VEGETATED TREATMENT OF VEHICLE WASH SEDIMENTS: DESIGNING A GRAPHICAL USER INTERFACE

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ABSTRACT

Graphical user interfaces (GUIs) help to create user-friendly interactions between a complicated mathematical model application and an inexperienced user. The GUI helps to package the various software components that are essential for effective user interactions, while the mathematical model helps to simulate the fate and transport of water and solute in subsurface soil environments. For a successful GUI deployment, integration of the following various components is essential: 1) an input component comprised of graphical units such as graphics editor, menu bars, tool bars, and dialog boxes allows the user to generate useful site-specific data; 2) a database component retrieves or updates information about specific soil properties, solute properties, plant properties, and climatic conditions of a site; 3) the mathematical model component, developed in FORTRAN, executes the input generated by the input component; and 4) the output component of the GUI displays to the user the model predictions in a graphical format. A friendly graphical manner of model predictions helps the user to quickly comprehend and make effective management-related decisions such as irrigation and fertilization requirements. This GUI is also a useful tool for practicing environmental professionals who are training to make decisions with regards to vegetation-based treatment systems and amount of time needed for producing a viable design.

Key words: *GUI, contaminated site, decision making*

INTRODUCTION

Vegetation-based treatment options are gaining acceptance as a viable treatment option for contaminated soils, sediments, and waters (Erickson et al., 1994; Schnoor et al., 1995; Davis et al., 1998). Using vegetation to treat a contaminated soil, sediment, or water requires specialized knowledge about the contaminant, climate, choice of vegetation, and interaction of all these factors. Most practicing environmental professionals do not possess a complete knowledge of all these areas. The purpose of this technology transfer project is to provide an easy-to-use means for practicing environmental professionals to make decisions regarding the use of vegetation in designed remediation systems. The project consists of a number of parts, including a graphical user interface (GUI) for practicing environmental professionals to use as part of a decision support system (DSS). The purpose of this GUI is to provide an easy manner for practicing environmental professionals to enter data for the fate-and-transport model and to obtain easy-to-interpret results from the model.

THE DECISION SUPPORT SYSTEM (DSS)

A DSS is used to access various combinations of input data to reach a decision. The types of problems that a DSS can be employed with can be simple or complex. For example, as a user installs software on a computer system, they may be prompted to provide certain information through a DSS. This simple DSS for the software installation may ask questions regarding where the program will reside on the machine, what files to install, and what preferences to set up in the application. These questions are asked so that the user installs the software in the best manner for their usage.

A complex DSS may ask questions or provide a manner to enter data to best solve, possibly mathematically, a given problem. A complicated mathematical model may be embedded in the core of a DSS. In our DSS design, a mathematical model is used to provide information on the fate and transport of contaminants in a specified vegetated treatment system. Output from the DSS (essentially from the model) depends on the desired solution. For example, if land farming is the preferred method of remediation, the output may include the depth to place the contaminated soil, recommended soil aeration, and possible length of treatment time required.

A DSS for a vegetated treatment system involves a number of components. The operation of the DSS needs to be well thought out in order to have a successful system. For our application, the GUI was designed as a DSS for choosing various parameter values (listed in Table 1) associated with the underlying core solute fate-and-transport model. Next, the fate-and-transport model would be executed, after the input is checked for completeness. Finally, the output from the DSS, such as effect of vegetation to enhance biodegradation, possible containment of the contaminant, and extent of volatilization of contaminant, is presented for analysis.

FATE AND TRANSPORT MODEL

The fate-and-transport model used in the DSS and GUI was specifically designed for this application. The model is for flow in the vertical or z dimension. The model incorporates soil-water movement, soil-water uptake by plants, contaminant movement, degradation, volatilization, and uptake by plants. Required inputs to this model are soil texture, contaminant type and level, planting type, climate type, and other site-

Table 1. Typical parameters associated with the input of a vegetated DSS for remediation.

