VEGETATED TREATMENT OF VEHICLE WASH SEDIMENTS: DESIGN OF A MULTI-MEDIA AID DECISION SUPPORT SYSTEM

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ABSTRACT

The design of a vegetated treatment system requires a vast amount of knowledge regarding plants, climate, soils, contaminants, and their interactions. Most practicing environmental professionals do not have this background. The objective of this technology transfer activity was to provide a user-friendly system for designing vegetated treatment systems. As a method to bridge the gap of knowledge needed in designing a vegetated treatment option, a series of decision support tools were designed. The first tool was an introductory pamphlet of information regarding vegetated treatment options. The second tool was a decision support tree to help environmental professionals choose vegetation types for a particular site. The third tool was a graphical user interface decision support system that will allow the environmental professional to calculate specific parameters, such as time of treatment, regarding the site. The last tool was a manual detailing answers to various questions regarding vegetated treatment options. A multimedia decision support system, developed by combining these tools, was designed as an aid to practicing environmental professionals. Details regarding the development of the multimedia aid are presented in this paper, as well as additional information on the products used in the development.

Key words: *phytoremediation, petroleum hydrocarbons, contaminated soil, vegetation*

INTRODUCTION

When faced with remediating a contaminated site, there are many different cleanup options to choose from, including *in situ, ex situ*, technical, and simple solutions. *Ex situ* treatments include the need to remove the contaminated soil, sediment, or water from the site and transport it to a treatment or disposal facility. *In situ* treatments available include thermal treatment, chemical treatment, soil washing, volatilization, encapsulation, and biological treatment (Riser-Roberts, 1998). A recent development in biological treatment has been the incorporation of vegetation into traditional biological treatment systems such as land farming. One drawback to designing a system that incorporates vegetation is the lack of information on design parameters (Schmidt et al., 1998). A technology transfer project, using a field site at Fort Riley, Kan., is developing a multimedia product to assist practicing environmental professionals' design systems utilizing vegetation.

DESIGN REQUIREMENTS

The objective of this portion of the technology transfer project is to design an interactive system that a practicing environmental professional can use in designing vegetation-based treatment systems. Questions asked by these professionals include: "Will the vegetation work? How long will it take? What is the risk to groundwater?" In order to answer these questions, the technology transfer project needed to learn more regarding potential users and their needs. A survey of potential users

was undertaken that focussed on the technical background of the user, in terms of software usage, computer literacy, and questions that they are interested in having answers to. Results of this survey showed that the potential user wanted a system that required a limited amount of training to use (Burckhard et al., 1998, 1999). Suggestions were made that the system have databases of required information to choose from or links to sources of information, and that the design be flexible to accommodate different background levels of the potential users. A graphical user interface (GUI) that interfaced with an existing model (Burckhard et al., 1997) was designed and given to the user group for evaluation. Results from this evaluation indicated that too much emphasis had been given to the model and not enough to the simple questions that the users had. From this feedback and other comments, a combination of different products was designed to meet the needs of the users. The products consisted of a brochure on phytoremediation with a few simple case studies, a decision support tree to choose suitable candidates for vegetation (Burckhard et al., 2000), a GUI incorporating a fate-and-transport model (Narayanan et al., 2000a, 2000b), and a manual on phytoremediation.

This distributed design allowed for the different experience levels of the users and provided information that the potential user could pass on to administrators or regulators to educate them regarding the beneficial use of vegetation. The individual products are being incorporated into a multimedia product. Development of each of the products, and especially the multimedia product, involves a number of different disciplines and backgrounds. The multidisciplinary team involved in this project includes computer programmers, soil scientists, environmental professionals, regulatory personnel, researchers, agronomists, engineers, and others.

COMPONENTS OF THE DESIGN

The individual components of the design, as mentioned above, include a brochure, a decision support tree for selecting candidate vegetation types, a GUI for a fate-and- transport simulation model, and a phytoremediation manual. The integration of each of these individual products was done so that the overall product would be easy to use. The design of the multimedia product needed to be seamless and have each component within the product be compatible with and complement the other components. The integrated series includes the four components, plus a quick tour and tutorial on how to use the system.

The first highlighted component in the product is the brochure (Figure 1). The phytoremediation brochure was developed by Peter Kulakow, Larry Erickson, and Lucinda Jackson. It offers the user introductory information on phytoremediation, including a short series of case studies showing different uses of vegetation for treatment systems. The second highlighted component is the decision support tree or phytoremediation plant selector wizard. The design for this was based on a questionnaire-based decision support tree for identifying candidate vegetation types for phytoremediation

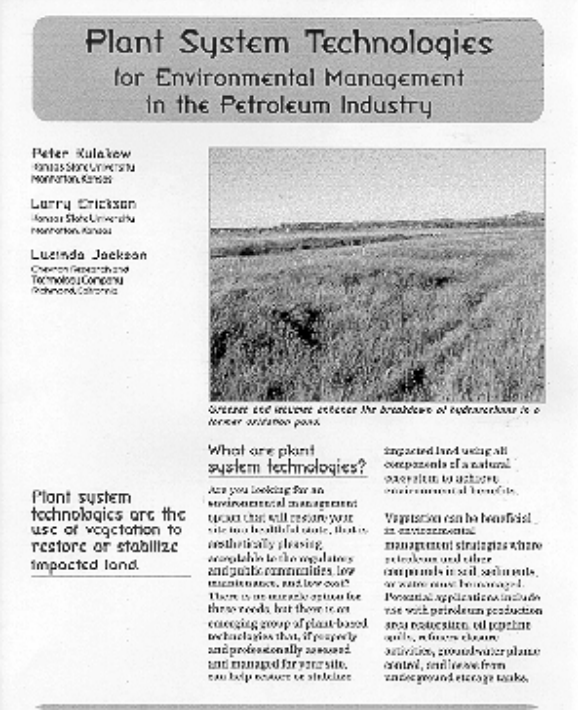

Figure 1. Front page of the brochure that is used in this multimedia product.

projects. The wizard is designed to ask questions and collect information from the user regarding required climate, soil, and contaminant parameters, to assess whether vegetation would work on the site. The output from the wizard includes a list of candidate plants that meet the climate characteristics of the region (Burckhard et al., 2000).

