABSTRACT: Our group is leading a large-sale demonstration of dredged material decontamination technologies for the New York/New Jersey Harbor. The goal of the project is to assemble a complete system for economic transformation of contaminated dredged material into an environmentally-benign material used in the manufacture of a variety of beneficial use products. This requires the integration of scientific, engineering, business, and policy issues on matters that include basic knowledge of sediment properties, contaminant distribution visualization, sediment toxicity, dredging and dewatering techniques, decontamination technologies, and product manufacturing technologies and marketing. A summary of the present status of the system demonstrations including the use of both existing and new manufacturing facilities is given here. These decontamination systems should serve as a model for use in dredged material management plans of regions other than NY/NJ Harbor, such as Long Island Sound, where new approaches to the handling of contaminated sediments are desirable.

Key words: beneficial use, decontamination, New York/New Jersey Harbor

PROJECT DESCRIPTION

The goal of this project is to develop sediment decontamination facilities that can be used to handle a substantial fraction (ca. 375,000 m^3/year) of the

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dredged material produced in the Port of New York/ New Jersey as a result of dredging for maintenance of navigational channels and for environmental purposes. To this end, more than 10 different technologies for decontamination have been carried through bench-, pilot-, and large-scale tests. In addition, consideration has been given to the basic science needed to understand contamination transport, decontamination chemistry, biotoxicity, and beneficial use. Such information is needed for making dredging decisions, assessing environmental and human health effects, and optimizing several types of decontamination technologies. Summaries of project work have been given in a number of publications and reports (Jones *et al.*, 2000; 1999a & b; 1998a & b; 1997; Ma *et al.*, 1998; Stern *et al.*, 1998a,b & c). Publications and technical reports on project demonstrations can be found on our project web site (http://www.wrdadcon.bnl.gov).

During 2001, a project using a sediment/soil washing technique will be implemented in cooperation with BioGenesis and BASF. The work will combine remediation of a BASF brownfield site together with construction of a BioGenesis sediment processing facility with a throughput of 180,000 m^3/year on that site. Another 2001 project using a high-temperature process developed by the Gas Technology Institute/Endesco will be constructed on a second site. It will be able to process about 22,500 m^3/year of as-dredged sediment with moisture content of 60%.

Sediment cleaning is a multistep process beginning with dredging the sediment, cleaning, and ending with disposal of the clean material. The beneficial use of the material is a key factor in determining the success of the decontamination process. The beneficial use products from the facilities will be manufactured soil and cement which can be sold to generate a revenue stream to bring tipping fees into a range that is economically feasible for the Port of NY/NJ.

Demonstration Projects

We have taken a very broad view of the need for decontamination technologies in the NY/NJ Harbor region. The two obvious requirements for any technology are that they have affordable treatment costs and no adverse environmental impacts. The technologies were selected from responses to several requests for proposals. The work was structured as a series of step-by-step demonstrations proceeding from small-scale to large-scale. At the end of each step, the technologies that would move forward in the demonstration process were selected. A list of all the technology organizations participating in the demonstrations is given in Table 1.

Table 1. Technology organizations participating in the dredged material decontamination demonstrations.

	Gas Technology Institute/Endesco
Biogenesis/Weston	U. S. ACE Waterways Experiment Station
Marcor	International Technologies
Metcalf & Eddy	NUI Environmental
JCI/Upcycle	BEM Systems
BioSafe	Westinghouse Plasma Systems/Global Plasma Systems

Science

Pathways for contaminant accumulation and transport include complicated physical and chemical processes that depend on sediment properties on a grain-size scale. These processes depend on sediment properties such as grain size, specific surface area, mineral composition, and contaminant chemistry. Information of this type is needed not only on a macroscopic scale, but also on the grain-size scale. This type of data is necessary for improved modeling of transport and fate of the contaminants and also to help in optimizing physicochemical approaches to sediment decontamination. We have conducted microscale survey experiments using high-intensity synchrotron x-ray sources at the Brookhaven National Synchrotron Light Source (NSLS) (http://nslsweb.nsls.bnl.gov) and the European Synchrotron Radiation Facility (ESRF) (http://www.esrf.fr). The techniques that have been applied include x-ray fluorescence, x-ray radiography, x-ray absorption near-edge spectroscopy (XANES), Fourier transform infrared spectroscopy, and absorption and fluorescent computed microtomography. The spatial resolutions used generally range from about 0.0001 mm to 0.015 mm.

A computed microtomogram measured for a

sediment sample is shown in Figure 1 as an example of this approach. The experiment gives a three-dimensional view of the packing of sediment particles and shows the pore space and the connectivity of the material. Data of this nature will serve as the foundation for a microscopic model of contaminant transport. Other experiments show the distribution of organic and inorganic compounds on the sediment grains. These data can be used as the basis for designing water jets used for mechanical cleaning of particle surfaces and for choosing the best approaches for use of chemical removal of contaminants by chelators and surfactants.

