
Name of Organization: USACE, Research and Development Center

Type of Organization: Federal Agency

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Project Title: Phyto-Land Treatment of Dioxin Contaminated Dredged Material

Project Category: Contaminated Sediments

Rank by Organization (if applicable): 0

Total Funding Requested (\$): 45,800 **Project Duration:** 2 Years

Abstract:

Dioxins and related chemicals, furans, are highly toxic environmental contaminants that attach to soil particles and airborne particulate matter because of their highly hydrophobic nature. They enter aquatic systems through atmospheric deposition and overland runoff and are frequently found in sediments near urban and industrial areas. In 1998, the U.S. Army Corps of Engineers, Detroit District and the Waterways Experiment Station conducted a laboratory treatability study on dioxin/furan contaminated sediment from the Saginaw River, MI. This study showed that PCB and furan concentrations in the sediment were reduced by land treatment technology, but dioxins were resistant to land treatment technology. This proposal will be a pilot-scale demonstration of a unique phyto-land treatment technology to biodegrade dioxins and furans in dredged material from the Saginaw River. Plant materials, both existing and introduced, will be grown on the Bay City, MI confined disposal facility (CDF) and managed to produce optimum plant biomass. After reaching vegetative maturity the plants will be cut and incorporated into the dredged material obtained from the Saginaw River. Pilot-scale tests will be conducted in 9.1 m diameter 0.9 m height test cells at the CDF. Dioxin/furan TEQs will be periodically measured using an innovative biomarker technique that costs about one-fifth that of standard analytical techniques. The study will evaluate the effects of plant application rates on dioxin/furan TEQ. Selection of plant materials and dosage rates will be based on laboratory bench studies conducted using various plant materials from the CDF and dioxin/furan contaminated dredged material from the Saginaw River that is already on hand. The study will be leveraged with the Corps of Engineers Dredging Operations and Environmental Research Program (DOER).

Geographic Areas Affected by the Project

States:

- | | |
|--|---------------------------------------|
| <input type="checkbox"/> Illinois | <input type="checkbox"/> New York |
| <input type="checkbox"/> Indiana | <input type="checkbox"/> Pennsylvania |
| <input checked="" type="checkbox"/> Michigan | <input type="checkbox"/> Wisconsin |
| <input type="checkbox"/> Minnesota | <input type="checkbox"/> Ohio |

Lakes:

- | | |
|---|------------------------------------|
| <input type="checkbox"/> Superior | <input type="checkbox"/> Erie |
| <input checked="" type="checkbox"/> Huron | <input type="checkbox"/> Ontario |
| <input type="checkbox"/> Michigan | <input type="checkbox"/> All Lakes |

Geographic Initiatives:

- | | | | | |
|--|----------------------------------|-------------------------------------|--------------------------------------|---|
| <input type="checkbox"/> Greater Chicago | <input type="checkbox"/> NE Ohio | <input type="checkbox"/> NW Indiana | <input type="checkbox"/> SE Michigan | <input type="checkbox"/> Lake St. Clair |
|--|----------------------------------|-------------------------------------|--------------------------------------|---|

Primary Affected Area of Concern: Saginaw River, MI

Other Affected Areas of Concern:

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

Prohibitively high cost and nonselectivity of chemical and thermal treatment technologies for contaminants in dredged material and sediments, as well as public resistance to conventional dredged material management alternatives, call for innovative management strategies for contaminated dredged material. Management methods that take advantage of the natural capability or inherent potential of sediment associated microorganisms to reduce toxicity and to eliminate or substantially reduce concentrations of contaminants could provide cost-effective alternatives to the presently available alternatives, such as capping and storage in confined disposal facilities (CDFs). Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/F) as a class are some of the most toxic xenobiotic chemicals known. Because of their physical/chemical properties these compounds are frequently found in sediments, and sediments contaminated with PCDD/Fs can be an important exposure route for aquatic life. PCDD/Fs at pg/g levels in Saginaw River sediments, for example, threaten ecological health and pose major problems for management of navigation dredgings. Little information is available on the potential for microbial transformation of PCDD/Fs, and the information that is available presents conflicting views of the biodegradability of TCDD/Fs. It is generally agreed, however, that if biodegradation of TCDD/Fs does occur in natural systems, it occurs very slowly. It is also generally agreed that photodechlorination is a principal pathway for disappearance of TCDD in environmental compartments exposed to sunlight. In 1998, the U.S. Army Corps of Engineers, Detroit District and the Waterways Experiment Station conducted a laboratory treatability study on dioxin/furan contaminated sediment from the Saginaw River, MI. This study showed that PCB and furan concentrations in the sediment were reduced by land treatment technology (simple tilling), but dioxins were resistant to land treatment technology. The data suggested that PCBs biodegraded and furans volatilized, but dioxins were stable and did not volatilize, biodegrade, or photodegrade (probably due to shading by sediment solids). The data from a follow on pilot-scale study conducted in the Fall of 1999 at the CDF are not yet available, but the results are not expected to differ significantly from the laboratory study. For the land treatment technology that was used (simple tilling) to work for the full suite of hydrophobic organics in Saginaw River sediment, tilling needs to be augmented with an improved approach.

