DESIGN OF A GRAPHICAL USER INTERFACE DECISION SUPPORT SYSTEM FOR A VEGETATED TREATMENT SYSTEM

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ABSTRACT

The use of vegetation in remediating contaminated soils and sediments has been researched for a number of years. Positive laboratory results have lead to the use of vegetation at field sites. The design process involved with field sites and the associated decision processes are being developed. As part of this development, a computer-based graphical user interface decision support system was designed for use by practicing environmental professionals. The steps involved in designing the graphical user interface, incorporation of the contaminant degradation model, and development of the decision support system are presented.

Key words: *phytoremediation, simulation*

INTRODUCTION

Vegetation has been shown to increase the degradation of petroleum and organic contaminants in contaminated soils. Laboratory experiments have shown promising results which has led to the deployment of vegetation in field trials. The design of field trials is different than the design of a treatment system. In a field trial, the type of vegetation, use of amendments, placement and division of plots, and monitoring requirements are geared toward producing statistically measurable results. In a remediation treatment system, the design is based on optimizing the amount of degradation in order to reach a defined goal. In some cases, the cost of the treatment system is the most important factor; while in the other cases, the time required for treatment is more important than the cost. A design tool to assist practicing environmental professionals with the various aspects involved in designing vegetated treatment systems would decrease the amount of time needed for producing a viable design. In order to understand the various elements that are included in a decision support system (DSS) and the design of its associated delivery system, a summary of each element is given along with the resultant product.

ELEMENTS OF A GRAPHICAL USER INTERFACE

Graphical user interfaces (GUIs) came into increased usage with the popularity of the Windows operating system. The idea of point and click applications made it possible for more people to use computer systems without extensive training. A GUI is a sophisticated visual presentation that accesses resources through menus that allow the choosing of options by picking them with a mouse pointer or other input device. The interface has a restricted set of options, making it more difficult for the user to choose incorrect or improper items.

A GUI makes extensive use of a person's recognition memory. The learning curve for a GUI is typically shorter than with non-graphical interfaces. The typing requirements are limited and therefore fewer errors are associated with using a GUI. Since most GUI designs are for a Windows-based operating system, certain menus and options are standard, such as: File, Edit, View, and Help.

ELEMENTS OF A DECISION SUPPORT SYSTEM

A decision support system (DSS) is a system used to simulate various combinations of a decision options in order to choose the best set of options to solve a given problem. The DSS may have a complicated simulation model as its base or a simple economic comparison model. The types of variables needed as input to the DSS depends on the type of problem that is being solved and the possible solution types that are simulated. Output from the model also depends on the possible solution types that are simulated. For a landfarming DSS, the output may include the depth to place the contaminated soil, the recommended intervals for aerating the soil during treatment, and the possible length of time required for treatment.

ELEMENTS OF A TREATMENT SYSTEM FOR VEHICLE WASH PIT WASTE

Facilities used to wash dirt from vehicles typically collect the wash water in such a manner as to trap the grit and soil, thereby not allowing the material to enter the wastewater collection system. Typically, the sediments found in these collections systems are contaminated with various hydrocarbons such as lubricants, fuel, and oil. Due to this contamination, disposal of these sediments is governed by various regulations. Disposal options for the sediments are placing the sediments in a licensed solid waste disposal facility or treatment to remove the contamination. With the number of solid waste disposal facilities decreasing in recent years and the need to conserve landfill space becoming more critical, treatment of the sediments to remove contamination is being performed. Various treatment options include chemical leaching treatment, bioremediation, and phytoremediation (Riser-Roberts, 1998).

Chemical leaching techniques cost more compared to bioremediation or phytoremediation options, due to the cost of chemicals and the disposal of the used chemicals. Landfarming and composting approaches to remediate contaminated soil require labor for monitoring and maintenance of the soil during the treatment process. A phytoremediation or vegetated treatment system is designed to require limited maintenance or other inputs. The optimal design of a vegetated treatment system depends on a number of factors.

