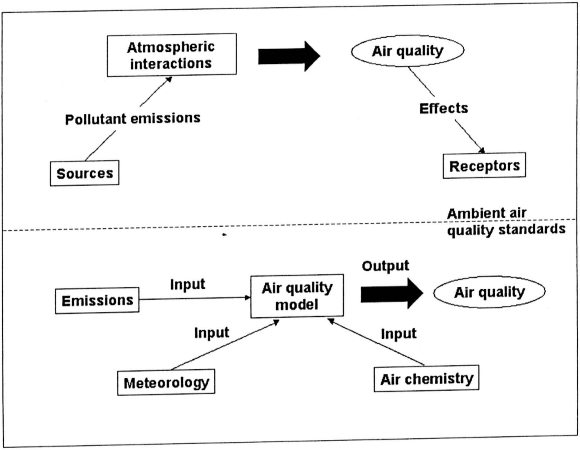
2. LITERATURE REVIEW

2.1 INTRODUCTION

This section will review and elaborate on the three important component of this project i.e. air quality modelling, environmental monitoring report and geographical information system. Only the basic principle of each component is being reviewed to provide an overview and basic understanding of each component. To conclude this chapter, a brief review on the current practise of integrating the air quality model and environmental monitoring is discussed.

2.2 AIR QUALITY MODELLING

The air quality impact of a source or collection of sources is evaluated by the use of models. The elements of a model are shown in **Figure 2.2.1**. Models simulate the relationships between air pollutant emissions and the resulting impact air quality. The inputs to the model include emissions, meteorology and air chemistry, all of which are determined by formulating impact scenarios (Rau, 1980).



Source: Rau (1980)

FIGURE 2.2.1: RELATION BETWEEN AIR QUALITY MODEL AND THE REAL WORLD

When pollutants are emitted into the atmosphere, they are immediately diluted, transported and mixed with the surrounding air. The role of air quality modelling is to represent these processes mathematically. Models are not absolute. The users needs to

1. be experienced (or, in the absence of experience, solicit guidance and perspective from an experienced user); and

2. recognize that air quality models are indicative of the cause-effect relationship between air quality and the emissions of primary pollutant – despite the apparent sophistication.

The complexity of atmospheric meteorology, the mechanics of atmosphere stability and uncertainty of atmospheric chemistry clearly demonstrate the rationale of the preceding cautionary advice.

2.2.1 PRINCIPAL OF AIR QUALITY MODEL

By far the most frequently used approach to regulatory air quality modelling has been the Gaussian diffusion formulation (USEPA, 1999). This approach stems from the fact that the well-known normal, or Gaussian, distribution function provides a fundamental solution to the classic Fickian diffusion equation. In the Gaussian plume model, the crosswind plume concentration distributions are taken to be Gaussian in form. This has been partially substantiated through field experiments for typical meteorological conditions. In the strict sense, Gaussian diffusion is valid only for long diffusion time and for homogenous, stationary conditions. However, this type of model has been found to give useful results for many applications.

The Gaussian plume algorithm has the advantages of inherent simplicity, ease of use, flexibility and short computation time. But it also has the following disadvantages:

- Concentrations are not time-dependent in the usual sense (the approach is "quasi-steady-state" in that the input variables are normally updated once per hour).
- Spatial variability in the meteorological parameters is difficult to incorporate.
- Difficulties are encountered when the wind speed is light and wind direction is ill-defined.
- The approach cannot be used for reactive or secondary pollutants, because in these cases superposition of individual source contributions at a receptor is not valid.

Many computer programs have been developed for air quality simulations. Some of them, generally the simplest, are well documented and relatively easy to use. Most of them, however, require users with good technical skills and often, the supervision of the developers of the codes. Available codes are discussed in Chapter 14 of Zannetti (1990). Roth et al. (1988) offer a comprehensive compendium of air quality models in their Appendix B, Part 2 and Appendix C.

Many air quality models have been developed by or for the USEPA, which has periodically provided guidelines and recommendations (USEPA 1998). Many non-EPA models can also be used such as AVACTA II and

DEGADIS, especially for studies that do not involve regulatory aspects and therefore, need not be performed with "approved" software.

