AN EXPERT SYSTEM FOR PREDICTING GROUNDWATER POLLUTION POTENTIAL FROM THE IMPACT OF LIVESTOCK FARMING

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ABSTRACT

The large production of waste in modern society and developed agriculture such as intensive livestock farming can often pose a threat to groundwater quality Accuracy and quality of groundwater environmental impact assessment report depend significantly on the environmental scientists with the experience or proficiency in specific field of study in groundwater to clearly assess the impact of livestock farm activities Therefore, the application of a computer technology in the form of an expert system will be able to help in the analysis, management and mitigation measures of the groundwater pollution information. An expert system for predicting the impact of livestock farming on groundwater pollution potential was established by using CLIPS software This expert system could predict the groundwater pollution potential under several condition of livestock farming and existing environments. Therefore, appropriate mitigation measure can be applied efficiently

INTRODUCTION

Since Malaysia is one of the highly developed countries in South-east Asia and in the developing world as a whole, the intensive use of natural resources has resulted in large production of wastes in developed agriculture such as intensive livestock farming. Degradation of groundwater quality can take place over large areas from non-point or diffused sources such as deep percolation from intensively farmed fields into the underground environment. In regions with high livestock density, deposition of ammonia can have a serious impact on groundwater.

Problems on modern industrial farms include; ugly buildings, noise and vermin. Liquid and gaseous byproducts of farms are a source of smells and microbiological contamination, while animal wastes contaminate, groundwater and increases its nitrate content (Humbert, 1993). In many areas, livestock farming is undoubtedly the largest single source of nitrogen. A nitrate problem results whenever the nitrogen applied, of whatever kind, is not taken up by plants and reaches groundwater aquifers (Bonnieux et. al., 1995). As a result , there is a huge quantity of manure which cannot be disposed of through normal agricultural practices (the pollution of groundwater and this surplus being the pollution of groundwater and surface water by nitrate (Bennett and Baldock , 1991)). In sandy regions of the Netherlands , intensive pig production has led to groundwater contamination such as nitrate , and heavy metals (copper , zinc and cadmium) (Coleoul , 1992). In Northwest Germany for example, pig and poultry of the individual farm populations are very dense, so that slurry can be safely disposed of without causing groundwater pollution (Bohnenkemper , 1993).

Expert systems are typically classified according to the type of problem to which they are applied. Categories of expert systems include interpretation, diagnostic, prediction, design, planning, control, repair, debugging, monitoring, and instruction. The three most common applications of expert systems in groundwater contamination studies are interpretation, diagnostic and prediction (Crowe, 1994).

OBJECTIVE

The main objective of this study is to produce an evaluation or guideline to used for selection the appropriate model for groundwater, environment impact assessment. The specific objectives are following :

- To extract opinion from selected experts on groundwater and knowledge base from established literature related to the impact of livestock farming development.

-To develop a comprehensive expert system for groundwater environmuntal impact assessment of livestock farming that could be used as a tool in evaluating , approving , monitoring, and mitigation measure of the compliance of the approved guidelines.

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METHODOLOGY

A study was carried out from several sources of established literature and domain expert to get knowledge base and rule base for expert system. The detail of methodology are following :

-An expert system for predicting the impact of livestock on groundwater pollution potential was developed by using CLIPS (C Language Integrated Production Systems.), a computer software developed by NASA/ Lyndon B. Johnson Space Centre in 1984 (Joseph, 1993).

-To predict groundwater pollution potential, DRASTIC model was incorporated into this expert system. (DRASTIC is a method of empirical model and consisted of several factor for determining relative aquifer vulnerability. Where, D is depth to water table, R is net water recharge, A is aquifer medium, S is soil medium, T is topography, I is impact of vadose zone medium, and C is hydraulic conductivity (Baum, 1994)

- To minimize and compensate groundwater pollution , mitigation measure and monitoring program will be introduced by using the knowlege base from environmental impact assessment reports(EIA) submitted to Department of Environmental(DOE) , established literature and domain expert.