Parameter	Examples of required information
Soil	Texture, specific storage, specific retention, saturated hydraulic conductivity, specific yield, soil dispersivity, organic matter content
Vegetation	Plant type, root-water pressure head, maximum water uptake by plants, root-length density along depth
Contaminant	Henry's law coefficient, carbon adsorption coefficient, degradability, gaseous diffusion coefficient, octanol-water partition coefficient
Simulation controls	Soil domain of interest, output variables, time length for simulation
Initial conditions	Groundwater table, plant type, contaminant type and level, water content
Boundary conditions	Upper boundary as climactic variations, contaminant type, and level

specific information. For further information on the model development, please refer to the paper by Narayanan et al., entitled, "Vegetated Treatment of Vehicle Wash Sediments: Mathematical Modeling of Groundwater and Solute Transport," included in these proceedings.

GRAPHICAL USER INTERFACE (GUI)

GUIs are sophisticated visual software tools with "menus", "toolbars" and "dialogs" that enable easy choosing of options, execution, and analyses of results. The restricted options of a GUI help the user by preventing the choice of improper items for input variables, execution settings, or analyses. GUIs gained popularity with the Windows operating system. One attractive characteristic of a GUI is the learning curve for a graphical-based tool is shorter than the corresponding textual-based tool (Galitz, 1997). The GUI could be developed in Visual C++, Visual Basic, or Visual Java computer languages. The GUI presented here is developed using Visual C++. System requirements for this GUI are for a Windows 95 OS or higher versions, minimum processor speed of 486x, and disk space of 20 MBytes.

There are a number of expectations for the GUI designed for this application. The first is to promote user-friendly interactions between the complicated model and the non-technical user. The second is to package the tools such as input data set, databases, complicated mathematical model, and output data set for easy usage, execution, and analyses of results. Third, the GUI is to provide easy graphical plots of the output predictions from the mathematical model to help the user analyze various types of output. After interviewing individuals targeted as part of the potential user group, a number of specific outputs were identified (Burckhard et al., 1998; 1999). These outputs, shown in Table 2, were grouped in four categories: soil-water movement, solute transport in soil and extent of degradation, the role of vegetation in containing contaminant infiltration, and assessment of a vegetation-based treatment strategy as a whole. In addition, help in making management-related decisions on extent of irrigation and fertilization required can be based on the model results. This GUI is intended to act as a tool for practicing environmental professionals making decisions with regard to the use of vegetation-based treatment systems at a contaminated site.

COMPONENTS OF THE GRAPHICAL USER INTERFACE

Figure 1 shows the interaction of the various components within the GUI. The GUI is the interfacing boundary between the user and the fate-and-transport model. The GUI contains links to a series of databases and a graphical output system to view model results. A data set is constructed, with the aid of the GUI, for the fate-and-transport model. Through proper controls in the GUI, the fate-and-transport model is executed and output data is generated. Once the output data is generated, it can be viewed within the GUI environment.

Figures 1 through 8 show a series of screens and menus that the user will see as he or she constructs input files for the model. The first screen, Figure 2, shows a welcome screen and

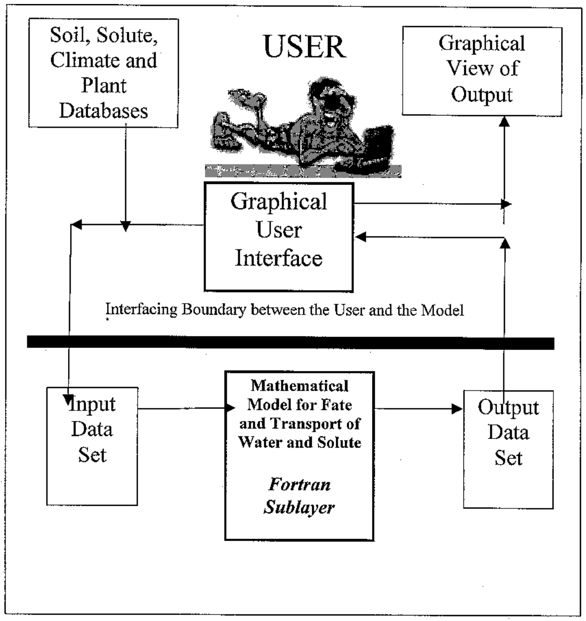

Figure 1. Schematic representation of component interactions within the graphical user interface.