Proposed Work Outcome:

The proposed work would continue the initiatives currently underway and would attempt to develop a new and innovative land treatment technology to detoxify Saginaw River dredged material. The proposed project would tackle the remaining problem, dioxins, in a pilot-scale study on the Saginaw CDF, Bay City, MI using fresh dredged material from the Saginaw River. The above-ground portions of plants grown on the CDF will be harvested and subsamples collected for moisture (plant juices), C:N ratio, and other determinations. The plants tops will be immediately tilled into dredged material in 9.1 m diameter by 0.91 m height test cells. (These test cells were constructed under the ARCS program.) Recent studies have shown that plant juices significantly enhance biodegradation of nitroaromatics in soils. The mechanism(s) by which enhancement occurs is not known, but it is speculated that enzymes and co-enzymes extracted from the plants facilitate

biodegradation of contaminants by soil microorganisms and may also facilitate biodegradation of TCDD/Fs. The incorporation of growing plant as a green manure will also provide a soil climate suitable for the buildup of microbial populations and fungi which may enhance degradation. Plant species and application rates will be based on bench greenhouse studies conducted using dredged material already on hand from the Fall 1999 study and already fully characterized by standard analytical techniques for TCDD/Fs and congener specific PCBs. An innovative biomarker technique developed in the Corps Dredging Operations and Environment Research Program (DOER) will be used to monitor treatment effectiveness in both the laboratory batch and field pilot experiments. This biomarker responds to the presence of TCDDs, TCDFs, coplanar PCBs, and PAHs and is a measure of the toxicity of sediments containing these chemicals. Biomarker results and conventional GC/MS analysis of sediments for TCDD/Fs, expressed as TEQs, show good correlation. At about one-fifth the cost of conventional GC/MS for TCDD/Fs, the biomarker technique is estimated to save over \$300K for the experimental design proposed for this study. The proposed experimental design includes both laboratory and pilot-scale testing and encompasses testing the efficacy of plant incorporation in laboratory studies under ideal conditions and then demonstration of treatment performance under realistic field conditions at pilot-scale on the CDF. In the laboratory study, three dosages of plant tissue from five selected plants adaptable for the Saginaw climate will be incorporated into dredged material and maintained under wet, dry, and sequential wet/dry conditions. A single control at zero dosage will also be run. Treatment effectiveness will be measured as TEQ (determined by biomarker) decline over time (6 sampling times). There will be no replication in the laboratory experiments, since each biomarker analysis generates six replicates as part of the standard protocol. The lab results will be used to determine if the field work should be pursued and if so, which plant species to use and to estimate application rates for the field study. In the field study, above-ground plant tissues from one plant species will be applied at two application rates, plus a control with no plants. Each test cell (3 total) will be tilled at two week intervals and sampled immediately prior to tilling for TEQ determination by biomarker. Five replicate samples will be collected from each test cell at each sampling event in order to effectively deal with the heterogeneity of dredged material in pilot-scale systems. The field study will run three months during late summer and early fall in order to avoid nesting gulls. At the beginning and end of the field study, samples (five replicates) will be collected for standard analysis of TCDD/Fs and congener specific PCBs. Field and laboratory data will be reduced using graphical techniques for time trends and a pseudo-first order biokinetic model will be fitted to the data to estimate half-lives. ANOVA statistical analysis will be used to determine significance of the various treatments. A Quality Assurance Project Plan (QAPP) will be prepared for the field study prior to initiation of the field study. The WES and the Detroit District have previously developed QAPPs in the ARCS program and other studies funded by GLNPO. Progress reports as per GLNPO requirements will be prepared, and an interim report on the laboratory study will be prepared. A final report in standard scientific format will be prepared, and it is anticipated that articles describing various aspects of the study will be submitted to the Journal of Great Lakes Research for publication.

Project Milestones:

Dates:

Produce Plant Material for Lab Study	09/2000
Initiate Lab Study	10/2000
Complete Lab Experiments	12/2000
Interim Report on Lab Study	05/2001
Setup Field Tests	08/2001
Complete Field Tests	11/2001
Complete Analysis of Field Data	05/2002
Complete Final Report	12/2002

Project Addresses Environmental Justice

If So, Description of How:

This project does not have a specific environmental justice component.

Project Addresses Education/Outreach

If So, Description of How:

Project Budget:

	Federal Share Requested (\$)	Applicant's Share (\$)
Personnel:	28,800	35,000
Fringe:	0	0
Travel:	7,000	7,000
Equipment:	0	0
Supplies:	0	2,000
Contracts:	5,000	5,000
Construction:	5,000	5,000
Other:	0	0
Total Direct Costs:	45,800	54,000
Indirect Costs:	0	0
Total:	45,800	54,000
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

The Detroit District has committed more than \$290K at Saginaw toward this project in FY 98 through FY 00, and the Corps Dredging Operations and Environmental Research (DOER) has committed \$50K in FY 99 through FY 00 toward this project. DOER is resourcing \$100k toward the proposed budget for FY 01 through FY 02. The Detroit District anticipates an additional \$150K to support the project in FY 02, and other District funds may become available in FY 00 and FY 01 for the project. Of course, fund availability will depend on the level of Congressional funding, Detroit District project priorities, and DOER research priorities each year.

Description of Collaboration/Community Based Support:

U.S. Army Engineer District, Detroit
Corps of Engineers Research and Development Center (Waterways Experiment Station)