2.2.2 ISCST3 MODEL

The Industrial Source Complex Short Term model (ISCST3) provides options to model emissions from a wide range of sources that might be present at a typical industrial source complex.

The basis of the model is the straight-line, steady-state Gaussian plume equation, which is used with some modifications to model simple point source emissions from stacks, emissions from stacks that experience the effects of aerodynamic downwash due to nearby buildings, isolated vents, multiple vents, storage piles, conveyor belts, and the like (USEPA, 1999).

Emission sources are categorized into four basic types of sources, i.e., point sources, volume sources, area sources, and open pit sources. The volume source and the area source may also be used to simulate line sources. The model algorithms used to model

1. each of four source types (point, volume, area and open pit)
2. calculating dry deposition for point, volume, area and open pit sources,

3. calculating wet deposition,

4. calculations for simple terrain (defined as terrain elevations below the release height).

The ISCST3 model accepts hourly meteorological data records to define the conditions for plume rise, transport, diffusion, and deposition. The model estimates the concentration or deposition value for each source and receptor combination for each hour of input meteorology, and calculates user-selected short-term averages. For deposition values, either the dry deposition flux, the wet deposition flux, or the total deposition flux may be estimated. The total deposition flux is simply the sum of the dry and wet deposition fluxes at a particular receptor location. The user also has the option of selecting averages for the entire period of input meteorology.

Brief History of the ISCST3 Model

The ISCST3 model is based on revisions to the algorithms contained in the ISCST2 model (USEPA, 1999). The latter came about as a result of a major effort to restructure and reprogram the ISCST3 model that began in April 1989, and was completed in March 1992. The reprogramming effort was largely motivated by the need to improve the quality, reliability, and maintainability of the code when numerous "bugs" were discovered after the implementation of the revised downwash algorithms for shorter stack.

It became widely recognized that the code, originally developed in the 1970's and modified numerous times since, had become impossible to reliably modify, debug or maintain. However, the goals of the reprogramming effort also included improving the input file structure and the output products, and to provide better "end user" documentation for revised models. The ISCST2 model was developed as replacements for and not updates to the previous version.

2.2.2.1 DESCRIPTION OF KEYWORD/ PARAMETER APPROACH

The input file for the ISCST3 model makes use of a keyword/ parameter approach to specifying the options and input data for running the model. The descriptive keywords and parameters that make up this input runstream file may be thought of as a command language through which the user communicates with the model that he/ she wishes to accomplish for a particular model run. The keywords specify the type of option or input data being entered on each line of the input file, and the parameters following the keyword define the specific options selected or the actual input data. Some of the parameters are also input as descriptive secondary keywords.

The input data structure describes below is specific for MS-DOS version and the runstream file is divided into a functional "pathways". These pathways are identified by a two-character pathway ID placed at the beginning of each runstream image. The pathways and the order in which they are input to the model are as follows:

CO – for specifying overall job **CO**ntrol options;

SO – for specifying **SO**urce information;

RE – for specifying **RE**ceptor information;

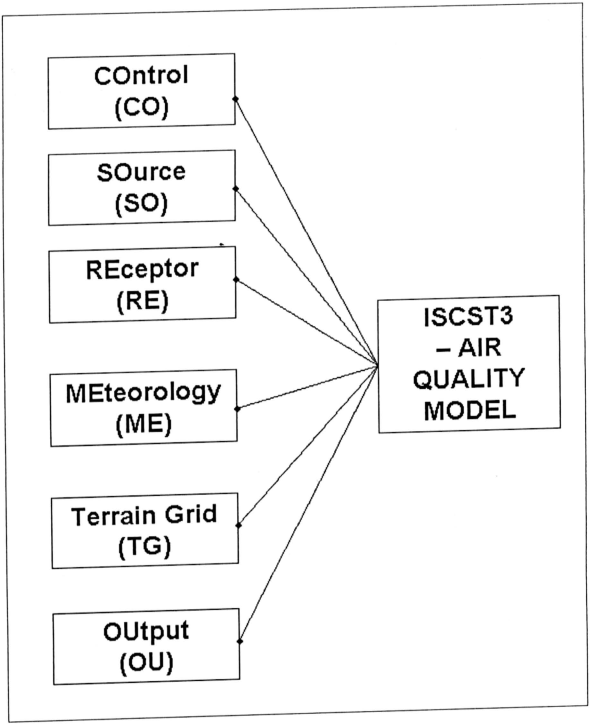
ME – for specifying **ME**teorology information;

TG – for specifying **T**errain **G**rid information; and

OU – for specifying **OU**tput options.