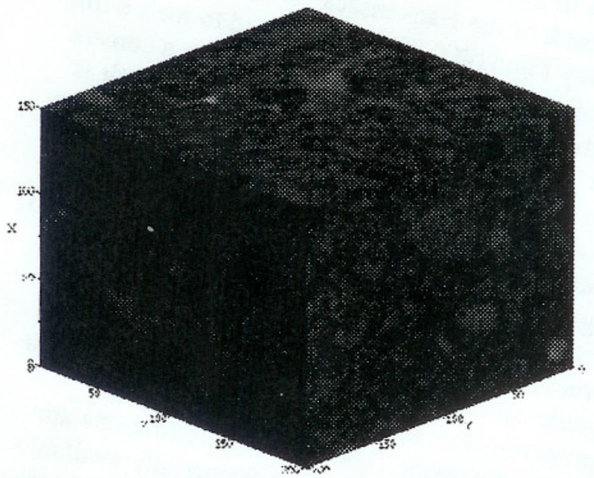

Figure 1. Computed microtomogram showing grains and pore spaces in Newtown Creek sediments. The color scale shows the variation of the x-ray absorption coefficients in the different particles with the lighter areas being the most strongly absorbing. The dark spots are indicative of pore space. The linear pixel dimension is 0.0068 mm.

Physico-Chemical Sediment Properties

The macroscopic properties, as well as the microscopic properties, of the sediments from the Port of NY/NJ are of great importance for understanding contaminant transport, selection and application of decontamination technologies, and evaluation of beneficial use avenues. For example, a simple measurement of the grain-size distribution is crucial for design of protocols for applying the BioGenesis sediment washing technology. As shown in Figure 2, the sediments in the Port are very fine grained and thus present a challenge for the application of a washing technology. X-ray diffraction is used for determination of major oxide composition. This information is needed so that in a cement production process compounds can be added for optimal cement composition. Thermal desorption measurements are helpful in giving qualitative information on the concentrations of the organic materials found in the sediments.

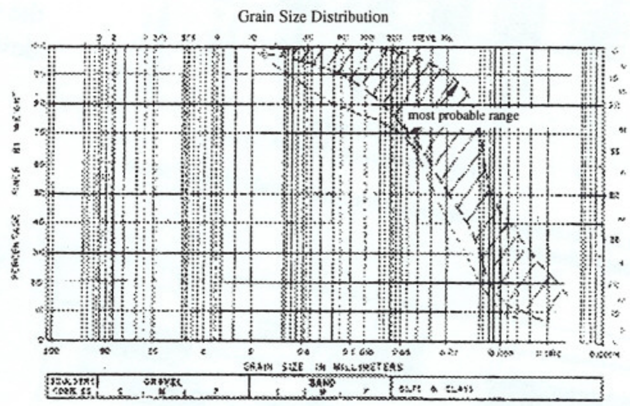

Figure 2. Distributions of grain sizes found for typical dredged material from NY/NJ Harbor. (Courtesy of The Port Authority of New York & New Jersey)

Technology Treatment Effectiveness

Treatment effectiveness, as determined in the bench-scale tests, is shown for seven different technologies in Figure 3. The three at the right are high temperature approaches and are the most effective in destruction of organic compounds. The results for BioGenesis/Weston and the Gas Technology Institute/Endesco projects are numbered 1 and 6, respectively. See the descriptions of their continuing demonstrations below.

BioGenesis/Weston Sediment/Soil Washing Demonstration, Kearny, NJ

The BioGenesis/Weston demonstration uses a combination of a high-pressure water jet, surfactants, and chelators to remove metals and organic materials from contaminated sediments and soils. It is an advantageous approach since the capital costs are comparatively modest and the throughput is high. The equipment is modular so that the total processing capacity can be readily increased. A schematic diagram of the process is shown in Figure 4. The demonstration unit will process

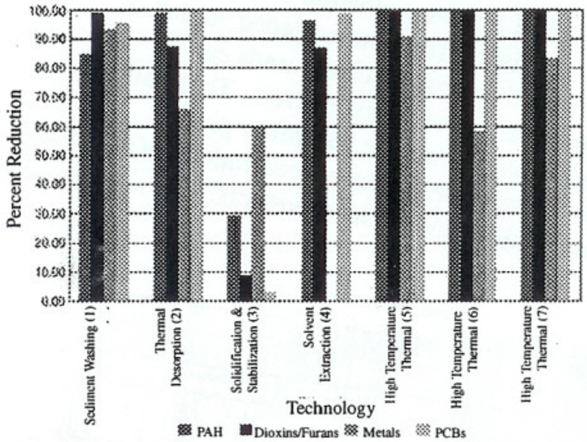

Figure 3. Treatment effectiveness for bench-scale tests of seven different technologies.

