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# RULE BASE SYSTEM IN DEVELOPING GROUNDWATER POLLUTION EXPERT SYSTEM: PREDICTING MODEL

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## ABSTRACT

New techniques are now available for use in the protection of the environment. One of these techniques is the use of expert system for prediction groundwater pollution potential. Groundwater Pollution Expert system (GWPES) rules are a collection of principles and procedures used to know the comprehension of groundwater pollution prediction. The rules of groundwater pollution expert system in the form of questions, choice, radio-box, slide rule, button or frame are translated in to IF-THEN rule. The rules including of variables, types, domains and descriptions were used by the function of wxCLIPS (C Language Integrate Production System) expert system shell.

## INTRODUCTION

Groundwater is the largest source of fresh water stored under ground. Presently, due to economic reasons, the most preferred use of groundwater is for drinking purposes although it could also be used for domestic, agricultural and industrial purposes. Groundwater pollution is defined as the decrease of water quality due to human activities. [In decision related to environmental problems and protection have using computer applications.] One technique available to them was the use of expert system. There are many applications and studies using the technology of expert system to support Environmental Impact Assessment (EIA) (Berka, 1995, Kleban and Stephen, 1996). An expert system is a knowledge-based program that provides expert "quality" solutions to problems in a specific domain. The structure of expert systems cannot be clearly defined owing to the many tools and languages in which they are developed. The basic structures of most expert systems can be generalized into several categories. These are knowledge-based, context, interference mechanism, explanation facility, knowledge acquisition and user interface (Mercer 1995). The main objective of this study is to produce an expert system that more efficient groundwater pollution control plan could be developed and undertaken especially helping to understand groundwater pollution and also to predict the pollution.

## SYSTEM DEVELOPMENT METHODOLOGY

After, knowledge acquisition sessions with the expert and others document then overall structure and organization of the system's knowledge is defined. Methods are also defined for processing the knowledge. A software tool is chosen where it can represent and reason with the system's knowledge in a manner that is similar to the approach taken by the human expert. During the design stage, an initial prototype system is built to review the test result with the domain expert. The task starts with the selection of the knowledge representation technique. Groundwater Pollution Expert system (GWPES) is a small prototype system is then built to both validate the project and to provide guidance for future work. The system is then further developed and refined to meet the project objectives.

### Prototype Development

The GWPES development is carried out after wxCLIPS (C Language Integrate Production System) is selected as the software that best meets the requirements of this project. The purpose of this prototype is to: validates the expert system approach, confirm the choice of knowledge representation technique and control strategy, and provide a vehicle for knowledge requisition. Different shells use different mechanisms for representing and handling knowledge; some mechanism, are appropriate for some type of expert system applications but totally in appropriate for others (Van Name et al., 1989). The wxCLIPS is ideal for the initial prototype of GWPES. Just as any conventional software, system prototypes in expert system allow users to experiment with requirements and to see how the system supports their work. Prototyping in expert system software development is a means of requirement validation, The benefits of developing prototype early in the software process are elaborated by Sommer Ville (1996). There are missing user services may be detected, problematic function may be identified and refined, any inconsistent/incomplete requirements can be identified, demonstrate the feasibility and usefulness of the application to management, and the prototype can be used as a basis for writing the specification.

In this study, the prototype of GWPES illustrates in Figure 1. It is divided into six main parts. There are introduction, EIA procedure, concept, Model, mitigation and monitoring. The introduction, EIA procedure, and concept parts will help all interesting people and the environmental impact assessment proponents to produce existing groundwater introduction, to understand groundwater pollution and to fill-in the groundwater parts of matrix. The last three main parts; i.e. prediction, mitigation and monitoring will be incorporated into the expert system to predict the future situation of groundwater, to propose the possible mitigation measures and to approach the groundwater quality monitoring program.