The TG pathway is an optional pathway that is only used for implementing the dry depletion algorithm in elevated terrain. **Figure 2.2.2** shows the pathways of the ISCST3 air quality model.

Each line of the input runstream file consists of a pathway ID, an 8-character keyword, and a parameter list. An example of a line of input from a runstream file, with its various parts identified, is shown in **Figure 2.2.3**.



Adapted from USEPA (1999)

FIGURE 2.2.2: ISCST3 KEYWORD/ PARAMETER APPROACH

```
Column: 1234567890123456789012345678901234567890123456789012345678 9

        CO MODELOPT DFAULT RURAL CONC
        .  .        .      .     .
        .  .        .      .     .
        .  .        .))))))2)))))2)))))))))) Parameters
        .  .
        .  .)))))))))))))))))))))))))))))))))))) 8-Character Keyword
        .
        .))))))))))))))))))))))))))))))))))))))))))))) 2-Character Pathway ID
```

FIGURE 2.2.3: EXAMPLE OF INPUT LINE IN THE RUNSTREAM FILE

2.2.2.2 ADVANTAGES OF THE KEYWORD APPROACH

The keyword approach provides some advantages over the type of input file that uses non-descriptive numeric option switches and requires rigidly formatted inputs. One advantage is that the keywords are descriptive of the options and inputs being used for a particular run, making it easier for a reviewer to ascertain what was accomplished in a particular run by reviewing the input file. Another advantage is that the user has considerable flexibility in structuring the inputs to improve their readability and understandability, as long as they adhere to the few basic rules described above.

Some special provisions have been made to increase the flexibility to the user in structuring the input files. One provision is to allow for blank records in the input file. This allows the user to separate the pathways from each other, or to separate a group of images, such as source locations, from the other images. Another provision is for the use of "comment cards", identified by a "**" in the pathway field. Any input image that has "**" for the pathway ID will be ignored by the model. This is especially useful for labelling the columns in the source parameter input images. It may also be used to "comment out" certain options for a particular run without deleting the options and associated data (e.g. elevated terrain heights) completely from the input file. Because of the descriptive nature of the keyword options and the flexibility of the inputs it is generally much easier to make modifications to an existing input runstream file to obtain the desired result.

Another aspect of the "user-friendliness" of the ISCST3 model is that detailed error-handling has been built into the model. The model provides descriptions of the location and nature of all of the errors encountered for a particular run. Rather than stopping execution at each occurrence of an input error, the model will read through and attempt to process all input records and report all errors encountered. If a fatal error occurs, then the model will not attempt to execute the model calculations.

2.2.2.3 ISTSC3 MODELLING CAPABILITIES

The modelling capabilities of the ISCST3 air quality software is as follows (USEPA, 1999):

- The ISCST3 model may be used to model primary pollutants and continuous releases of toxic and hazardous waste pollutants.

- The ISCST3 model can handle multiple sources including point, volume, area and open pit source types. Line sources may also be modelled as a string of volume sources or as elongated area sources.
- Source emission rates can be treated as constant or may be varied by month, season, hour-of-day, or other optional periods of variation. These variable emission rate factors may be specified for a single source or for a group of sources.
- ISCST3 can account for the effects of aerodynamic downwash due to nearby buildings on point source emissions.
- The model contains algorithms for modelling the effects of settling and removal (through dry deposition) of large particulates and for modelling the effects of precipitation scavenging for gases or particulates.
- Receptors locations can be specified as grid and/or discrete receptors in a Cartesian or polar coordinates.
- The ISCST3 model uses real-time meteorological data to account for the atmospheric conditions that affect the distribution of air pollution impacts on the modelling area.