Figure 2. Opening screen of the graphical user interface.

has links for instructions in using the GUI, model development, and help menus. From the welcome screen menu, the user chooses an existing project or new project. Figure 3 shows the screen and menu items for a partially completed project. Figure 4 shows the menu for choosing the time-related simulation parameters; while figures 5, 6, and 7, allow the user to input information on the soil, vegetation and climate, and solute (contaminant), respectively. Figure 8 is the menu for entering information on groundwater depth, and Figure 9 shows the menu for entering degradation parameters for the contaminant. Further menus guide the user through the model execution. After the model has been executed, the user can access the output data for analysis. Besides the menu system, a series of help menus are provided. Additionally, default settings have been entered in some menus to help the user build the input file. Where appropriate, an explanation of the

Table 2. Typical output associated with the vegetated DSS for remediation.

Parameter	Examples of information reported
Soil-water	Profiles of: 1. Soil-water content along the soil depth at any time of simulation
Contaminant	Profiles of: 1. Contaminant levels along the soil depth at any time of simulation 2. Data on contaminant movement past any soil location along simulation time
Water velocity	Profiles of: 1. Water velocity along the soil depth at any time of simulation
Contaminant flux	Profiles on direction of solute movement: 1. Along the soil depth at any time of simulation 2. Against time at any particular soil location

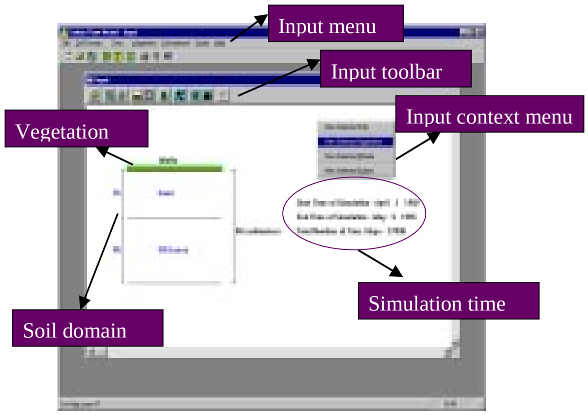

Figure 3. Example screen showing a project using alfalfa as the vegetation type chosen for a two-layer soil system, and sand and silt loess, with a three-year time of simulation.

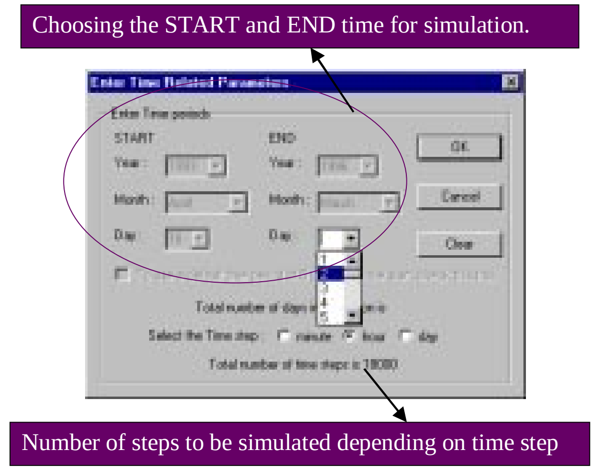

Figure 4. Menu for entering simulation start and end times.

required information is provided as part of the menu.