RESULTS AND DISCUSSION

The outcome of this study is a production of an expert system that used for groundwater environmental impact assessment to aid in predicting the impact of livestock farming development.

GROUNDWATER POLLUTION EXPERT SYSTEM SKELETON

In developed to this expert system structure with using by CLIPS CLIPS is an OPS like forward chainmg production system written in ANCI C. The CLIPS inference engine includes truth maintenance , dynamic rule addition , and customizable conflict resolution called COOL (C LIPS Object OrientedLanguage) which is directly integrated with the inference engine. This expert system will be developed using a modular programming technique and window capabilities "Toolbox" facilities will be use extensively especially for the input output operations. CLIPS provide a cohesive tool for handling a wide variety of knowledge with support for three different programming paradigms:

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1. RULE BASED

Rule based programming is one of the most commonly used techniques for developing expert systems. Rule are used to represent heuristics or "rules of thumb". which specify a set of actions to performed for a given situation. It is composed of two portions : 1. If , and 2. Then.

The if portion is a series of patterns which specify the data or fact which cause the rule to be applicable. The process of matching data or facts to pattern is called Pattern Matching. The expert system tool provides a mechanism (i.e. the inference engine) which automatically matches fact against patterns and determines which rules are applicable.

The then portion is the set of actions to be executed when the rule is applicable. The actions of applicable rules are executed when the inference engine is instructed to begin execution. The inference engine selects a rule and then the actions of the selected rule are executed. The inference engine then selectes another rule and executes its actions. This process continues until no application rules remain.

2. OBJECT ORIENTED

Object oriented programming allows complex system to be modeled as modular components. Object oriented design and programming is a way of developing a computer program by packaging data variablesand process function in to common group called objects (Sullo, 1994).

3. PROCEDURAL

The procedural programming capabilities provide by CLIPS are similar to capabilities fourd in languages such as C , Pascal, ADA and LISP.

The expert system skeleton for predicting groundwater pollution potential can be presented as the main flowchart shown in Figure land 2. The skeleton of the expert system for groundwater is divided into four main parts :

1. Introduction
2. Concept
3. Model
4. Mitigation

Both the introduction and concept parts will help the environmental impact assessment proponents to produce existing groundwater introduction and to fill-in the groundwater parts of matrix. The last two main parts; i.e. model and mitigation will be incorporated into the expert system to predict the future situation of groundwater and to propose the possible mitigation measures.

PRODUCTION OF AN EXPERT SYSTEM

Developec expert system can be used easily by any users , sine the expert system is setup for running in WINDOW structure frame of expert system will be consisted of choice which can be selected by user will tell user by loading data files, calculating data base , thus,

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user can get more information of groundwater pollution impacts by project activities , mitigation measure , groundwater data base , groundwater standard, and general information groundwater evaluation. The outcome of expert system will present on monitor , file output, picture graphical , sound and print out.

INPUT EXISTING DATA FOR PREDICTING

Using expert system to predicting groundwater pollution potential will have the question and possible answer to choose. Just key in the answer number of derived question as shown in figure 3-4. The number of the result is the characteristic of the fact of the area condition using for agriculture in the area where needs to evaluate. There are only 7 questions and answers are not more than 9 choices. They are in narrow scope. It is because to wake it easy for the evaluation , uncomplicated for the user. Eventhough, the fact of the area conditions where are evaluated will hare the geological or hydrogeological complicated, and there is the difficult answers. Thus, to use the expert system is slightly correct However, the expert system may be an alternative which is able to predict the trend of the result that will cause the groundwater pollution from agriculture and other activities. In the near future , the expert system will be completely develetely and can be widely used in other development activities.