2.3 ENVIRONMENTAL MONITORING REPORT

The Department of Environment, Malaysia in its Environmental Impact Assessment Guidelines for Industrial Projects (Department of Environment, 1995) had defined environmental monitoring as observation of effects of development projects on environmental resources and values. It includes sampling, analysis, temporary monitoring during the project construction stage and continuous monitoring following commencement of the project operation. The objectives of the environmental monitoring are as follows:

- To ensure project operating procedures and controls follow EIA constraints.
- To check actual impacts on environment.
- To determine whether project design bases for protecting the environment are valid.
- And if not valid, to furnish feedback for correcting or modifying unacceptable impairments.

Sadler and Davies (1988) have delineated three types of environmental monitoring which might be associated with the life cycle of an undertaking. These are:

1. Baseline monitoring. This type of monitoring refers to measurement of environmental variables during a representative pre-project period to determine existing conditions, ranges of variation and processes of change.
2. Effects or impact monitoring. This involves the measurement of environmental variables during project construction and operation to determine the changes which may have occurred as a result of the project.

3. Compliance monitoring. This takes the form of periodic sampling and/or continuous measurement of levels of waste discharge, noise or similar emissions, to ensure that conditions are observed and standards are met.

Pre-EIA monitoring includes baseline monitoring, while post-EIA monitoring encompasses effects or impact monitoring and/or compliance monitoring.

Purposes of Environmental Monitoring

Numerous purposes (and implied benefits) can be delineated for pre- and/or post EIA environmental monitoring. For example, Marcus (1979) identified the following six general purposes or uses of information gleaned from the conduction of post-EIA monitoring:

1. Environmental monitoring provides information that can be used for documentation of the impacts that result from a proposed federal action; this information enables more-accurate prediction of impacts associated with similar federal actions.

2. The monitoring system could warn agencies of unanticipated adverse impacts or sudden changes in impact trends.

3. The monitoring system could provide an immediate warning whenever a pre-selected impact indicator approaches a predetermined critical level.

4. Environmental monitoring provides information which could be used by agencies to control the timing, location and level of impacts of a project.

Control measures would involve preliminary planning as well as the possible implementation of regulation and enforcement measures.

5. Environmental monitoring provides information which could be used for evaluating the effectiveness of implemented mitigation measures.

6. Environmental monitoring provides information which could be used to verify predicted impacts and thus validate impact-prediction techniques. Based on these findings, the techniques – for example, models – could be modified or adjusted, as appropriate.

Presentation of Monitoring Result

The result of environmental monitoring is usually presented in the form of table and graph using word processing software such as Microsoft Word, Excel or Lotus. The objective of using the software is only for the visual presentation of the result. An example of the environmental monitoring result is shown in **Table 2.3.1** and **Figure 2.3.1**.

Environmental monitoring reports are usually being enhanced by the use of visual-display materials. Woolston, Robinson and Kutzbach (1988) have suggested that visual-display materials are used in the following situations:

1. when words will not suffice;