CONCLUSIONS

A GUI-based DSS is a useful tool for non-technical users who are tasked with making technical decisions. In this paper, the design of a GUI, for use in a DSS for practicing environmental professionals making decisions regarding use of vegetation in designed-remediation systems, is presented. The expectations of the DSS, and therefore the GUI, necessitated the development of a fate-and-transport model and an easy-to-use system for inputting data to the model, executing the model, and viewing output from the model. The system shown has many components and additional support documentation to help the user. A non-technical user would be able to go through the series of menus and build a remediation project for the fate-and-transport model to run. At this time, further work is planned on the implementation and testing of the GUI, the model, and the DSS.

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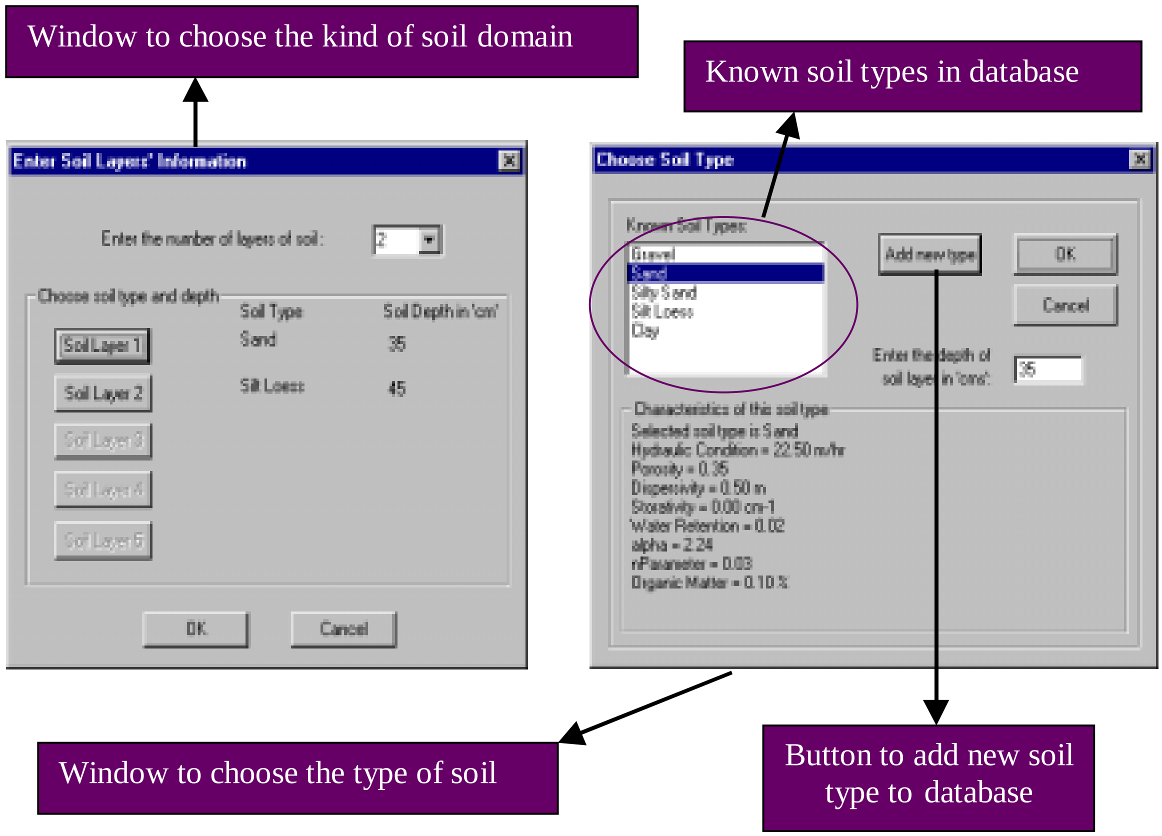

Figure 5. Menus for entering the number and types of soils present in the simulated remediation project.

agency, and no official endorsements should be inferred.

