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Environmental Engineering Options for Managing Contaminated Sediment

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Abstract

Technologies that have been identified as feasible for remediating contaminated sediment and are being considered for demonstration in the Great Lakes are presented in this paper. This review is limited to the components and technologies required for removal and management of highly contaminated sediment. Over two hundred technology process options were reviewed for effectiveness, implementability and costs. However, few of these processes have actually been applied to contaminated sediment on a full scale. Most of the technology evaluations have been conducted at the bench scale with limited data available for pilot scale assessment. Therefore, further testing and evaluation of the most promising technologies is being conducted as part of larger studies of sediment remediation like the Assessment and Remediation of Contaminated Sediments (ARCS) studies in the Great Lakes (Horvatin 1989).

Introduction

Contaminated sediments are frequently encountered in marine waters and waters of the United States. The potentially large volumes of sediment requiring special management, to include remediation, limit the feasible engineering options to in-place controls or removal and

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subsequent physical containment, chemical immobilization contaminant degradation, contaminant removal, or volume reduction.

Averett et al. (1990) published the results of a review of technologies for the Great Lakes. The purpose of the review was to identify technologies and process options that may be feasible for remediating contaminated sediment and that may be considered for further demonstration under the ARCS program.

Components for Removal Alternatives

Removal alternatives may be developed by adding all of the steps or components necessary to remove sediments from the waterway, prepare it for treatment, treatment, and disposal of decontaminated sediment or concentrated residues. The components reviewed for this paper are restricted to sediment excavation, transport of the dredged materials for subsequent processing, pretreatment, treatment, and disposal. Over 200 process options were identified for screening. The number of process options, including the number of options considered and recommended for further study is presented by component type in Figure 1. The factors that were considered when evaluating removal alternative technologies included state of

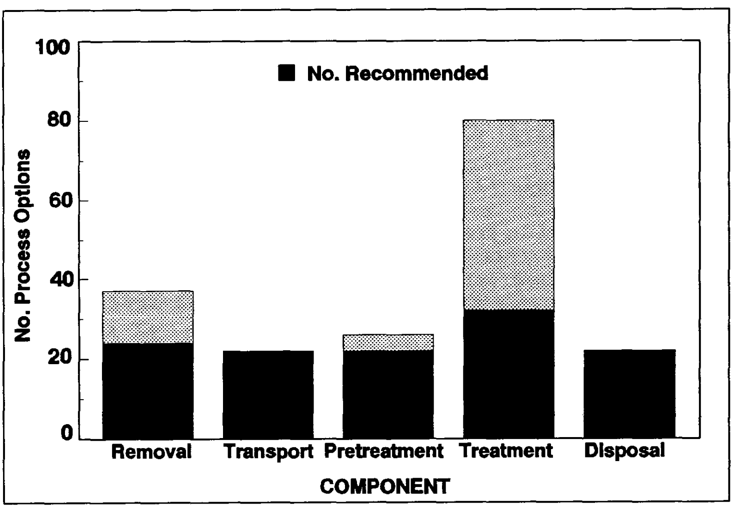

Figure 1. Comparison of Process Options by Component Type for Removal Alternatives

technology, availability, effectiveness, implementability and cost. Of the 122 process options recommended for further consideration, approximately 20 technologies were recommended to be evaluated on either a bench scale or in a field pilot demonstration.

Excavation Component

Principal concerns during the excavation of contaminated sediment are the prevention of contaminant releases from the sediment being removed with subsequent transport of contaminants to previously uncontaminated area and efficient removal of contaminated sediment without excessive over-cutting. If unavoidable release occurs, undesirable consequences could result in regards to the environment, costs, and public relations. Over-cutting increases the volume of material for treatment or disposal and increases costs. Technologies reviewed for the excavation of contaminated sediment include the following:

- Selection of appropriate mechanical or hydraulic dredges
- Use of operational controls during excavation activities
- Deployment of barriers to central transport of suspended solids during sediment removal

Transport Component

Primary transportation methods used to move contaminated dredged sediment include pipelines, barges or scows and hopper dredges. Overland transport could also include railways and trucks. Of primary interest during transport is the need to minimize or contain overflow, leaks, or spillage of contaminated sediments, paying particular attention to loading and unloading points.

Pretreatment Component

Pretreatment technologies are defined for the purpose of this paper as technologies that prepare dredged sediment for additional treatment or disposal. These technologies are designed to accelerate treatment in a disposal site, to reduce the water content of the dredged material, or to separate fractions of the sediment by particle size. Pretreatment technology include dewatering, particle classification and slurry injection. These technologies are primarily applicable to hydraulically dredged sediment. Physical separation or particle classification is being demonstrated on a pilot scale on sediments from the Saginaw River. Approximately 300 tons of PB-contaminated sediment will undergo soil washing and hydrocycloning to separate 80 percent sand from the remaining silt fraction.