2. when information is faster and easier to understand in graphic form; and

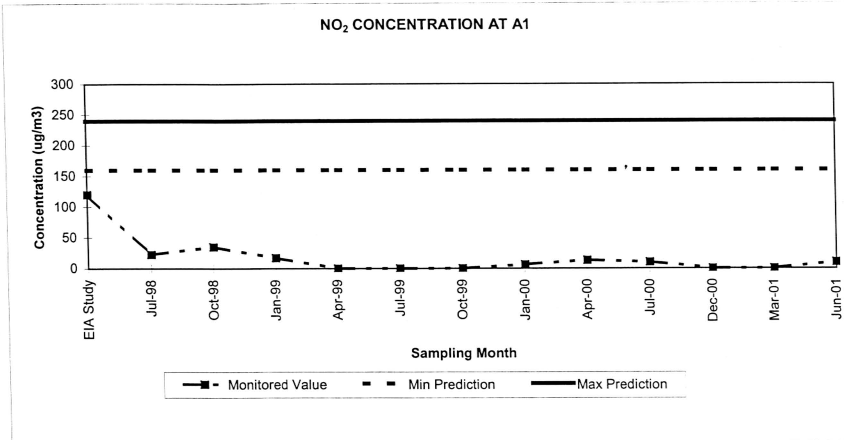
TABLE 2.3.1: EXAMPLE OF ENVIRONMENTAL MONITORING RESULT IN TABLE FORM

PARAMETER		RESULTS (μg/m³)			
		PM_{10}	SO_2	NO_2	VOC
A1	July 98	56	<5	23	3.1
	Oct. 98	14	11	35	2.4
	Jan. 99	13	5	17	2.4
	April 99	21	10	<5	5.4
	July 99	98	<5	<5	44
	Oct. 99	37	5	<5	57
	Jan. 00	28	<5	6	7
	April 00	36	<5	13	39
	July 00	61	<5	10	22
	Dec. 00	21	<5	<5	<0.01
	March 01	35	<5	<5	21
	June 01	45	<5	10	<0.5
A2	July 98	39	<5	58	0.4
	Oct. 98	19	<5	55	0.6
	Jan. 99	8	5	30	2.1
	April 99	16	<5	<5	<0.5
	July 99	5	<5	<5	39
	Oct. 99	24	<5	<5	82
	Jan 00	29	<5	5	47
	April 00	68	<5	7	56
	July 00	54	<5	<5	23
	Dec. 00	32	<5	18	<0.01
	March 01	44	<5	<5	200
	June 01	50	<5	20	49
A3	July 98	26	<5	38	1.1
	Oct. 98	25	<5	17	1.3
	Jan. 99	7	5	41	1.0
	April 99	14	<5	<5	<0.5
	July 99	22	<5	<5	45
	Oct. 99	37	16	<5	119
	Jan. 00	50	<5	<5	<0.5
	April 00	22	<5	20	<10
	July 00	80	<5	16	29
	Dec. 00	22	<5	22	<0.01
	March 01	38	<5	8	68
	June 01	60	<5	12	<0.5
Air Quality Guidelines		**150**	**105**	**320**	-

Note: *Malaysian Ambient Air Quality Guideline limits are for 24-hour averaging time, except for NO_2 (1-hour averaging).*

Source: Perunding Utama Sdn Bhd (1998-2001)

FIGURE 2.3.1: EXAMPLE OF ENVIRONMENTAL MONITORING RESULT IN GRAPH FORM



Source: Perunding Utama Sdn Bhd (1998-2001)

3. when visual-display material can be used to highlight an important point.

Visual-display material can include charts or graphs, drawings and photographs, and tabular presentations (Mills and Walter, 1978).

The Environmental Monitoring Report (EMR) discusses the finding and observation concluded from the environmental monitoring exercise. The government authority will then assess the report and determine whether the particular establishment is contributing significantly or vice-versa to the surrounding environment. With the monitoring result, the authority is able to monitor the state of environment of the surrounding area.

Ambient air quality monitoring refers to appropriate sampling and analysis to establish the ambient concentrations of specific pollutants (Canter, 1996). Documentation of this information will allow the determination of the significance of air quality impacts incurred during projects or activities and will aid in deciding between alternative actions or in assessing the need for mitigating measures for a given alternative.

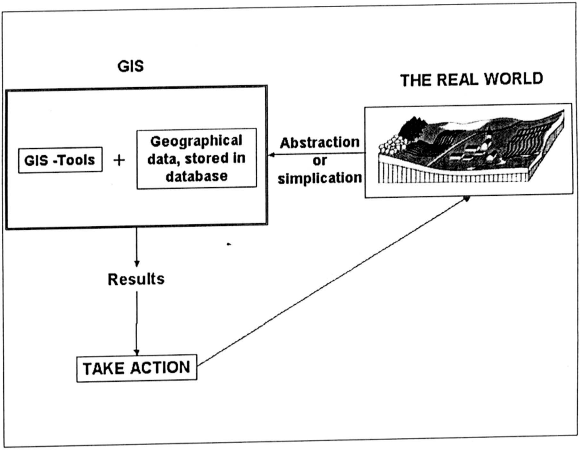
2.4 GEOGRAPHICAL INFORMATION SYSTEM

A geographical information system (GIS) is a computer-based system consisting of hardware, software, data and applications. The system serves to capture and update digital spatial data, to store and maintain, to analyse and present the data in an alphanumeric and graphic form (Bill, 1994).