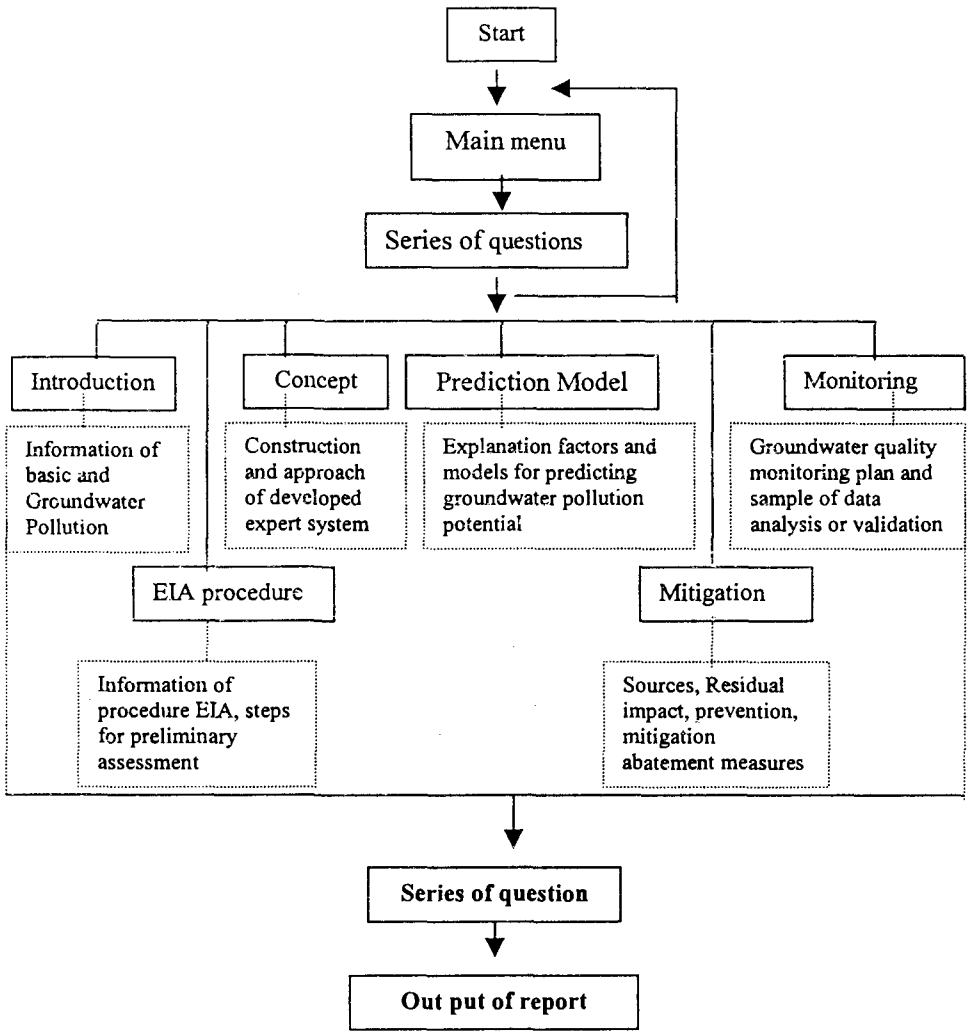


Figure 1: The prototype of the Groundwater Pollution Expert System (GWPES)

## Rule Base System

The human expert then reasons about the problem by combining the sort-term memory (STM) fact with the long-term memory (LTM) knowledge. Using this process, the expert infers new problem information and eventually arrives at conclusions about the problem. Figure 2 shows a backing diagram of the problem solving approach used by an expert. While, GWPES related about knowledge representation technique that best matches the way the expert mentally models the problems of predicting groundwater pollution was required. In this study, wxCLIPS expert system shell uses rules-based representation. The rule-based model is illustrated in Figure 2. The IF-THEN rule has a goal to look for corrective action of a prediction mode where Action is a parameter that appears in the then part of the rules i.e. all the rules that provide a recommendation to the user.

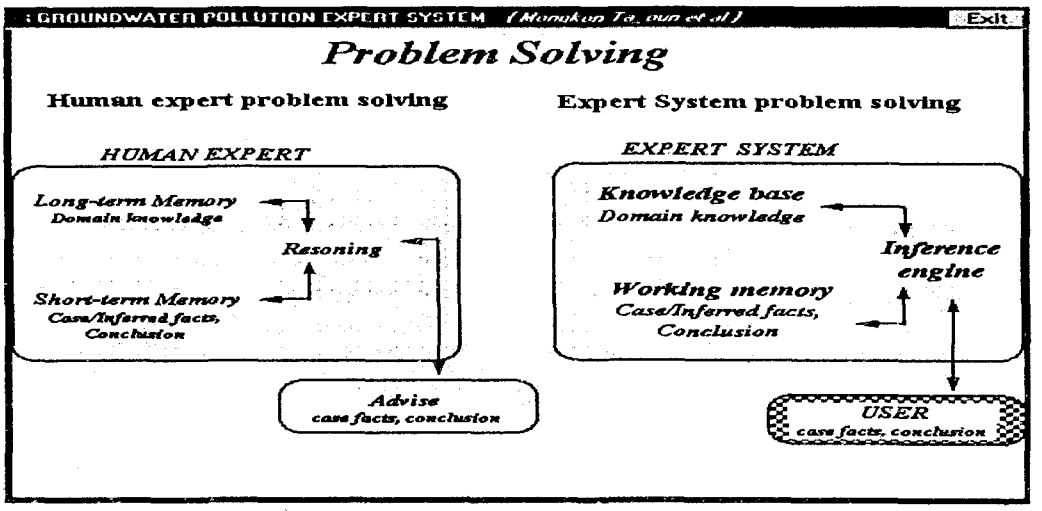


Figure 2: Human Expert Problem Solving and Groundwater Pollution Expert System (GWPES) Problem Solving by Using Rule Based Model

The rules of groundwater pollution expert system in the form of questions, choice, radio-box, slide rule, button or frame are translated in to IF-THEN rule. The rules including of variables, types, domains and descriptions were used by wxCLIPS language function. There are the variables shown in the Table 1. The rules topics used for GWPES, there are six parts which shown in the Table 2. The details, which are listed in table, will be discussed in the section only Rule for Model Prediction Functions.

