



UNIVERSITI PUTRA MALAYSIA

**AN EXPERT SYSTEM FOR PREDICTING AIR POLLUTION
DUE TO DEVELOPMENT**

NASSERELDEEN AHMED KABBASHI

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**AN EXPERT SYSTEM FOR PREDICTING AIR POLLUTION
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BY

NASSERELDEEN AHMED KABBASHI

**Thesis Submitted in Fulfilment of the Requirements for the
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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

To my beloved Wife,

Son Musaab,

and all my Family.

I dedicate this work with great and appreciation for their kindness,
encouragement, patience, endurance and sacrifice.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligent
ES	Expert system
KB	Knowledge base
WM	Working memory
IE	Inference engine
LTM	Long term memory
STM	Short term memory
HVS	High volume sampler
EIA	Environmental impact assessment
DOE	Department of environment
EIS	Environmental impact statement
PM	Procedural manager
DSS	Decision support system
Eis	Environmental impact system
TSP	Total suspended particulate
GIS	Geographical Information System
NO ₂	Nitrogen dioxide
SO ₂	Sulfur dioxide
PM10	Particulate matter
LHS	Left hand side
RHS	Right hand side



Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

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BY

NASSERELDEEN AHMED KABBASHI

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Chairman : Dr. Ir Mohamed Daud

Faculty : Engineering

Air is one of the important media for living creatures to survive their lives. The number of pollution complaints received by the Department of Environment (DOE) rose sharply and the number of air pollution complaints far exceeded other complaints, a few air pollutants called criteria air pollutants, can injure health, harm the environment, and cause property damage. In an environmental impact assessment (EIA) reports, the study to identify, predict and evaluate the impacts on the environment of a proposed project and to detail out the mitigating measures prior to project approval and implementation is very important. Due to shortage of manpower it is very difficult to verify that the developer or the project manager actually complies with the approved EIA guidelines



The purpose of this study is to develop a comprehensive expert system (ES) in air pollution that could be used as a tool in preparing an EIA evaluation and also as a tool to be used as an aid for approval and monitoring of an EIA study during the construction and operational stage of prescribed activities. This was carried out by: (1) detailed study of air impact analysis presented in EIA reports submitted to the DOE, (2) literature review about air quality and (3) Designing rules for air impact analysis to be incorporated into the EIA.

Therefore, the application of a computer technology in the form of an expert system for air pollution using CLIPS helps in the analysis and management of EIA information.



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**SISTEM KEPAKARAN UNTUK MERAMAMALKAN
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Oleh

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Udara adalah salah satu media yang penting untuk semua kehidupan. Aduan mengenai pencemaran udara yang diterima oleh Jabatan Alam Sekitar (DOE) semakin meningkat terutama jumlah aduan mengenai pencemaran udara. Sebahagian daripada kriteria pencemar udara, boleh mendatangkan kesan negatif terhadap kesihatan, membahayakan alam sekitar dan merosakkan harta benda. Di dalam laporan kesan alam sekitar (EIA), satu kajian adalah penting untuk mengenalpasti, menjangka dan menilai kesan terhadap alam sekitar daripada sesuatu projek yang akan dicadangkan, seterusnya mengambil tindakan yang perlu untuk kelulusan projek tersebut. Kekurangan tenaga kerja menyebabkan ia sukar untuk menentukan bahawa pemaju atau pengurus projek

telah benar-benar mengikuti garis panduan EIA. Oleh yang demikian, kajian ini bertujuan untuk mendapatkan satu sistem pakar yang comprehensif dalam bidang pencemaran udara di mana ianya akan berfungsi sebagai alat dalam menyediakan satu penilaian EIA. Ia juga sebagai bantuan untuk pengawasan dan kelulusan bagi sesuatu kajian EIA semasa peringkat pembinaan dan pelaksanaan.

Kajian ini telah dijalankan dengan mendapatkan: (1) analisa yang terperinci mengenai kesan udara daripada laporan EIA yang telah dihantar kepada Jabatan Alam Sekitar (DOE), (2) kajian bertulis mengenai kualiti udara dan (3) membuat peraturan mengenai kesan analisa untuk dimasukkan ke dalam laporan EIA.

Justure itu, amplikasi teknologi komputer dalam bentuk sistem pakar mengenai pencemaran udara yang menggunakan CLIPS membantu dalam penganlisaan dan pengurusan maklumat EIA.