Maguire et al. (1991) have defined a GIS as 'a computer system for capturing, storing, checking, manipulating, analysing and displaying data which are spatially referenced'. GIS excels at editing, data handling, interpolation and visualization of spatially or geographically referenced information – capabilities that are lacking in most information systems. As suggested by Fedra (1994) the basic concept of geographical information systems (GIS) is location of spatial distribution and relationship.

A GIS can answer queries of a spatial nature. Every feature on these maps can be represented by a series of coordinates, in the form of points, lines or polygons, where a line consists of series of points joined by straight lines, or arcs, and a polygon is a series of lines joined to form an enclosed area. Information on adjacency of points, arc and polygons is also stored (Eastman, 1993).

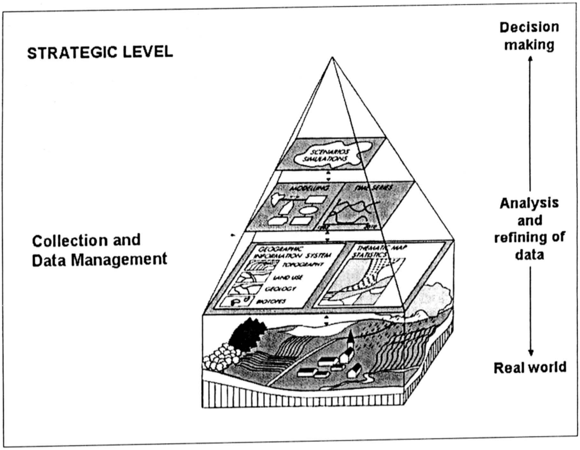
Geographical information allows us to apply general principles to the specific conditions of each location, any place and helps us to understand how one place differs from another (**Figure 2.4.1**). Geographical information then is essential for effective planning and decision making.



Source: Bernhadsen (1999)

FIGURE 2.4.1: ROLE OF GIS IN THE REAL WORLD

If we can express the contents of map or image in digital form, the power of the computer opens an enormous range of possibilities for communication, analysis, modelling and accurate decision making (**Figure 2.4.2**). At the same time, we must constantly be aware of the fact that the digital representation involves some degree of approximation.

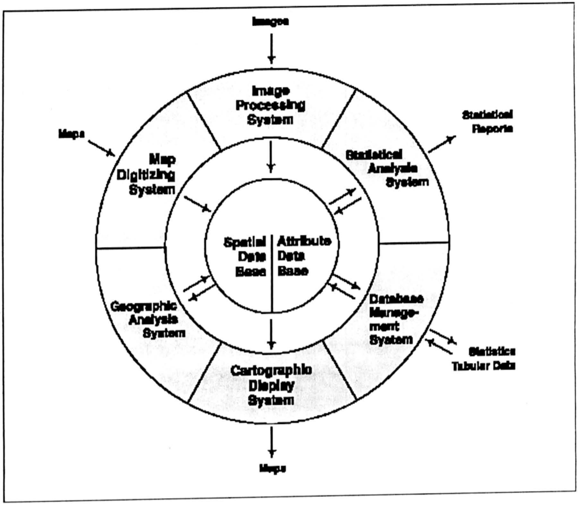


Source: Bernhardsen (1999)

FIGURE 2.4.2: APPLICATION OF GIS IN DECISION MAKING PROCESS

2.4.1 COMPONENTS OF GIS

Although we sometimes think of a GIS as a single piece of software, a GIS installation is made up of several different components. **Figure 2.4.3** gives a broad overview of the software components typically found in such a setup. Not all systems have all of these elements, but to be a true GIS, a system must contain an essential group, including cartographic display, map digitising, database management and geographic analysis (Eastman, 1993).



Source: Eastman (1993)

FIGURE 2.4.3: FUNCTIONAL COMPONENTS OF A GIS SOFTWARE

The typical components is as follows:

- Spatial and Attribute Databases. Central to the system is the database – a collection of maps and associated information in digital form. It comprises two elements – a spatial database describing the geographic (shape and position) of earth surface features and attribute database describing the characteristics or qualities of these features.