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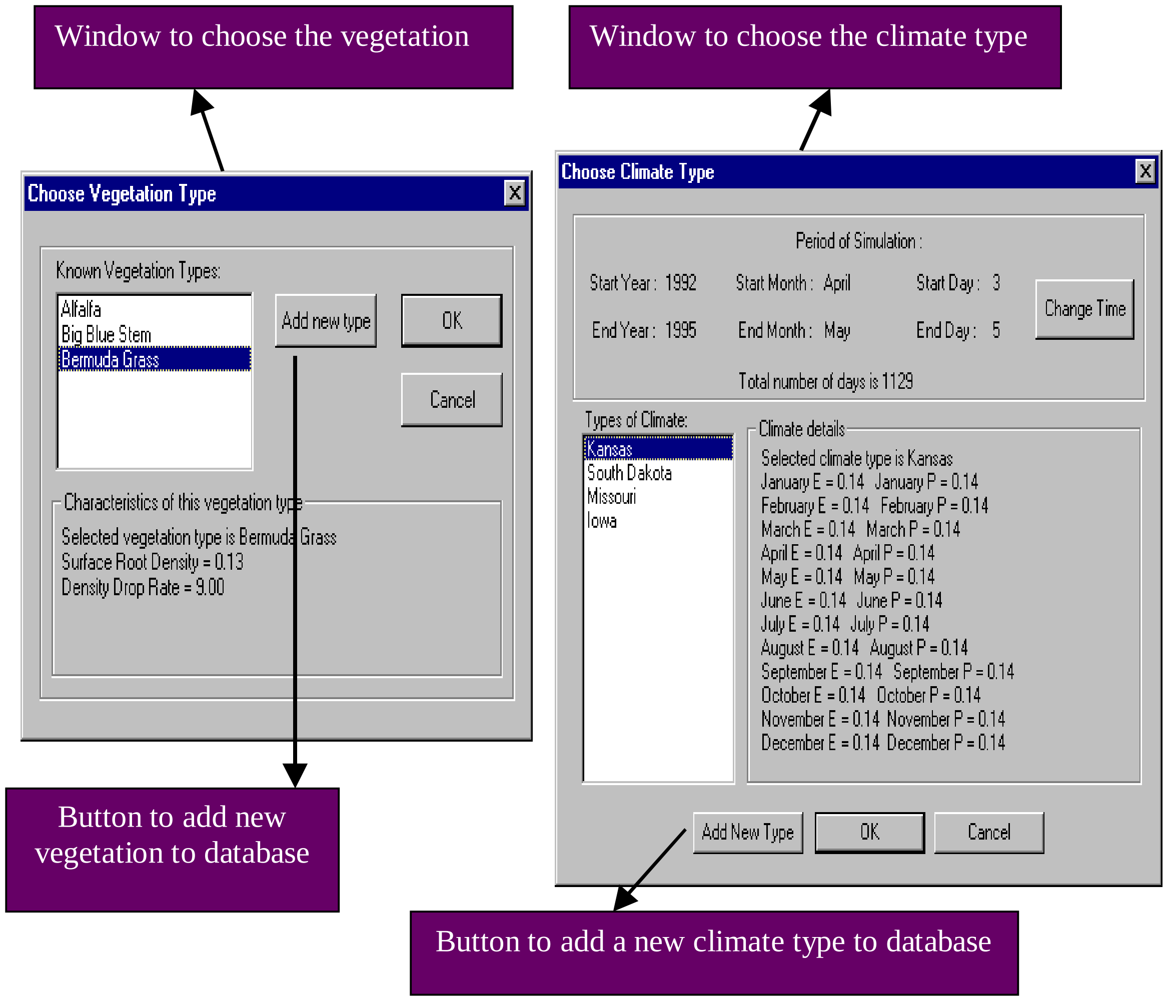

Figure 6. Menus for entering the type of vegetation to use for the simulated treatment system and the climate parameters associated with the project site.