CHAPTER I

INTRODUCTION

Artificial Intelligent (AI) has achieved a considerable success in the development of an expert system (ES) since the mid-1960s. This area of AI has concentrated on the construction of high performance programs (Roth, 1983). An expert system is based on an extensive body of knowledge about a specific problem area. Characteristically this knowledge is arranged as a collection of rules, which allows drawing of conclusions from the given data.

Durkin (1994) defines an expert system as a computer program design to model the problem-solving ability of a human expert. Expert systems have been developed for a variety of complex applications, including blood infection, configuring computer systems, planning gene-cloning experiments, monitoring and controlling computer operating systems, and trouble-shooting telephone networks.



The essential components of a fully expert system are:

- 1) Knowledge base (KB)-- it is a part of an expert system which contains domain knowledge;
- 2) Working memory (WM)-- part of an expert system that contains the problem facts that are delivered during the session. Working memory contains information supplied by the user and inferred by the system;
- 3) Inference engine (IE)-- the processor in an expert system that models the facts contained in the working memory with the domain knowledge contained in the knowledge base to draw conclusions about the problem;
- 4) Explanatory interface (EI)-- is the interaction between the expert system and the user; and
- 5) Knowledge acquisition (KA)-- is the process of acquiring, organizing and studying knowledge.

When providing advice, an expert stores the knowledge domain in his Long Term Memory (LTM); and the expert obtains facts about the problem in his Short Term Memory (STM). The expert then reasons out the problem by combining the STM facts with the LTM knowledge. By this, the expert infers (new) problem information and eventually arrives at conclusions about the problem (Figure 1).

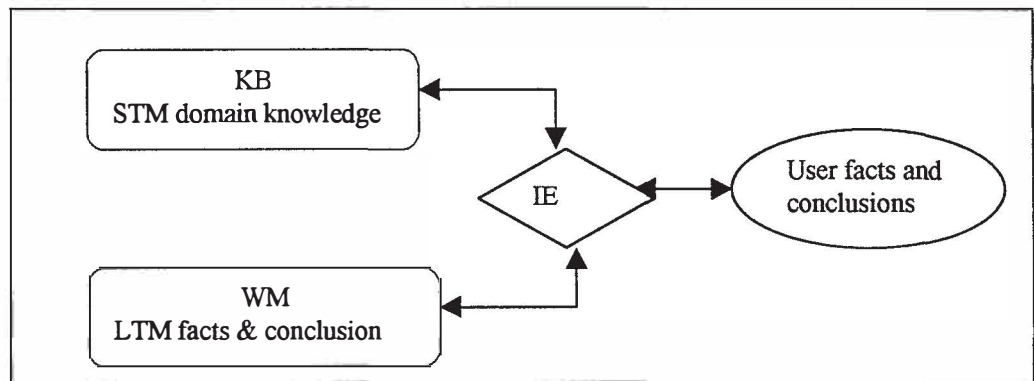


Figure 1: Expert System Model

Expert systems build up of rules; which are forms of procedural knowledge. A rule is a knowledge structure that relates some known information to other information that can be concluded or inferred to be known (Durkin, 1994). The rules consist of a conditional part and a conclusion part, as follows:

IF <condition>

THEN <conclusion>

If all the statements of the conditional part are verified, then all the conclusions are verified, too (Bosio, 1988).

This research talks about predicting air pollution from environmental impact assessment reports using the expert system. Air pollution is defined as any atmospheric condition in which any natural or man-made chemical elements or compounds capable of being airborne are present to produce a measurable effect on man, animals, vegetation, or materials (Seinfeld, 1986). Weather varies throughout the year, from day to day, and often from hour to hour. Pollution emitted into the air moves with the air except for the larger particles of grit and dust, which falls down close to their point of origin (Scrorer, 1971). Therefore, air is one of the important media for living creatures to survive.

Environmental Impact Assessments

Environmental Impact Assessment (EIA) is a study to identify, predict, evaluate, and communicate information about the impacts on the environment of a proposed project and to detail out the mitigating measures prior to project approval and implementation (DOE, 1993). EIA is an essential planning tool for preventing environmental problems due to an action. It seeks to avoid costly mistakes in project implementation, costly either because of the environmental damage that are likely to arise during project implementation, or because of modifications that may be required subsequently in order that the action is environmentally acceptable to the government and to the community.

In Malaysia, EIA is required under section 34A. EIA, when integrated into the existing planning and decision-making machinery, provides additional information towards better decision-making. The aim of environmental impact assessments in Malaysia is to assess the overall impacts due to environment of development projects proposed by the public and private sectors. The objectives of environmental impact assessment are:

- 1) To examine and select the best from the project option available;
- 2) To identify and incorporate into the project plan an appropriate abatement and mitigating measures;
- 3) To predict significant residual environmental impacts;
- 4) To determine the significant residual environmental impacts predicted;
and
- 5) To identify the environmental costs and benefits of the project to the community.