- Cartographic Display System. It allows one to take selected elements of the database and produce map outputs on the screen or some hardcopy device such as a printer or plotter.
- Map Digitising System. It is used to convert existing paper maps into digital form. Map digitisation can be accomplished through scanning devices.
- Database Management System (DBMS). Traditionally, this widely used term refers to a type of software that is used to input, manage and analyse attribute data. It is also used in that sense here, although we need to recognize that spatial database management is also required. Thus, a GIS typically incorporates not only a traditional DBMS but also a variety of utilities to manage the spatial and attribute components of the geographic data stored.
- Geographic Analysis System. With a geographic analysis, we extend the capabilities of traditional database query to include the ability to analyse data based on their location.
- Image Processing System. It allows one to take remotely sensed imagery (such as LANDSAT or SPOT satellite imagery) and convert it into interpreted map data according to various classification procedures.
- Statistical Analysis System. For statistical analysis, most geographic information systems offer both traditionally statistical procedures as well as some specialized routines for the analysis of spatial data.

2.5 GIS AND MODELLING

Geographical Information System (GIS) are powerful tools for modelling environmental processes. Models can be developed directly within GIS using a GIS-based programming language. Essentially three methods exist which could be adopted to empower GIS with dispersion modelling abilities. Strong comparisons of procedures for linking of GIS with models are provided by Abel (1994), Fedra (1994), and Haining and Wise (1992). The three possible methods of integration are:

1. Full Integration
2. Loose Coupling
3. Tight Coupling

2.5.1 FULL INTEGRATION

In the full integration approach, a programming language such as MapInfo's MapBasic or ArcInfo's Arc Macro Language (AML) is used to create and implement the model and the model becomes one of the analytical functions of GIS.

This method is adequate for modelling simple processes where computational requirements are not extremely great, and may be utilized if a phenomena to be modelled is very specialized. Advantages of this method include: a common data structure and data model can be used to represent the real world features, and data handling and visualization can be performed within one system.

Using this method for complicated processes such as large-scale atmospheric modelling can prove to be slow in cases where computer instructions are interpreted and a plethora of temporary files are utilized. Bishop and Robey (1994) created a model to run within the GIS, written as a series of AML commands, that used the GRID module's capacity to undertake visibility, proximity and overlay analysis. They suggested work is made easier if models use data from, or are implemented within a GIS, although processing times can be slow.

Dragosits (1994) assessed and compared the accuracy and efficiency of an ArcInfo GIS only model with the coupling of a model with ArcInfo GIS. In her study, she quantified the advantages and disadvantages of these two approaches concluding the ArcInfo GIS only model was on the magnitude of three times slower than a coupled GIS model solution. In addition to the slow performance, the possibility of error propagation becomes evident when transposing the source code from an existing model to the GIS. These errors certainly can render the model ineffective if unchecked.

As suggested by Goodchild (1992) although GIS supports a broad range of data models, several of the fundamental primitives necessary to support environmental modelling are absent and must be added by the user. At present, the ability to write the environmental model directly in the command language of the GIS is still some distance away (Steyaert and Goodchild, 1994). Current GIS are typically limited to analytic compromises that include static representations of dynamic space/ time processes; use of simple logical operations to explore complex relationship; non-stochastic treatment of uncertain events; and quasi-two-dimensional or perspective treatment of inherently three dimensional properties (Parks, 1993). Nyerges (1992) and Fedra (1994) and others argue that, since the capabilities of current GIS are limited for running complicated mathematical models, the best approach is to link GIS and other systems, resulting in more efficient modelling tools.

2.5.2 LOOSE COUPLING

System integration essentially seeks to fuse capabilities available in the individual systems (Chou and Ding, 1992) and to provide some desired level of usability. A loose integration consists of two systems which are run separately from each other, but complement each other through shared data input or data output; the two systems are not knitted together to facilitate usability.