Table 1: The Variables, Local, Global Used by the GWPES Program

| No. | Variable Name | Type | Domain | Description |
|---|---|---|---|---|
| 1 | MK_TA | global | all function | sub frame variable |
| 2 | panel1 | global | all function | panel variable |
| 3 | tex-win1 | global | all function | text-win variables |
| 4 | save,quit,clear | local | button, choice | save, exit, clear function |
| 5 | dialog | local | dialog-box | questions function within dialog box |
| 6 | choice | local | choice-create | questions function within choices list |
| 7 | bitmap | global | all function | image variable |
| 8 | button | local | frame-button | list information |
| 9 | check | local | check-box | list information |
| 10 | radio | local | radio-box | questions function within radio box |

Table 2: The Rules Topics Used for GWPES Development

| Rules Topics: Groundwater Pollution Expert System (GWPES) | |
|---|---|
| Function | Description |
| 1 Introduction | General information of groundwater |
| 2 EIA procedure | Principle of Environmental Impact Assessment (EIA) |
| 3 Concept | Procedure of construction of this expert system/GWPES |
| 4 Prediction | Factors and modelling for predicting groundwater pollution |
| 5 Mitigation | General groundwater pollution mitigation / protection |
| 6 Monitoring | Approach the method of groundwater quality monitoring |

**Rule for Model Prediction Functions**

Rules for Groundwater Pollution Predictions are to illustrate the principle of factors and modelling for predicting groundwater pollution using slide buttons and expert system questions. The details of functions are listed below will be discussed in the following sections.

*1 Basic factors for prediction*

Basic factors for predicting are to explain ranking of factors environmental affecting to groundwater pollution by scoring. Rules of basic factors for predicting groundwater pollution potential were to explain factors environmental affecting to groundwater pollution. There are shown in Table 3. The description of them will provide information of Peninsula Malaysia and some factors from Northern Boniua ( Saba and Salawak). In case of the user no existing factors available in the project area, users will be guided by selecting the interesting information of the factors to be used in the models for predicting groundwater pollution potential.

*2 Predicting groundwater pollution potential*

*2.1 Demonstration slide model*

Rules for Groundwater Pollution Predictions represent on demonstration slide model are to illustrate the principle of factors and modelling for predicting groundwater pollution using slide buttons. The principle shows prediction of groundwater pollution potential in construction area or operation of project activities. The slide-button or demonstrate slide model, which is easy to understand the factors affect the vulnerability of that area. It is three dimension's model with slide scale moving showing the violence of each factor. The violence degree vary according to the type of the factor depended on the existing environment of development project strength of violence various by type of factors of existing environment of development project. The user can print out the prediction and data in order to collect as text file for the report or another purposes.

Table 3: Rule base of groundwater pollution vulnerability

| Factors | Domain Expert Recommendation (Rating) |
|---|---|
| **Depth to groundwater (feet)** | |
| 0 –5, 5 –15, 15 –30, 30-50, 50-75, 75-100, 100+ | very high, high, medium, low, very low |
| **Net annual recharge (inches )** | |
| 0 – 2, 2-4, 4-7, 7-10, 10+ | very low, low, medium, high, very high |
| **Primary media(aquifer)** | |
| 1. Massive shale | very low |
| 2. Metamorphic/Igneous/Weathered metamorphic/ Igneous | low |
| 3. Glacial till | medium |
| 4. Massive sandstone or Limestone<br>Bedded sandstone ,limestone ,and sequences | high |
| 5. Basalt or Sand and grave | high |
| 6. Karst limestone | very high |
| **Soil media** | |
| 1. Non shrinking and non aggregated clay | very low |
| 2. Clay loam | low |
| 3. Silt loam | low |
| 4. Loam | medium |
| 5. Sandy loam | medium |
| 6. Shrinking and/or aggregated clay | high |
| 7. Sand | very high |
| 8. Gravel or Thin or absent | very high |
| **Topography factor (Percent slope ( %).** | |
| 0 – 2, 2-6, 6-12, 12-18, 18+ | very high, high, medium, low, very low |
| **Vadose zone media** | |
| 1. Confing layer | very low |
| 2. Silt clay or Shale | low |
| 3. Limestone orMetamorphic / Igneous | medium |
| 4. Sandstone or Bedded Limestone ,Sandstone, and Shale or Basalt or Sand and grave / with significant silt clay | medium<br>medium |
| 5. Sand and gravel | high |
| 6. Karst limestone | very high |
| **Hydraulic conductivity (gpd / ftt$^2$)** | |
| 1-100, 100-300, 300-700, 700-1000, 2000, 2000+ | very low, low, medium, high, very high |
| **Texture of Aquifer Media** | |
| Clay loam, silt clay, lateritic clay | very low |
| fine-medium sand, some silt | very low |
| medium sand | low |
| medium-coarse sand | medium |
| medium-coarse sand | high |
| coarse sand or gravel | very high |