First, the sediments being removed from the collection basin, after draining, would need to be tested for TPH (total petroleum hydrocarbon) content. The sediments would then be transferred to a site, with limited access, and placed in a layer so that they may be seeded. After seeding, the site would require limited monitoring of the vegetation's growth and the TPH level within the soil. The health, extent, and diversity of the vegetation can be visually monitored, while the TPH level would require the collection of soil samples.

DECISION SUPPORT SYSTEM DESIGN PROCESS FOR THE VEGETATED TREATMENT SYSTEMS

In designing a DSS, the problem that is to be solved, the types of simulated solutions and their associated decision variables, and the simulation model need to be defined. In the vegetated treatment system, many parameters are associated with simulation models. A list of the typical parameters is shown inTable 1. Using this list as a base, each parameter was examined and categorized as readily available from the literature, available from standard testing of a field sample, and others. Each parameter was discussed with the group of environmental professionals involved in the design of this GUI. Besides discussing parameters, the group was asked to provide a list of their desired outputs from the DSS (Table 2).

By comparing the list of readily available input parameters and the desired outputs, a flowchart of the DSS operation was generated (Figure 1) along with a description of the required simulation model. It was decided to write a specific simulation model to use for simulating the fate and transport of contaminant under the influence of a vegetated treatment system. Several models were noted in the literature (Davis et al., 1993; Jin et al., 1994; Campbell, 1991) but were not considered appropriate due to the amount of required inputs and the limitations of the outputs.

GRAPHICAL USER INTERFACE DESIGN PROCESS FOR THE DECISION SUPPORT SYSTEM

In general, the GUI design process can be split into twelve steps (Galitz, 1997):

1. Know your user
2. Understand the 'business function
3. Use good screen design
4. Select the proper types of windows
5. Develop the system menus
6. Select the proper device-based controls
7. Choose the proper screen-based controls
8. Organize and layout the windows
9. Choose the proper screen colors
10. Create meaningful icons
11. Provide meaningful messages
12. Test, test, and retest

Following the design process, a questionnaire was prepared to better understand the 'typical' environmental professional who would be using the GUI. Questions were divided into several categories: computer hardware and software literacy, user profile, and talk analysis. Some of the questions, although basic in nature, were required to ascertain the type of computer operating system to design for and the types of support system that would be incorporated in the design.

INCORPORATION OF THE CONTAMINANT DEGRADATION MODEL

The contaminant degradation model used for this DSS is a 1-D solute transport model, incorporating root growth, water movement, contaminant movement, contaminant degradation, and the effect that vegetation has on these. Required inputs to this model are soil texture, climate data, plant type, contaminant type, and contaminant level.

THE WASH PIT WASTE DECISION SUPPORT SYSTEM PRODUCT

The initial screen for the Wash Pit Waste Vegetation Treatment System DSS allows the user to open a project, and access various menus from the menu bar or by pointing at the icons shown. Each menu bar entry, Figure 2, allows the user to enter information required for input or output from the simulation model. The icon bar, Figure 3, also allows the user to enter information. Each icon represents a different set of parameters to enter. The first three icons are for the soil, contaminant, and degradation parameter menus. The next three represent the boundary and initial conditions; and the last three are for the physical and temporal simulation parameters, and the run button for the model. Users can build a project and run a project, then view the output by accessing the appropriate menu items. Help menus are provided to guide the user through the process.

CONCLUSIONS

A decision support system designed for a vegetated treatment system for vehicle wash pit waste was designed to meet the needs of a group of environmental professionals. Within the design process, various data had to be collected on the people using the DSS, the characteristics of the vegetated treatment system, and the typical wash pit waste generated.

FUTURE RESEARCH

Additional research is planned on comparing the model output results to those collected for several field sites.

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Table 1. Typical parameters associated with the simulation of a vegtated remediation treatment system.

Parameter type	Examples of required information
Soil	Texture, specific storage, specific retention, saturated and unsaturated hydraulic conductivity, specific yield
Vegetation	Plant type, leaf area index, root hydraulic conductivity, root permeability, root death rate, root proliferation rate, root elongation rate, biomass yield, permanent wilting point
Contaminant	Henry's law coefficient, solubility, adsorption coefficient, degradability, diffusion coefficient, dispersion coefficient, root concentration factor, transpiration stream concentration factor
Simulation Controls	Number of nodes in problem; maximum allowed number of plants, soils, contaminants; output variables, time step for calculations
Initial conditions	Soil, plant, contaminant, water content

Table 2. Data provided by the contact group regarding input and output parameters.