Treatment Component

Many of the process options are not stand alone processes, but are sub-elements of a system that may involve multiple treatment processes to address multiple contaminant problems. Most of these processes also require one or more of the pretreatment processes discussed above.

Biological processes

Biological degradation technologies use bacteria, fungi, or enzymes to break down PCBs, pesticides, and other organic constituents into innocuous or less toxic compounds. The microorganisms may be indigenous microbes, conventional mutants, or recombinant DNA products. Biodegradation processes have not been applied and evaluated for contaminated dredged material other than on a bench scale and limited pilot scale projects.

Enhanced natural biodegradation of PCB's in sediments is being evaluated in a pilot contained treatment facility at the Sheboygan River Superfund remediation project. The treatment system was designed to accommodate approximately 3000 cubic yards of sediments dredged from the upper Sheboygan River. The treatment cell is divided into general treatment sections with controls to allow for regulation of nutrient and oxygen conditions for the bacteria. Both anaerobic and aerobic biodegradation conditions are being assessed in the study with technical support from the ARCS program.

Chemical processes

Chemical treatment technologies use chelating agents, bond cleavage, acid or base addition, chlorine displacement, oxidation, or reduction in the destruction, detoxification, or removal of contaminants found in the contaminated media. Few of these technologies have been used for treatment of organic and heavy metal contaminants in sediment. Chemical treatment technologies considered include chelation, detoxification, nucleo-philic substitution, oxidation of metals and organics, reduction of metals and organics, and thionation.

Extraction processes

Extraction is the removal of contaminants from a medium by dissolution in a fluid that is later recovered and treated. Soil flushing and soil washing are other terms that are used to describe extraction processes. Solvent extraction has been evaluated previously on sediments contaminated with PCB's from the New Bedford Harbor Superfund Site and on sediments/soils contaminated with creosote from the Bayou Bonfouca Superfund Site in Slidell, Louisiana.

Solvent extraction will be demonstrated for highly contaminated sediments from the Grand Calumet and Indiana Harbor Canal. A pilot study of the triethylamine (TEA) extraction process will be evaluated for removal of PAH's and PCB's from the sediment with support under the USEPA's Superfund Innovative Technology Evaluation (SITE) Program.

Immobilization processes

Most of the immobilization processes fall into the category of solidification/stabilization (S/S) processes. Objectives of S/S are generally to improve the handling and physical characteristics of the material, decrease the surface area of the sediment mass across which transfer or loss of contaminants can occur, and/or limit the solubility of contaminants by pH adjustment or sorption phenomena.

Effectiveness of S/S processes is usually evaluated in terms of reduction of leaching potential. Reductions are process and contaminant specific with immobilization of some contaminants accompanied by increased mobility of other contaminants. Implementability for most of these processes is better than chemical or extraction processes because they are not as sensitive to process control conditions. Costs for these processes are generally less than $100 per cubic yard.

The immobilization of residual wastes from the thermal desorption demonstration project at the Buffalo River Site will be evaluated. Previous bench scale studies of S/S processes have been conducted for the Indiana Harbor and Buffalo River sediments.

Thermal processes

The thermal type technologies include incineration pyrolysis, vitrification, supercritical and wet air oxidation, and other processes that require heating the sediment several hundred or thousands of degrees above ambient. Thermal desorption or extraction of low level polyaromatic hydrocarbons (PAHs) in sediments is being demonstrated for the Buffalo River and Ashtabula River demonstration projects. Low temperature thermal desorption does not destroy the organics. Instead, it removes the low temperature volatile compounds through the vaporization of the organics and water from the sediment. The VOC's and water vapor are collected for further treatment and disposal.

Thermal processes are generally the more effective options for destroying organic contaminants, but they are also the more expensive. Costs for thermal processes range from several hundred dollars to over a thousand dollars per cubic yard.

Disposal

Types of disposal technologies evaluated include confined disposal, open water disposal, and beneficial use. Confined disposal process options include controls necessary to limit contaminant transport out of the disposal site. Open water and beneficial use options should be considered for treated sediment residuals.

Summary

The alternatives available for managing contaminated sediment can be categorized as either non-removal or removal. The removal technologies reviewed for this paper have been assessed for their effectiveness, implementability and costs. Approximately thirty technology categories and over two hundred process options were reviewed as a basis for this presentation. An indication of where the treatment technologies being demonstrated in the Great Lakes ARCS program is also provided. These pilot projects will provide a basis for advancing the technology gaps that now exist for incorporation of these technologies into remedial action plans for contaminated sediments.

Appendix I. References

Averett, Daniel E., Perry, Bret D., Torrey, Elizabeth J., and Miller, Jan A. (1990). "Review of Removal, Containment, and Treatment Technologies for Remediation of Contaminated Sediment in the Great Lakes." Miscellaneous Paper EL-90-25, US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

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