OUTPUT OF EVALUATION FROM AN EXPERT SYSTEM

After putting in the answer numbers of the questions. Then the expert system will evaluate the data by the combination of these question. The result from the combination has 264,600 conditions and is able to divide into 4 groups. There are as follows:

1 The area which is vulnerability to negligibly groundwater pollution potential.

2 The area which is vulnerability to lowly groundwater pollution potential.

3 The area which is vulnerability to highly groundwater pollution potential.

4 The area which is vulnerability to extremely groundwater pollution potential.

Thus, the results of the evaluation are show in the figure 5 and 6. The expert system not only shows the result of the prediction in text form of the drastic level which will be able to affect the groundwater pollution in the studied area but also there is the combination of data both questions and answers to show the result of groundwater vulnerability model which is the button function shows slide scale of 7 factors using in the evaluation and there is the connection shows the result of the evaluation in the scale of the drastic level of the pollution as show in figure 6. However , the level of scale group or the percentage of the drastic using in the predicting groundwater pollution potential may be displaced it the condition of the results are in the range of two evaluation levels for instance, the level that is

not drastic and slightly drastic or the level which has highly drastic and extremely drastic. However, the result of the evaluation from the expert system will be an alternative which should be used tc evaluate the groundwater pollution impact from project developments and others activities.

CONCLUSION

The skeleton of an expert system for predicting groundwater pollution potential from the impact of livestock is divided into four main parts. Both introduction and concept parts will help the Environment Impact Assessment(EIA) proponents to produce existing groundwater introduction and to fill-in the groundwater parts of matrix. The last two main parts: i.e. model and mitigation will be incorporated into the expert system to predict the future situation of groundwater and to propose the possible mitigation measures. The expert rules will come in the form of "if-else". Knowledge extracted from EIA reports(rulebase) were used preparing the expert system skeleton. The expert system could predict the groundwater pollution potential under several conditions of livestock farming activity and existing environments. Therefore, appropriate mitigation measures can be applied efficiently. Using a sample of intensive farms, a policy scheme combining the control of animal feed and nitrogen use can be assessed.

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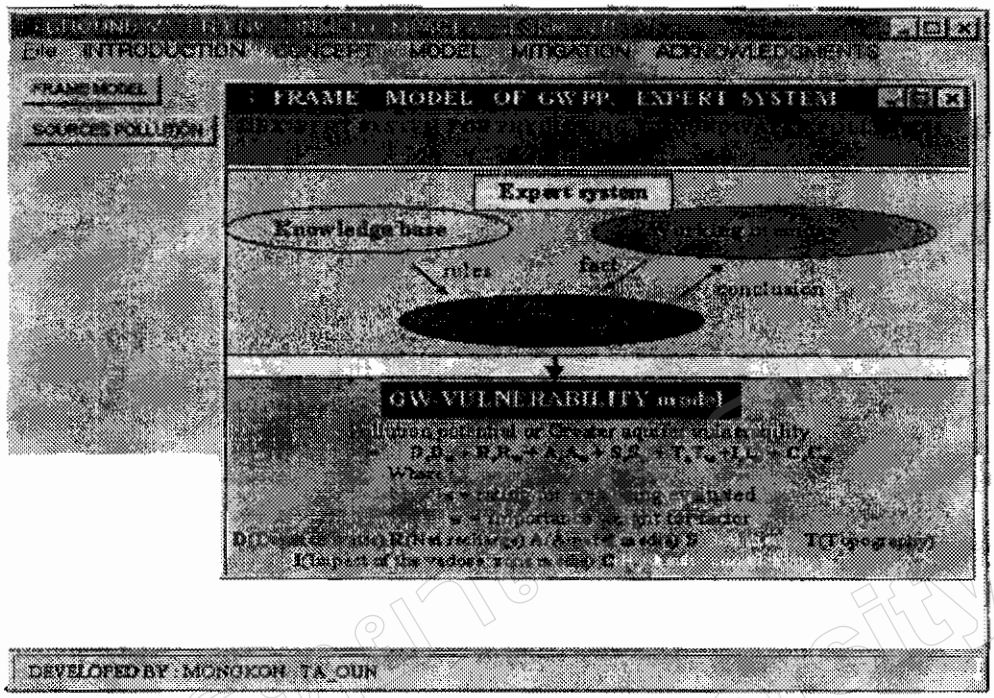

Figure 1 The component of expert system and modeling for groundwater environmental impact assessment.