Readily available input parameters	Desired output parameters
Soil texture, plant type, climate TPH contaminant level, target contaminant treatment level, volume of soil requiring treatment	Depth-to-layer contaminated soil for treatment, time-to-reach-target contaminant level, management needs of treatment system

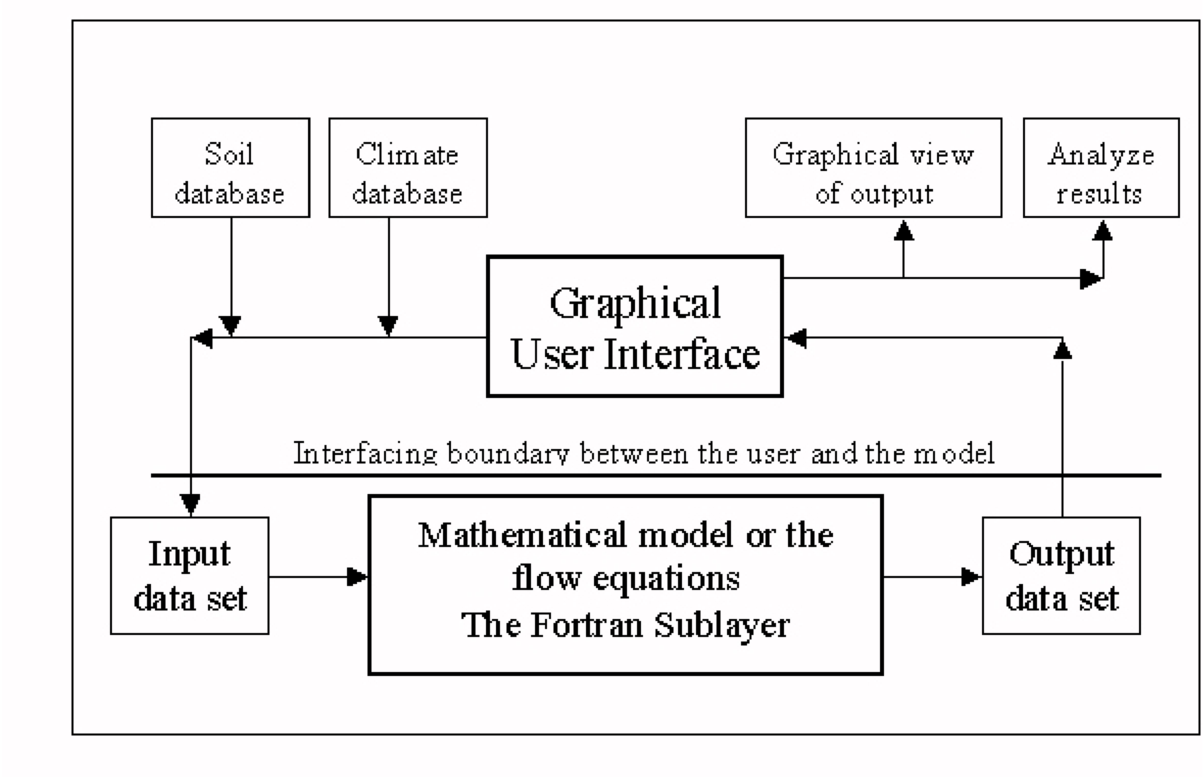

Figure 1. Flowchart describing the interactions between the simulation model and the graphical user interface.

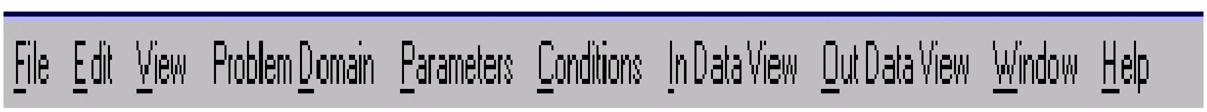

Figure 2. The menu bar for the graphical user interface.

Figure 3. The icon bar from the graphical user interface.