Using demonstration slide model prediction, there are seven factors affecting to groundwater pollution by using slide buttons and scales to identify the violence of each factor. Moving slide buttons is to predict the violence of groundwater pollution

vulnerability. On the main rules there are 8 buttons and 7 slide buttons. Upon clicking any of the buttons another screen appears for the user to read the information of the factors affecting to groundwater pollution vulnerability. All seven slide buttons illustrate the numeric value translated from the important factor related to groundwater pollution vulnerability. Thus, the prediction of groundwater pollution vulnerability must use both buttons and slides button of each factor.

*2.2 Predicting groundwater vulnerability*

Rules for predicting groundwater pollution vulnerability are to illustrate the principle of factors and modelling by using the expert system questions. The rules show the result of prediction on groundwater pollution vulnerability potential in pre-construction area of project activities. There is an interface between expert system and user. These rules consist of the question showing high resolution of prediction. To use this expert system effectively, user just answer expert system questions by selecting choices and inputting data of 7 factors environmental affecting. After answering the question to expert system. Expert system will analyse, evaluate, predict and identify groundwater pollution vulnerability. It proceeds to the numerical answer, showing the score, text document and information of existing environment of evaluated project activity area.

*2.3 Predicting nitrogen fertiliser impact*

Rules for predicting groundwater pollution potential from nitrogen fertiliser impact are used the questions in model which shows high resolution of prediction. this is an interface between expert system and user. To use this expert system effectively, user just answer expert system questions by selecting choices and inputting data of seven factors environmental affecting and factors of nitrogen fertiliser application. This model has the detail of general information of recommended nitrogen fertiliser rates that are suitable for various crop types in all over Peninsula Malaysia, particularly, Cameron Highland area in the state of Pahang. Where there have been being vegetable productions and high rate of nitrogen fertiliser application has been being used. After answering the question to expert system. Expert system will analyse, predict and identify groundwater pollution potential. It proceeds to the answer/resulting, showing the text document and information of existing environment of evaluated project activity area.

*2.4 Predicting agricultural activities impact*

To use this expert system effectively, user just answer expert system questions by selecting choices and inputting data of 7 factors environmental affecting and factors of significant impact of agricultural activities. After answering the question to expert system. Expert system will analyse, predict and identify groundwater pollution potential. It proceeds to the answer/resulting, showing the text document and information of existing environment of evaluated project activity area. The user can print out the prediction and data in order to collect as text file for the report or another purposes.

*2.5 Predicting project activities impact*

Rules for groundwater pollution prediction form project activities impacts are to illustrate the principle of factors and modelling. The prediction was used question model showing high resolution of prediction. The system has several questions for user selected in predicting groundwater pollution potential. There is an interface between expert system and user. To use this expert system effectively, user just

answer expert system questions by selecting choices and inputting data of 7 factors environmental affecting and factors of significant impact of project activities. The answer from the first question or choice selection directs the system to specified next question, while the answer from the second to the end question leads to knowing the system partial recommendation. The rules including of variables, types, domains and descriptions were used by wxCLIPS language. There are the variables. While, all recommendations consisting of text document and image files were used in these functions. All the knowledge bases were converted into the rules in the menu form and sub-main frame form.

After answering the question to expert system. Expert system will analyse, predict and identify groundwater pollution potential. It proceeds to the answer/resulting, showing the text document and information of existing environment of evaluated project activity area. The user can print out the prediction and data in order to collect as text file for the report or another purposes.

## CONCLUSION

The all rules of functions this expert system were translated into the form of questions and choice selections. They were showing some of the possible answers for all questions and choice selections. Rules for Groundwater Pollution Predictions are to illustrate the principle of factors and modelling for predicting groundwater pollution using slide buttons and expert system questions. In case prediction, GWPES has identified the significance of the relationship between sources of pollution and the area vulnerability to groundwater pollution.

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