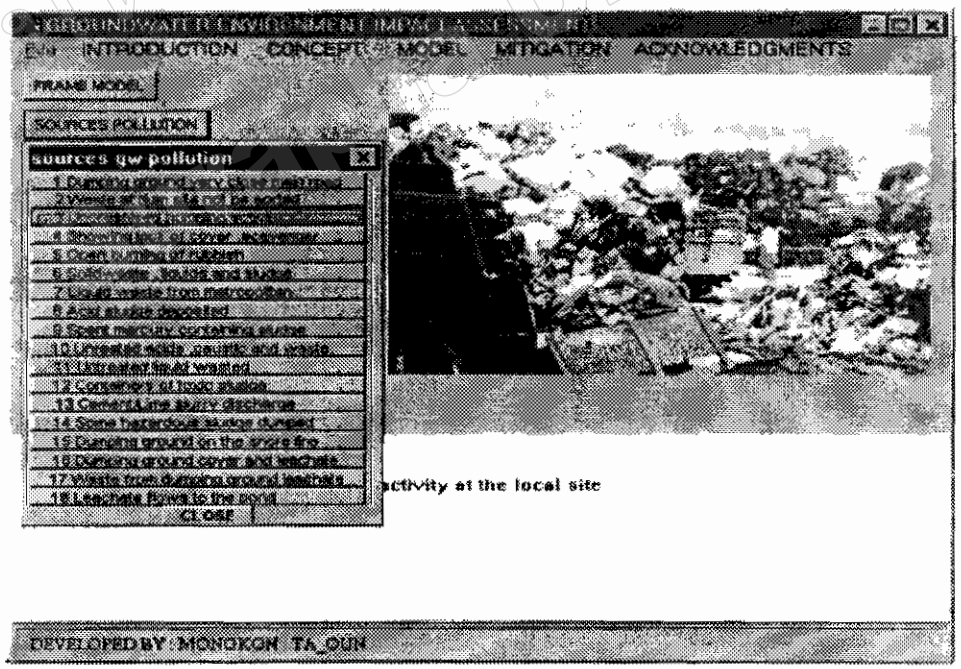

Figure 2 The structure of expert system and an example of groundwater pollution sources