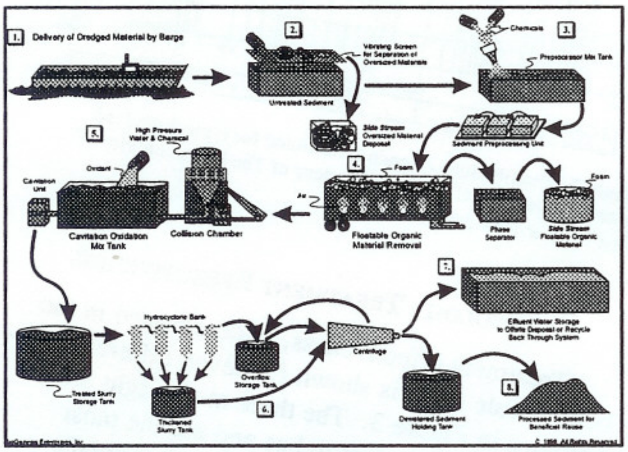

Figure 4. A schematic diagram of the BioGenesis Enterprises sediment washing process.

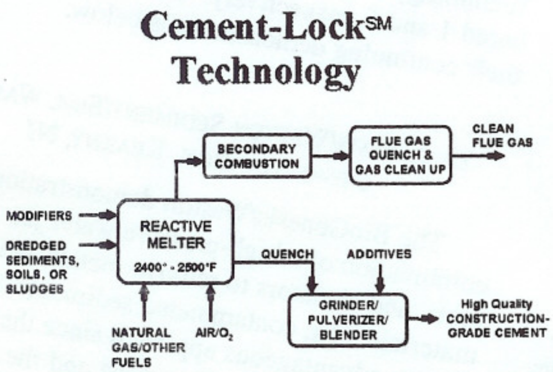

Figure 5. A simplified diagram of the GTI/Endesco process for producing cement from dredged material. Modifiers are added to adjust the composition to yield the best cement composition.

180,000 m^3/year. The decontamination work will be combined with remediation of a brownfield on the site and capping of contaminated sediment along the shoreline in order to produce a wildlife refuge, ecological, education center, and nature viewing area. This will be done as a public-private partnership involving local, state, and federal agencies, elected officials, and community groups working with the commercial groups of BioGenesis and the BASF Corporation. BASF is the owner of the site and has been instrumental in developing the concept.

Gas Technology Institute/Endesco Rotary Kiln Demonstration, Kearny, NJ

The Gas Technology Institute demonstration will be implemented at a brownfield site on the west bank of the Hackensack River in Kearny, NJ. A rotary kiln (1400 °C) will be used to melt a mixture of sediments and modifiers to form a cement matrix of calcium-alumino silicates. The melt is then pulverized and mixed with additives to make construction-grade cement. Organic compounds are destroyed and metals are locked in the product matrix. Exhaust gases are cleaned up to ensure no organic compounds are emitted and to remove volatile metals. A simplified diagram of the process is shown in Figure 5. The construction-grade cement produced has compressive strength properties that exceed ASTM standards for Portland cement. The metal concentrations are similar to those found in commercially available cements. The material also passes standard leaching tests for metal removal.

Production of a commercial-grade product was demonstrated in the initial bench- and pilot-scale tests. Effective beneficial use is dependent on the existence of a suitable market. Available data show the demand for cement increasing by about 800,000 metric tons per year. Thus, production of cement from sediment could help to reduce the need for added imports to meet demand. Marketing and distribution of the cement can be accomplished either by direct sales to end-users (*e.g.*, ready-mix plants, construction companies) or to an existing cement manufacturer. The high value of the product will help to make this process competitive with other dredged material management options.

Future Directions

It is clear that our most pressing near-term task is to bring the two large-scale demonstrations of GTI/Endesco and BioGenesis Enterprises to completion. One point to be considered in so doing is to solve the problem of matching high-peak volumes of dredged material generated in the dredging process to the capacities of the decontamination facilities. This can be done by inserting the equivalent of a buffer tank at the entrance to the processing treatment train. In practice, we propose to build, as a buffer tank, a small, contained disposal facility with a capacity of about 180,000 to 375,000 m^3 to serve as the input source of the dredged material to the BioGenesis Enterprises treatment facility.

Work on other tasks is also planned:

- The feasibility of using additional technologies for sediment processing needs to be investigated at the bench- and pilot-scale levels.
- The results of our demonstrations need to be implemented in other regions. Extending infant collaborations in the Great Lakes and Puget Sound regions can do this.
- There are several barriers to technology implementation (regulatory, contracting) that need to be overcome. One very important barrier is the reluctance of many agencies to let long-term contracts for processing dredged material. This makes raising private financing for facility capital construction costs difficult or impossible.

It is important to extend the types of beneficial use products that can be produced from sediments. This is of importance if we are to be able to view dredged material as representing a natural resource for the manufacture of a variety of products.

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