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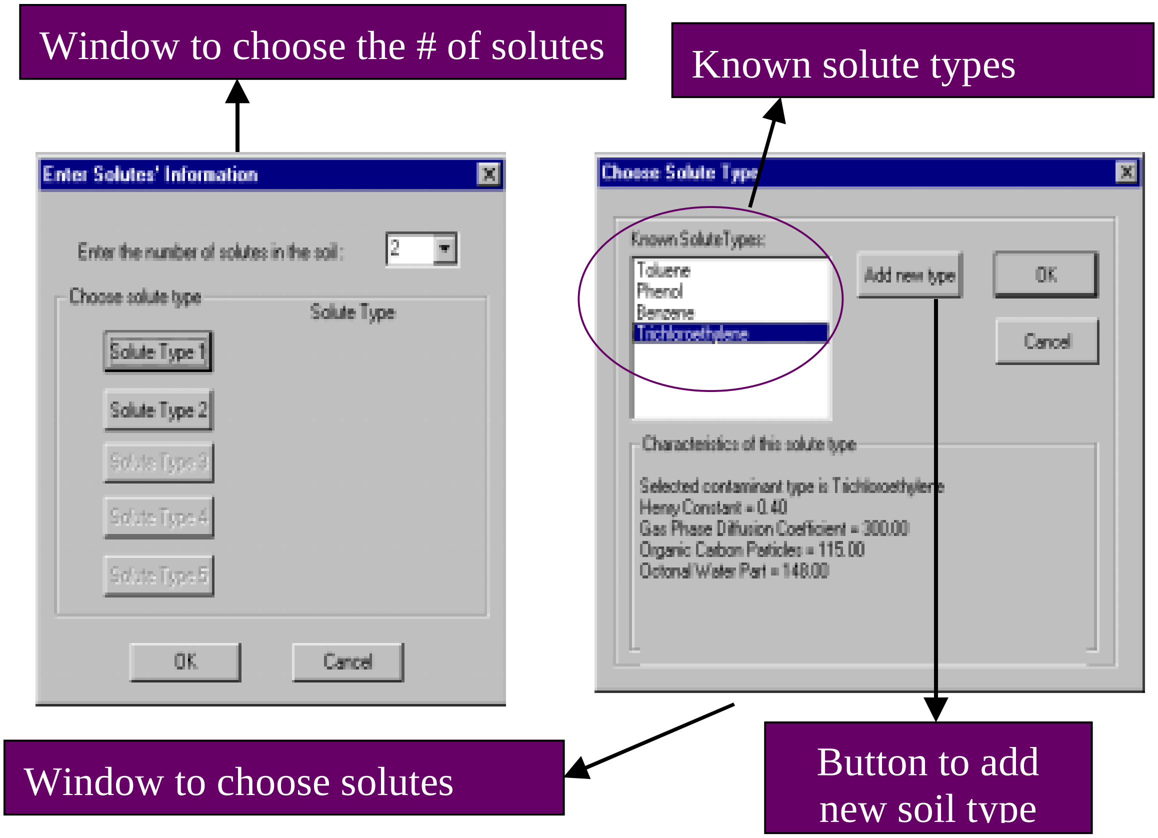

Figure 7. Menus for entering the number and types of solutes (contaminants) present in the simulated remediation project.