The GUI and associated fate-and-transport simulation model are the third highlighted component of the multimedia product. The simulation model is a one-dimensional, fate-and-transport model for solute (contaminant) flow under the influence of vegetation (Narayanan et al., 2000b). This simulation model can calculate the amount of remediation that occurs as a function of time, as well as the amount of contaminant expected to flow downward during the treatment period. The GUI is a Windows-based system to handle input, execution, and output from the model (Narayanan et al., 2000a).

The *Phytoremediation Manual* was written by A. Paul Schwab. It contains information on designing a field-based remediation project. The first part of the manual consists of a table that outlines the steps involved in a phytoremediation project. The manual provides guidance on what to data to collect, how to collect the data, and what to do with the data once it is collected. Additional information is included on the specifics of each step of designing a phytoremediation project.

The integrated product incorporated each of the specific text products, the brochure, and the manual by first converting the text into an acceptable format (PDF file). Then, links were added in the brochure or manual to specific sections of text. An additional link was made between the GUI help windows and appropriate sections of the components. The user can access the brochure or manual with or without using the GUI or decision tree.

There are several advantages of this integrated product, including an anticipated shorter learning curve due to the use of a point-and-click interface, and the ability to answer questions that are more specific with simpler answers than the previous version. One disadvantage of the integrated system was the need for a great deal of planning before any actual coding of the model, GUI, or decision tree took place. In some cases, parts of the design could not proceed without considering both future applications and other parts of the system.

SOFTWARE REQUIREMENTS

The integrated product runs on a Windows-based personal computer system. The overall package will be downloadable from a Web site and will be installed from a single compressed file. The development of the integrated product required numerous different software products. Three different computer programming languages were used. Visual Basic was used to program the plant selector wizard. Visual C++ was used to program the GUI, and Digital Visual Fortran was used for programming the simulation model. The brochure and manual were converted from their original text format into a PDF format with Adobe Acrobat. Once converted to a PDF file, the text was edited using Adobe Exchange to add the appropriate links to text sections. The databases accessed by the simulation model and the plant wizard were designed in MS Access and MS Excel.

Evaluation of the multimedia product is planned for the latter part of 2000, with initial evaluation being made by the identified group of cooperators to this technology transfer project. After feedback has been considered from this group, a release of the product will be available for other interested individuals.

CONCLUSIONS

It is anticipated that the integrated product will provide a convenient manner for practicing environmental professionals to answer simple questions regarding the use of vegetation in a treatment scenario. Data collected regarding a profile of the intended user was collected and incorporated into this design, as well as comments made regarding a non-integrated initial product design. The integrated product consists of four components, a brochure describing phytoremediation, a plant selector wizard, a GUI with an associated fate-and-transport model, and a manual describing the steps involved in implementing phytoremediation in the field. Each component of the integrated system has been designed to stand alone, as well as complement each of the other components. Evaluation of the integrated design will be in the latter part of 2000 with release of the product expected in 2001.

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REFERENCES

Burckhard, S.R., J. Kim, and V.R. Schaefer, 1998. Design of a Graphical User Interface for a Decision Support System, Presented at the 1998 Conference on Hazardous Waste Research, Salt Lake City, UT, May 19-21.

Burckhard, S.R., K. Thompson, V.R. Schaefer, P.A. Kulakow, B.A. Leven, and A. P. Schwab, 2000. Vegetated Treatment of Vehicle Wash Sediments: Development of a Decision Support Tree, Presented at the 2000 Conference on Hazardous Waste Research, Denver, CO, May 23-25, 2000.

Burckhard, S.R., M. Narayanan, V.R. Schaefer, P.A. Kulakow, and B.A. Leven, 1999. Design of a Graphical User Interface Decision Support System for a Vegetated Treatment System, Presented at the 1999 Conference on Hazardous Waste Research, St. Louis, MO, May 25-27.

Burckhard, S.R., V.R. Schaefer, and J.C. Tracy, 1997. Use of Simulated Annealing for the Screening of Phytoremediation Systems, Presented at the 12th Annual Conference on Hazardous Waste Research, Kansas City, MO, May 19-22, 1997.

Narayanan, M., J.B. Reddy, S.R. Burckhard, D.A. Gustafson, L.E. Erickson, P.A. Kulakow, and B.A. Leven, 2000a. Vegetated Treatment of Vehicle Wash Sediments: Designing a Graphical User Interface, Presented at the 2000 Conference on Hazardous Waste Research, Denver, CO, May 23-25.

Narayanan, M., S.R. Burckhard, L.E. Erickson, P.A. Kulakow, and B.A. Leven, 2000b. Vegetated Treatment of Vehicle Wash Sediments: Mathematical Modeling of Groundwater and Solute Transport, Presented at the 2000 Conference on Hazardous Waste Research, Denver, CO, May 23-25.

Riser-Roberts, E., 1998. Remediation of Petroleum-Contaminated Soils: Biological, Physical, and Chemical Processes, Lewis Publishers, Boca Raton, FLA.

Schmidt, A.M., S.R. Burckhard, and V.R. Schaefer, 1998. Parameters Used in the Modeling of a Vegetative Remediation System, Presented at the 1998 Conference on Hazardous Waste Research, Salt Lake City, UT, May 19-21.