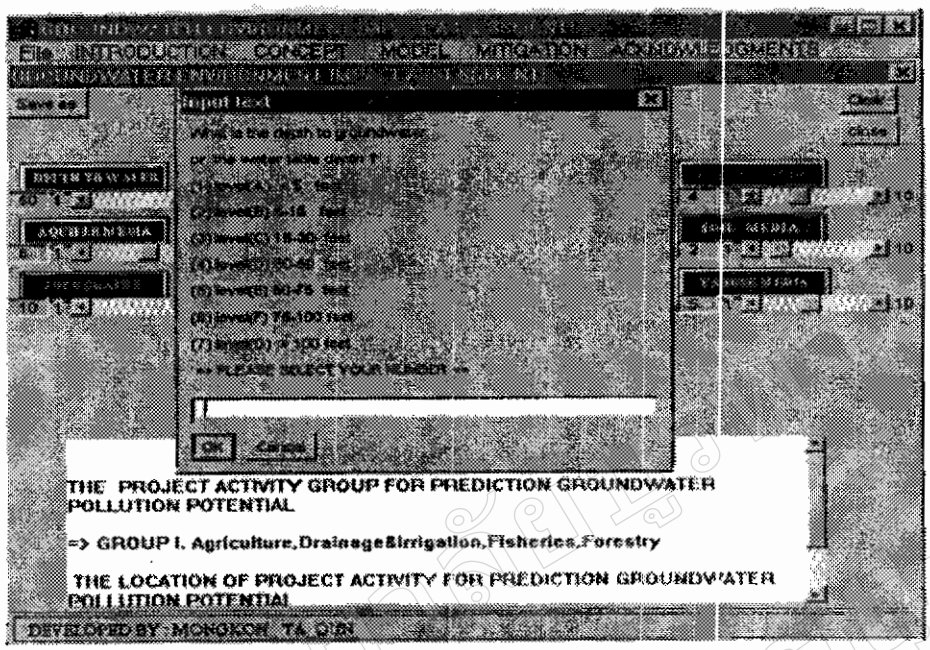

Figure 3 Question : What is depth to groundwater or the water table depth tending to affect on groundwater pollution potential? (possible answers are shown as choices on screen)

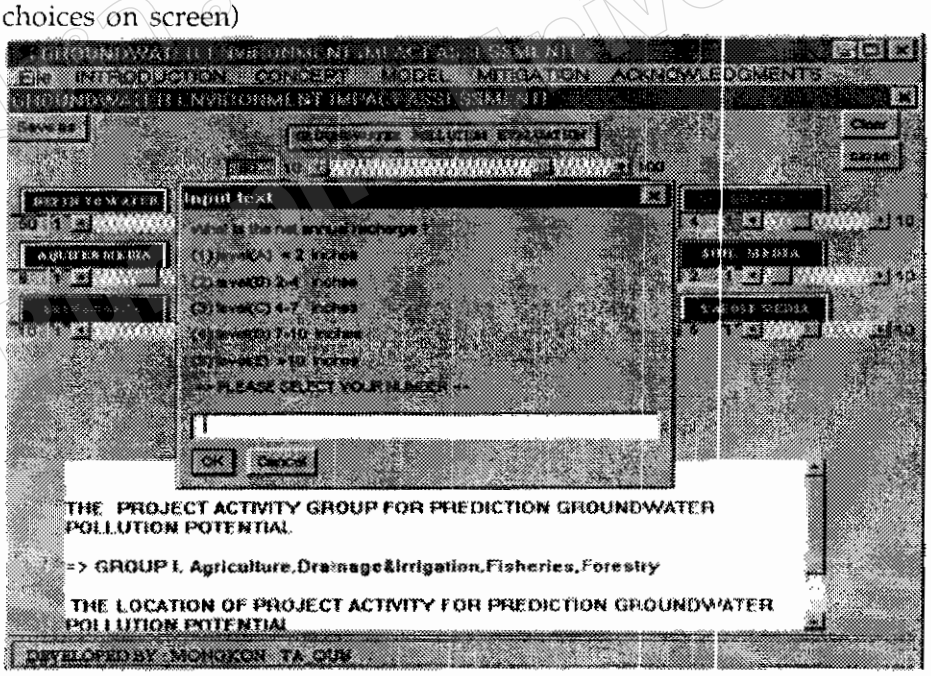

Figure 4 Question : What is net annual recharge tending to affect on groundwater pollution potential? (possible answers are shown as choices on screen)