Zack and Minnich (1991) applied a diagnostic wind field model for forest fire management. In this loose coupling approach, a GIS was used to help prepare model-input data, and display model analysis. Collins et al (1994) estimated pollutant concentrations using a stand-alone dispersion model then used GIS to visualize the model's numerical output, without directly linking the two systems. The advantage of this method is that each system complements each other; the model provides potentially valuable information to the GIS for further spatial analysis and the GIS can be used to prepare input files and allows model output to be visualised in map form. The disadvantage with this integration method is that repetitious processes such as converting model output to GIS, can be laborious and may have to be performed over and over again by the user, after each model run.

2.5.3 TIGHT COUPLING

Tight coupling involves full integration of an existing model with GIS, using one common graphical user interface (GUI) to facilitate the modelling process. The GUI provides a veneer, which assists and guides the user through the modelling process while hiding the processing intricacies. Such systems offer a virtual environment within which decision-makers and scientist can explore theory and evaluate competing management strategies (Bennett, 1997). One advantage of this method over the full integration approach is that the speed of model calculations is a function of the computers' processing speed, not the speed in which command-macros are interpreted by the GIS.

Buckley and Hodgin (1993) integrated atmospheric dispersion modelling with GIS technology to produce the Computer-Assisted Protective Action Recommendation System (CAPARS), which provides plume and health impact predictions from toxic chemical emergencies. In this integration, a sophisticated and fault tolerant system was designed to produce plume paths and predict plume spread over complex terrain.

Novak and Dennis (1993) provide a synopsis of a regional air quality and acid deposition model, and provide a plan to develop an integrated modelling and analysis framework to ensure that GIS functionality is directly accessible by the researchers. A tight-coupling approach has been applied in modelling the impact of atmospheric deposition and climate change on north-eastern forest ecosystem (Lathrop et al, 1994).

As stated by Goodchild (1993), the computational power of computers and GIS make it easier to integrate models, to disaggregate them to greater levels of spatial detail and to reaggregate results over relevant areas. In GIS function of visualization can be useful to make powerful products that carry far more weight than tables of numbers. The interactive nature of many current GIS allows the decision-maker to work with complex models in a comfortable, reassuring environment.

2.6 ENVIRONMENTAL MONITORING AND GIS

Many applications had been carried out for environmental monitoring using GIS. However, most of the works is mainly for management of natural resources such as forest and water. An example of a water management application is the USEPA BASINS application. This application is a comprehensive watershed modeling tool integrated with ArcView. It is used by government agencies in performing watershed, water quality and analysis (USEPA, 1998). No particular work had been carried out solely on ambient air quality monitoring. This component is usually forms an important component in an Environmental Information System (EIS) or Decision Support System (DSS).

Forming a component of an Environmental Information System (EIS), Naranjo et. al. (2000) uses the monitored air emission in its risk assessment model (RISKMOD) to predict the extend of the pollution caused by a smelter plant in Bolivia. The purpose of the EIS is to support the administration of mining activities at the study area.

Kvaal, Sanders and Walikis (2000) had developed an application which combines GIS, air dispersion models and industrial database into a desktop air quality management package termed KARES 2000. The analytical results were used for monitoring emission control programs and for submittal of permits to regulatory agencies.

Jensen (1996) develop a model for population exposure to traffic induced air pollution in order to improve assessment of health impacts and impacts of various traffic control strategies. The application combines modelled air pollution data using the Danish Operational Street Pollution Model (OSPM) and population data using a GIS (ArcView). Monitored data is obtained from the Danish Air Quality Monitoring Programmes monitoring station.

Wurtz and Haastrup (1996) uses monitored ambient air quality data for the town of Messina, Italy as an input in its dispersion model for urban air management application. This application is to be developed into a decision support system.

Fedra, Haurie and Kanala (1999) developed an integrated decision support system for air quality management in Cracow and Geneva, Switzerland and Vienna, Austria. The integrated DSS is composed of an energy and traffic model linked to an air pollution dispersion model. GIS is used to integrate both the data collection and the result display levels. It also permits, through a geographic analysis based on census data and emission maps, an evaluation of the exposure of population to health risk. A linkage with a network of measuring stations provides real time data that is used for model calibration.

From the above discussion, it could be concluded that the research work would reduce the current gap or void in integration of environmental monitoring database and GIS system. It would complement the existing works on environmental management and protection using GIS as a tool in planning and decision making process.