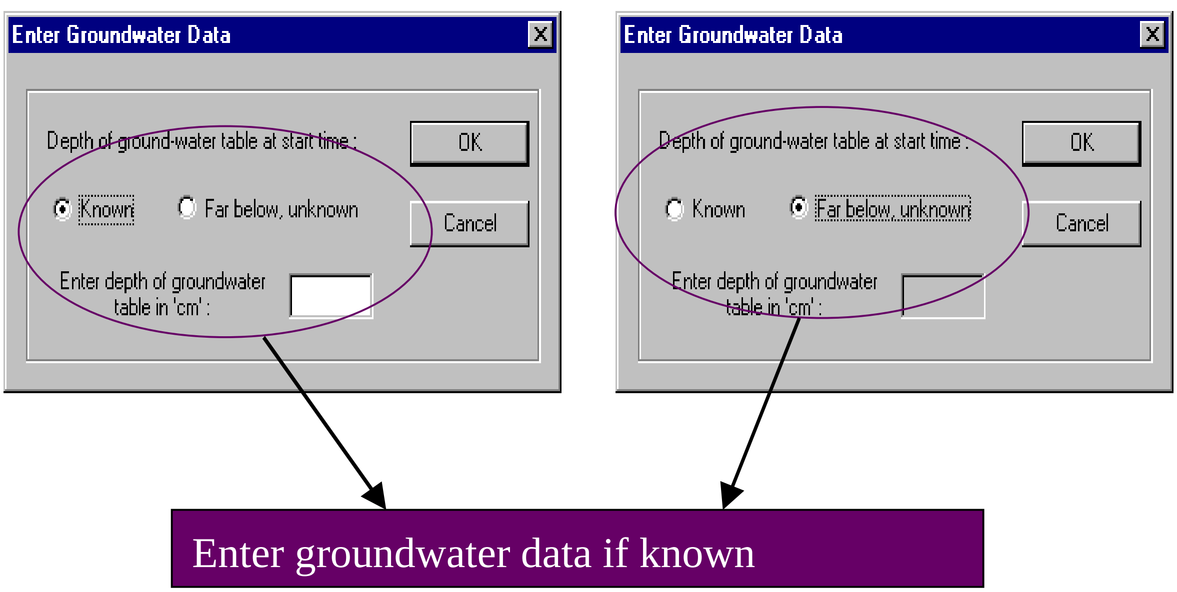

Figure 8. Menus to enter groundwater information.

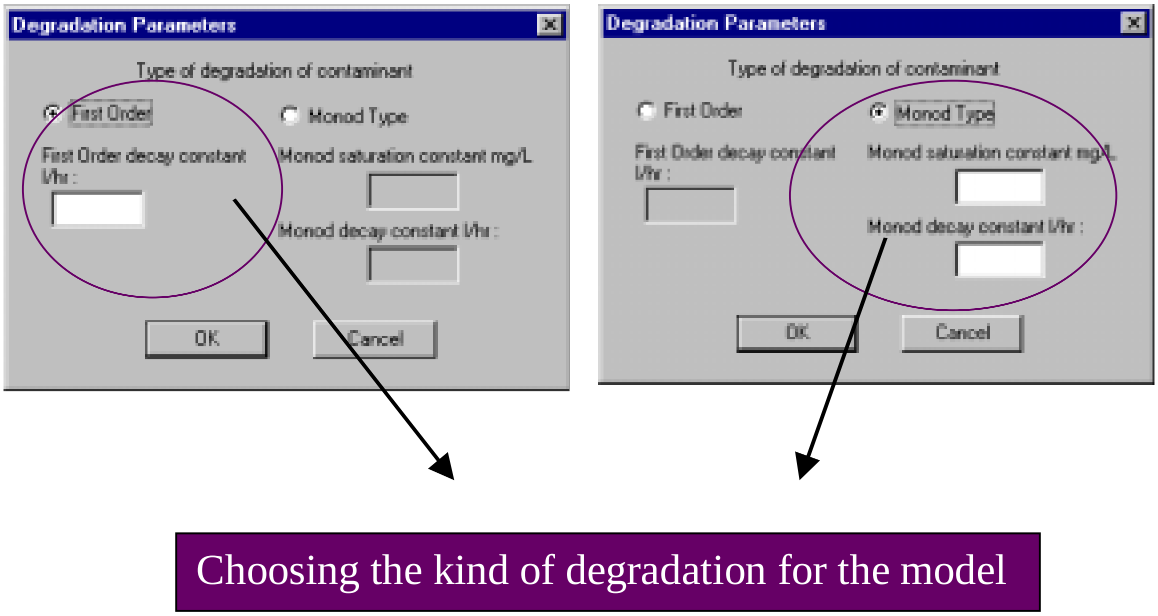

Figure 9. Menus for entering degradation parameters for the simulated remediation project.