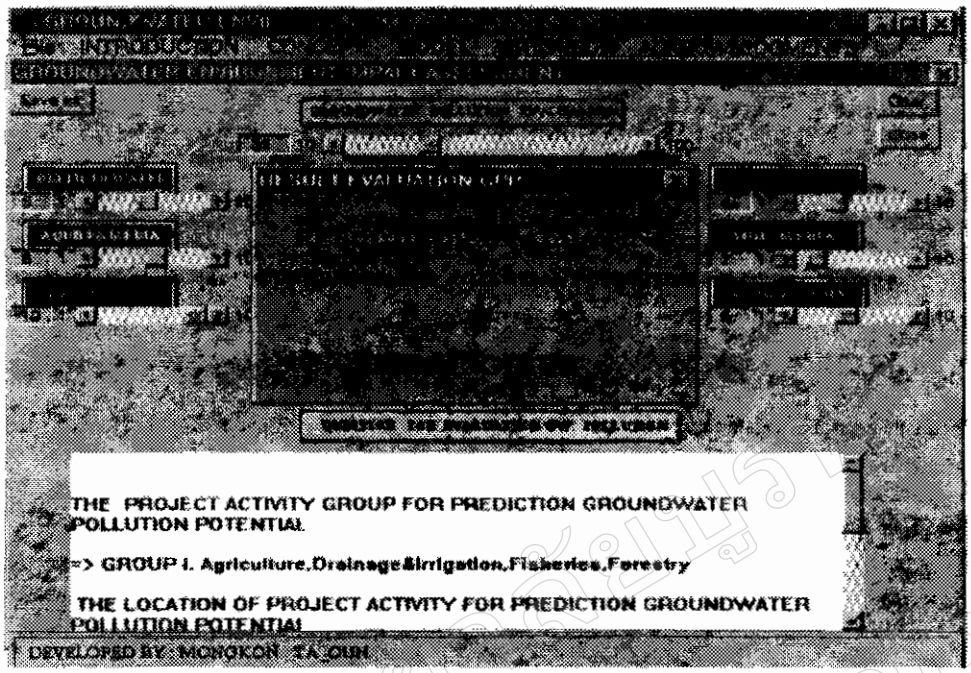

Figure 5 Example of result of evaluating groundwater pollution potential (Negligible)

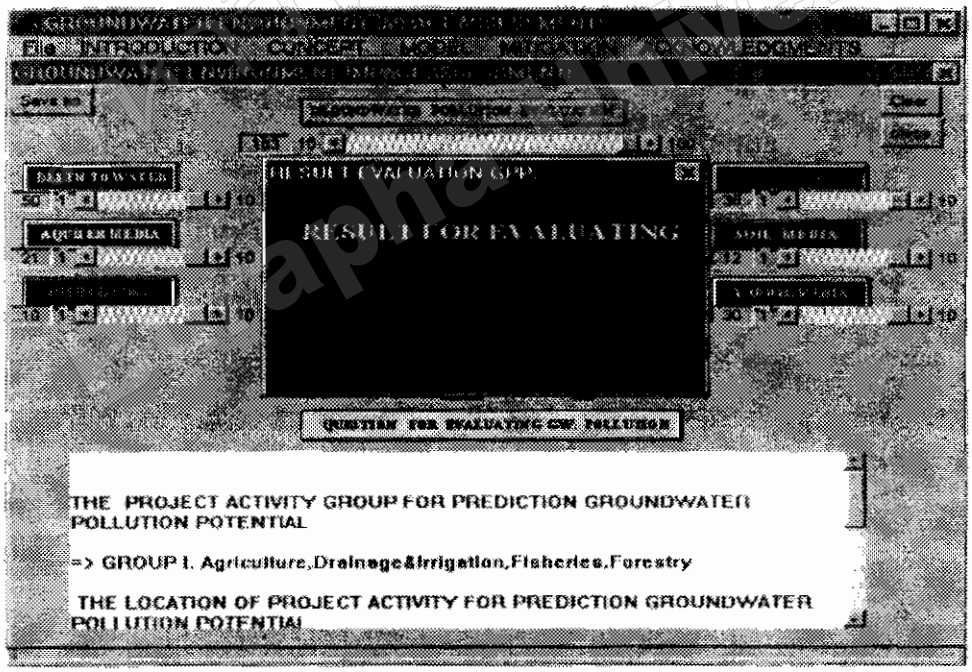

Figure 6 Example of result of evaluating groundwater pollution potential (Extreme) and scale of factors.