The monitoring programs to measure NO_x, SO_x and particulate concentration in the emissions perform two functions, as follows:

- 1) Provide a check on the environmental management of the project and ensure that the initiator meets the condition of the approval given for his project; and
- 2) Provide feed back to improve the database for environmental impact predictions in future project planning.

Problem Statement

Environmental air quality is a component of the physico-chemical environment that is required in an EIA report. Air is a very critical impact, unlike noise or water impacts, that has been given priority by the Public Works Department of Malaysia (JKR). Based on the 1995 Environmental Quality Report, air pollution was ranked first (69%), followed by water pollution (11%), noise pollution (6%), and others (14%), secondly, due to the high demand of land. Land development may affect the quality of air levels in the short term while in the long term it may damage all the lives, industrial process, and other activities. Last the EIA needs a big team of experts, finding a team expertise would be a major problem.

Therefore, a study on the development activities resulting in varied air quality levels (disturbing the immediate and overlying areas) is necessary, also identify the distribution effects of air pollution in the vicinity of the project area. This is the purpose of the environmental air impact analysis in an EIA report.

Objective of the Study

The purpose of this study is to assist air impact prediction in an EIA report during pre-construction, construction and post-construction stage. The objectives of this study are:

- 1) To produce ES that can produce EIA reports concerning the air pollution ;
- 2) To extract rules on air pollution from experts, literature review and EIA reports;
- 3) To use these rules to produce ES, and
- 4) To develop a comprehensive ES that could be used as a tool in preparing EIA reports.

Expected Results of the Study

The out come of this research is an expert system that can be used for predicting air pollution for various stages, that is, pre-construction stage, construction stage and post-construction stage. As such, it is visualized that the ES would become a very useful prediction and decision making tool for air pollution. Also, the EIA expert could be used to obtain information about air pollution studies and be used by project initiator to prepare his/her EIA report within a short time. It also includes information about potential impact and mitigating measures related to the existing environment. This means that no problem will arise from lack of EIA expert, and it can support EIA expert prediction.

This system is expected to be a powerful tool and has a friendly graphical user interface as well as a satisfying EIA report would be attained in a short time.

CHAPTER II

LITERATURE REVIEW

This chapter presents a summary of past research and application in related technologies, some applications of the expert systems in environmental science, and, a number of computer application that support environmental impact assessment study. Also presented are air quality guidelines, CLIPS expert system tool, and air pollution system are in the chapter.

Composition of Clean Tropospheric Air

Air is one of the important media for living creatures to survive their life. Air is considered normal if more than 99.99% of the air volume consists of only four gas molecules, nitrogen (about 79.09%), oxygen (19.94%), argon (0.94%), and carbon dioxide (0.03) and about a dozen other constituents are found in trace quantities, usually expressed in parts per million (ppm), but a typical urban air would contain some of these trace materials including, carbon monoxide, sulfur dioxide, hydrocarbon, nitrogen dioxide, and particulates (Turk, 1972).



Sources of Air Pollution

Air pollution is defined as any atmospheric condition in which any natural or man-made chemical elements or compounds capable of being airborne is present to produce a measurable effect on man, animals, vegetation, or materials. These substances may exist in the atmosphere as gases, liquid drops, or solid particles (Seinfeld, 1986). It is a common that the weather varies throughout the year, from day to day, and often from hour to hour. Pollution emitted into the air moves with the air except for the larger particles of grit and dust, which falls close to their point of origin. Inevitably, therefore, pollution exhibits a greater variety of behaviour patterns (Scrorer, 1971). Sources of air pollutants can be mobile or stationary while the receptors of the air pollutants include human beings, animals and vegetation. The affected areas are from the development of the project are the part.

Effects of Air Pollution

Substantial evidence has accumulated that air pollution effects the health of human beings and animals damage vegetation and soils, deteriorates materials, affects climate, reduces visibility and solar radiation, contributes to safety hazards, and generally interferes with the enjoyment of life and property Steubenville (1966).

Air pollutants can affect materials by soiling or through chemical deterioration. High smoke and particulate levels are associated with soiling of clothing and structure; and acid or alkaline particles, especially those containing sulphur, corrode materials, such as, paint, masonry, electrical contacts, and textiles. Once on plant leaf, pollutants destroy chlorophyll and disrupt photosynthesis.